Environmental Trends in Germany

Data on the Environment 2015

For our Environment

Umwelt Bundesamt

Contents

Preface

Dear readers,

2014 was the warmest year on average since the beginning of regular temperature records – both worldwide and in Germany. The concentration of greenhouse gases in the atmosphere continues to rise and is approaching the critical point where the international community's objective to limit global warming to two degrees Celsius, will be highly improbable to reach. As one of the international pioneers in climate protection, Germany, together with other countries, is under a particular obligation to set challenging targets and find innovative solutions. All of us are concerned – the countries of the world and all individual citizens.

Environmental policy requires great staying power not only in terms of climate protection. A look at air pollution control and water protection shows that while harmful emissions to the environment are decreasing in many areas, this is no reason to sound the all clear. For example, only ten percent of rivers and streams in Germany and only about one percent of examined sections of North and Baltic Sea coasts exhibit good ecological status, mainly because nutrient loads are still too high.

Successful environmental policy needs reliable information about the state and

development of the environment. Up-to-date, comprehensive and science-based environmental data provide the basis for this. They serve as information for citizens as well as policy makers, and show the trends in environmental impacts and highlight successes in environmental protection and environmental policy. They also demonstrate the extent to which previously set ambitious environmental objectives have been achieved. Data, facts and indicators compiled in this publication provide an overview of current developments and trends in the environmental field.

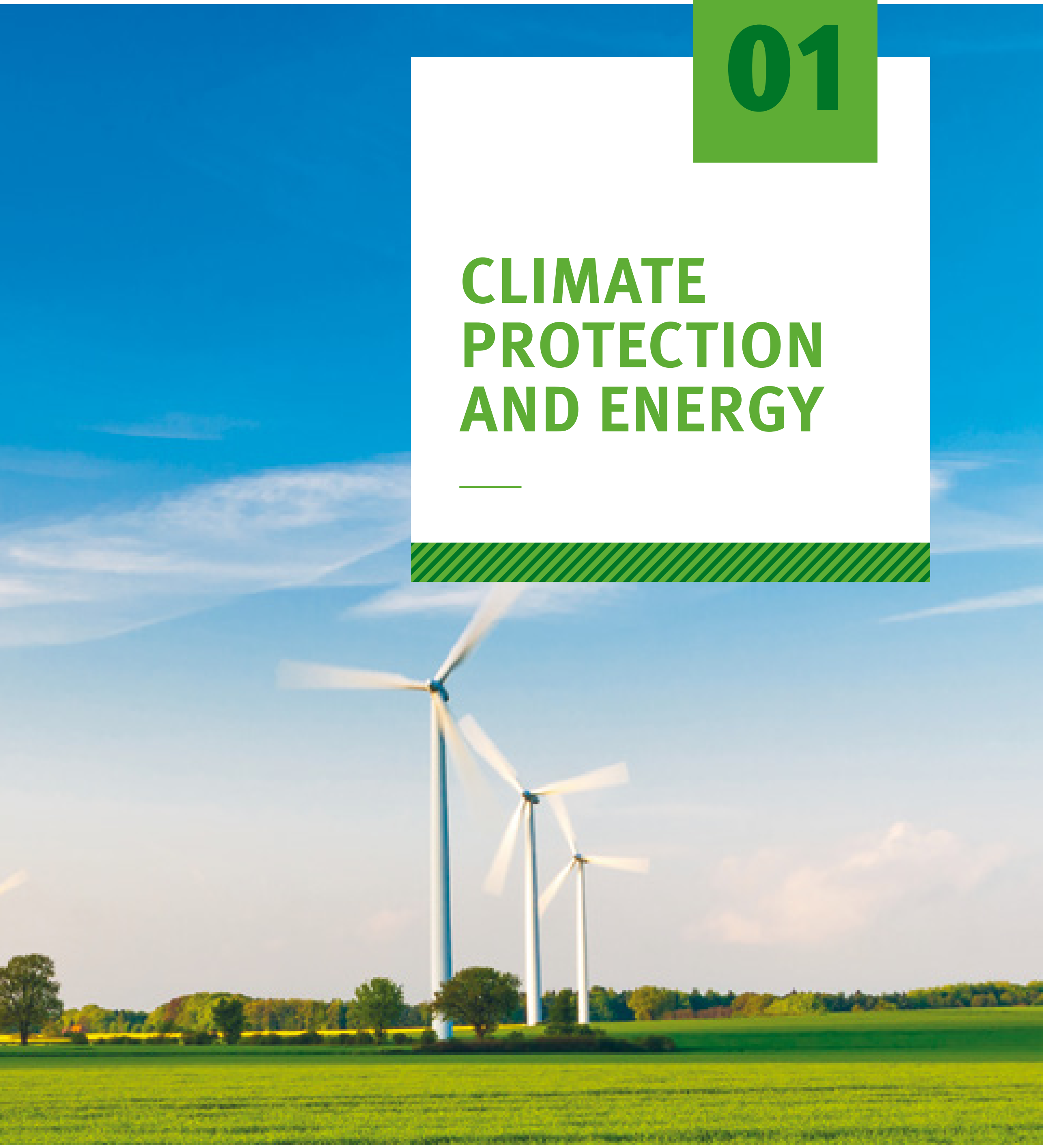
In December 2015, the international community will come together in Paris to discuss the next steps in global climate protection. We must set a signal for the future and adopt a comprehensive, ambitious and binding agreement to which all states will contribute and which will come into force in 2020. Germany can become greenhouse gas neutral by 2050 – as a Federal Environment Agency study shows. For this, Germany's energy consumption must be reduced as much as possible and the remaining energy demand (electricity, heat, fuels) should be covered by renewables. This is technically feasible. Whether it will be implemented, depends mainly on clear and binding policies. A success in the Paris climate negotiations would be helpful.

Maria Krautzberger

President
Federal Environment Agency

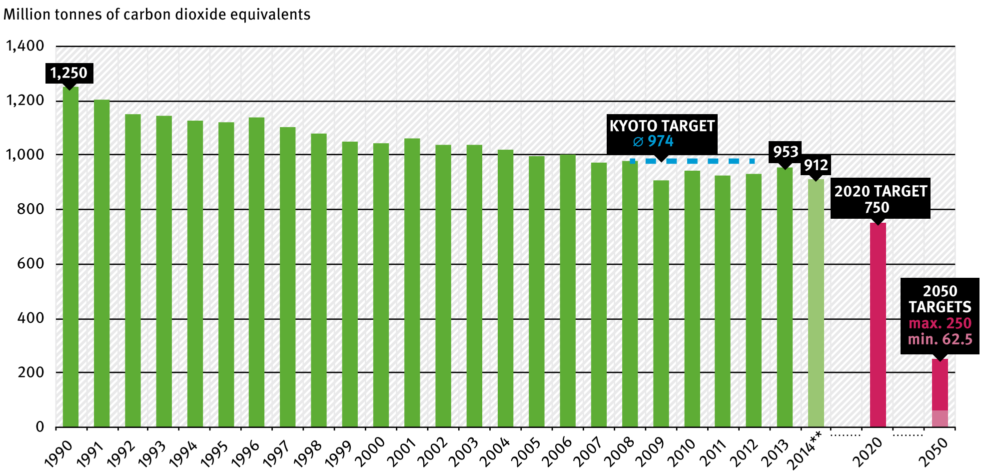
01

CLIMATE PROTECTION AND ENERGY



Greenhouse gas emissions

Greenhouse gas emissions in Germany since 1990*
and targets for 2008-2012 (Kyoto Protocol), 2020 and 2050 (Federal Government)



* Without carbon dioxide from LULUCF
** Short-term forecast for 2014

Source: Federal Environment Agency 2015, National Greenhouse Gas Inventory 1990 to 2013 and short-term forecast for 2014 (as of 03/2015)

Further reducing greenhouse gas emissions

Germany reduced its greenhouse gas emissions between 1990 and 2013 from 1,250 million tonnes (Mt) to 953 Mt, i.e. by 23.8 percent (%). The Federal Environment Agency's short-term forecast for 2014 shows a decrease in emissions by another 41 Mt to the lowest level since 2010. This represents a 27 % decrease compared to 1990. Much of the reduction in 2014 is due to the mild winter.

Industrialised countries such as Germany must reduce their greenhouse gas emissions by at least 80 - 95 % compared to 1990 by the middle of the century in order to limit temperature rise due to climate change to 2 degrees Celsius (°C) compared to pre-industrial levels. The German Government has in addition committed itself to reducing Germany's greenhouse gas emissions in an intermediate step by 40 % by 2020 compared to 1990. The steps initiated so far can achieve a reduction of about 33 to 34 % while maintaining economic development. In its "Climate Action Programme 2020", the German Government has adopted measures to fill the remaining gap.

In its latest report, the Intergovernmental Panel on Climate Change (IPCC) emphasizes that climate change has already begun [IPCC 2014]. It is caused by the emission of greenhouse gases, which accumulate in the atmosphere. They are mainly released in the production and use of energy, for example in electricity generation in power plants, heating of buildings or fuel consumption by driving. Other relevant emission sources include in particular agriculture and industrial solvent use.

The United Nations Framework Convention on Climate Change obligates the international community to limit climate change to a level that allows ecosystems to adapt naturally to climate change, does not threaten food production and enables economic development to proceed in a sustainable manner. To meet these criteria, it is considered necessary to limit global warming to 2 °C above pre-industrial levels.

The gradual reduction of greenhouse gas emissions is essential to achieve this goal. Production, transport and consumption must be organised over the long term in such a way that hardly any greenhouse gases will be released.

The reduction of greenhouse gases in Germany in the first half of the 1990s was due to the restructuring of the economy within the new German states (Länder). Since then, a number of climate policy instruments have been introduced that have contributed to reducing greenhouse gas emissions further, inter alia encouraging the development of renewables, the introduction of the European emissions trading scheme or the ecological tax reform. In recent years, however, emissions have again risen slightly. Therefore additional steps to reduce greenhouse gas emissions have become necessary. The "Climate Action Programme 2020" aims to guarantee the achievement of the 2020 reduction target. In addition, a fundamental reform of the European emissions trading scheme and a global agreement on climate change with concrete reduction targets are necessary.

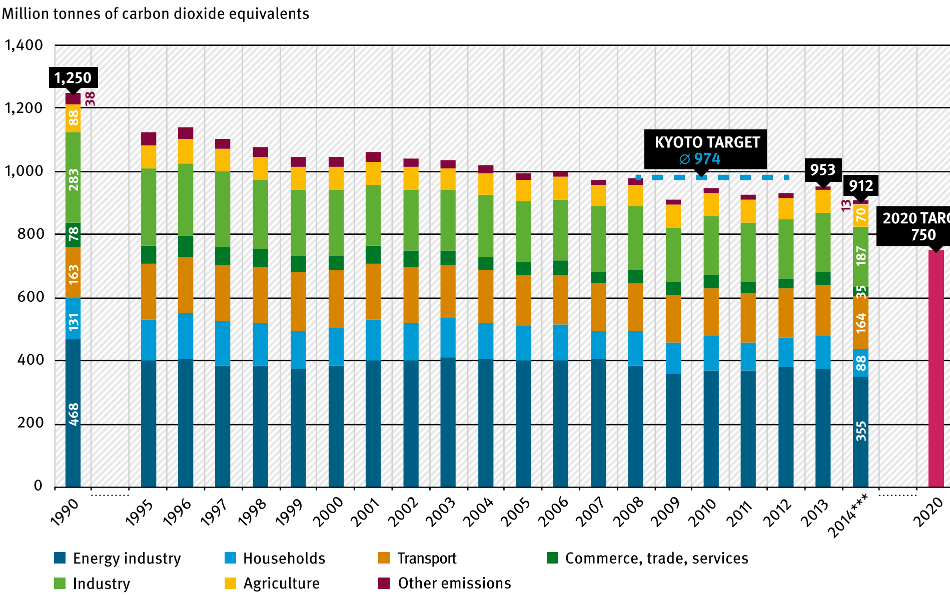
Climate protection and energy targets according to the Energy Concept 2010 of the Federal Government

	CLIMATE	RENEWABLES		EFFICIENCY				TRANSPORT
	Minimum reduction of Greenhouse gas emissions compared to 1990 by	Share in gross electricity consump-tion at least	Share in gross final energy con-sumption at least	Primary energy	Elec-tricity	Energy produc-tivity	Building renovations	
2020	-40 %	35 %	18 %	-20 %	-10 %	Increase by 2.1 % p. a.	Doubling the rate from 1 % to 2 %; Heating -20 % by 2020; Primary energy -80 % by 2050 compared to 2008	1 million electric vehicles by 2020; 6 million by 2030
2030	-55 %	50 %	30 %	↓	↓			
2040	-70 %	65 %	45 %					
2050	-80 to -95 %	80 %	60 %	-50 %	-25 %			

Source: Federal Ministry for Economic Affairs and Energy, Second Monitoring Report "Energy of the Future", April 2014

Greenhouse gas emissions by sector

Greenhouse gas emissions in Germany since 1990*
according to sectors of the Climate Action Programme 2020**



* Without carbon dioxide from LULUCF
** The breakdown of emissions differs from the UN reporting, total emissions are identical
*** Short-term forecast for 2014

Source: Federal Environment Agency 2015, National Greenhouse Gas Inventory 1990 to 2013 and short-term forecast for 2014 (as of 03/2015) and short-term forecast for 2014 (as of 03/2015)

Greenhouse gas emissions from the **energy sector** decreased between 1990 and 1995, mainly due to the reduced use of lignite. In addition, numerous old installations were shut down after Germany's reunification. The decrease since 2007 is due to greater efficiencies in energy production as well as an increasing use of renewable energies. To date, coal burning is the main source of emissions: it accounted for 78 % in 2012. The consistent implementation of the energy transition is supposed to significantly reduce this proportion.

In the early years after reunification, the decrease in greenhouse gas emissions from **industry** was particularly strong. This was due to the conversion of the German industrial landscape and the decline in industrial production in the new states (Länder). In recent years, the industry's total emissions have not changed much. The effect of the 2009 recession is however strongly reflected. Gas and electricity accounted for two-thirds of the industry's final energy consumption.

2012

GREENHOUSE GAS EMISSIONS FROM THE ENERGY SECTOR

78 %

from coal combustion

Approximately 95 % of greenhouse gases that were released in the **transport sector** in 2013 were from road transport. The majority of emissions naturally stems from the combustion of petroleum based products. Emissions from the use of natural gas and biofuels by engines (emission-neutral with respect to carbon dioxide) are also added. Between 1990 and 2000 the transport-related carbon dioxide equivalents increased by more than 11 % due to increasing transport activity and the trend towards more powerful and heavier vehicles. On the other hand, a reduction of emissions in the following years was experienced due to the introduction of more fuel-efficient engines and more efficient vehicle designs, which was strengthened by the increased use of diesel cars. Environmental tax, which was introduced

Promoting energy transition

Greenhouse gas emissions have decreased considerably since 1990. This also applies to the **energy industry**, which had reduced their emissions by 24 % by 2014 compared to the 1990 level. Nevertheless, with a proportion of approximately 39 % of total greenhouse gas emissions, they remained the largest emitter of greenhouse gases in Germany. Apart from that, emissions from **industry** and **transport** are significant contributors. Industry reduced its emissions by one-third between 1990 and 2014, but with 21 % of the releases, remained the second largest source of greenhouse gases. Emissions from transport slightly increased by about 0.6 %. Emissions from **private households** are subject to significant fluctuations, mainly due to weather conditions. They fell by 33 % over the entire period from 1990 to 2014. Other sectors have also achieved significant reductions: emissions from **agriculture** have decreased by about 21 % since 1990, releases from **commerce, trade and services** by as much as 55 %. Greenhouse gas emissions have experienced the strongest reduction since 1990 in the field of **waste management**: almost 70 % by 2014.

in the late 1990s, played another role: hereafter road tax was based on emission values rather than on engine capacity. This encouraged the use of cleaner vehicles. As a result, transport-related carbon dioxide equivalents decreased by about 13 % between 2000 and 2014.

More than 70 % of the final energy that **households** consume is used for heating. Therefore in cold winters higher emissions occur than in milder weather. In addition, economic and social factors influence the emissions from households. So the increasing number of private households plays an important role, as does the growing per person living space.

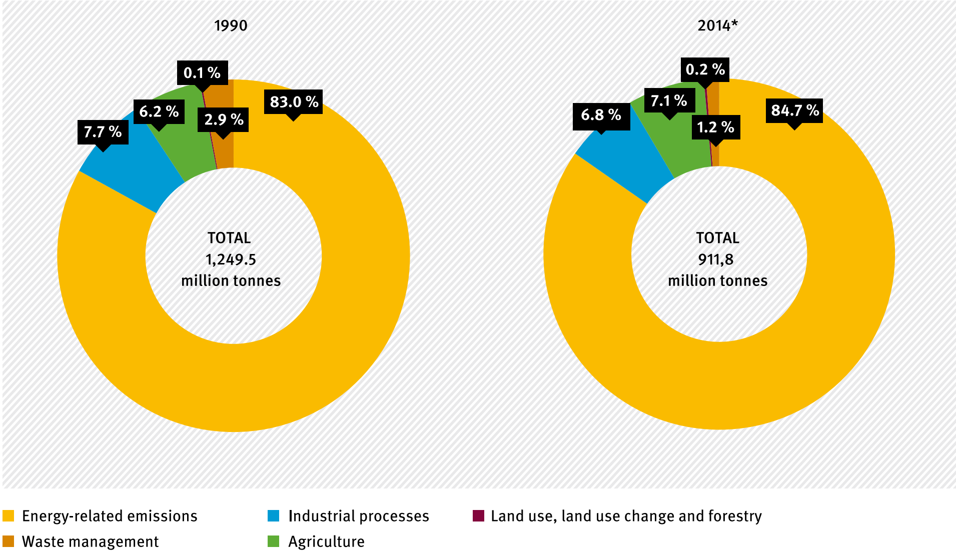
Agriculture mainly emits methane (CH_4) and nitrous oxide (N_2O) from animal husbandry and fertilisation. From 1990 to 1992, emissions from livestock farming decreased due to a decline in livestock. Mineral fertiliser use, especially of nitrogen (N) fertilisation, should be reduced in order to further lower emissions from agriculture. Another important component is the strengthening of organic farming. The sustainable management of natural resources and climate protection will be integral parts of the agricultural climate policy under the reformed Common Agricultural Policy (CAP) objectives after 2013.

Since 1990, greenhouse gas emissions from **commerce, trade and services** have almost been halved. Improved insulation, modernisation of equipment and machinery, and automation and optimisation of processes are the prime reasons for this reduction. Similar to private households, room heating is the key factor here that most affects the amount of GHG released.

Measures that restrict the release of methane from landfills contributed significantly to reducing greenhouse gas emissions from **waste management**. The same applies to the ban on dumping untreated municipal waste. This came into force in 2005. The recycling of paper, glass, packaging and organic waste reduces energy use and helps to reduce greenhouse gases.

Greenhouse gas emissions by source categories

Source categories of greenhouse gas emissions (in carbon dioxide equivalents) according to the Common Reporting Format



*short-term forecast, preliminary figures

Source: Federal Environment Agency 2015, National Greenhouse Gas Inventory 1990 - 2013 (as of 27/01/2015) and short-term forecast (as of 03/2015)

The (fossil) fuel sector is the strongest source of greenhouse gas emissions. Overall, energy-related emissions of all greenhouse gases decreased by about 26 % between 1990 and 2014. Emissions from transport incorporated in them are on about the same level in 2014 as they have been in 1990 while the emissions from stationary combustion plants have decreased significantly. This development in combustion-related emissions resulted from changes in the fuel mix used, increase in energy efficiency and technical efficiency as well as the increasing use of emission-free energy sources. By contrast, the increased use of mine gas, the renovation of gas distribution networks and

the introduction of vapour recovery equipment in fuel distribution have all had their effects on the distribution-related emissions.

Industrial processes, with a proportion of total emissions of almost 7 %, along with agriculture, are the most important ones among other source categories. Emissions decreased by 35.4 % compared to 1990. They are closely linked to the production level. Specifically, carbon dioxide emissions accurately reflect the business cycle of mineral, chemical and metal manufacturing industries. A trend, decoupled from the production, was achieved in nitrous oxide emissions because the manufacturers' measures to reduce emissions in nitric and adipic acid production have been effective. Overall, nitrous oxide emissions have decreased by about 95 % since 1990.

Agriculture stayed at the same order of magnitude with a relatively constant proportion of around 7 % over the few last years. Emissions fell by 17 % compared to 1990. This is mainly due to a decrease in livestock, but also to reducing emissions from agricultural soils and fertiliser application.

The most significant relative reduction of greenhouse gas emissions (- 69.7 %) occurred in **waste management**, and the 2014 proportion of total emissions was only 1.2 %. Here the intensified recycling of recyclable materials (yellow bag, Packaging Ordinance), and the ban on landfilling biodegradable waste since June 2005 has yielded a reduction exceeding 70 % of landfill emissions.

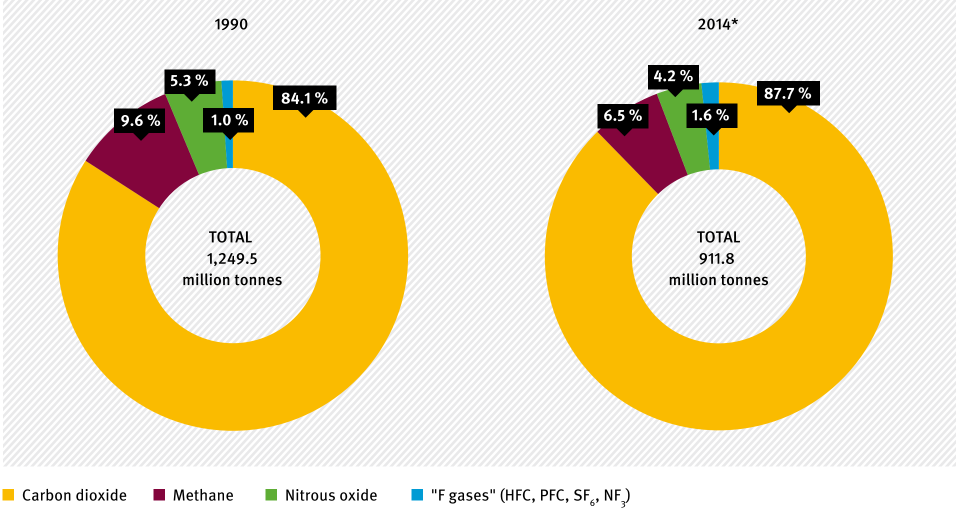
Greenhouse gas emissions from **land use change and forestry** (without taking into account carbon sinks) remained relatively constant between 1.7 and 1.8 million tonnes of carbon dioxide equivalent in 1990-2014, and were 0.2 % of 2014 total emissions. Emissions are mainly due to the use of timber by forestry.

Priority: reducing energy-related emissions

Emissions are grouped by their origin from five source categories for an internationally comparable reporting of greenhouse gas emissions under the United Nations Framework Convention on Climate Change (UNFCCC). Here transport is attributed to **energy-related emissions**. These account for over four-fifths of total greenhouse gases. This makes it clear that sustainable use of energy is of particular importance to climate protection. The proportion of energy-related emissions increases due to the decrease of emissions from **industrial processes** and, primarily, from **waste management**. Although technical measures can further reduce emissions, unavoidable base emissions remain until 2050 especially in the industrial processes and **agriculture**, according to a study of the Federal Environment Agency [UBA 2013a]. It is therefore essential to reduce emissions from the energy sector (electricity, heat and transport) to zero by switching to renewable energy and utilising existing efficiency potentials.

Greenhouse gas emissions by gases

Greenhouse gas emissions by gases (in carbon dioxide equivalents)



*short-term forecast, preliminary figures

Source: Federal Environment Agency 2015, National Greenhouse Gas Inventory 1990 - 2013 (as of 27/01/2015), short-term forecast (as of 03/2015)

Carbon dioxide emissions dominate

Carbon dioxide with a proportion of 87.7 % within the total greenhouse gas emissions is by far the most important greenhouse gas in Germany. Emissions fell by 24 % from 1,051 million tonnes to 800 million tonnes between 1990 and 2014. The increased proportion within total emissions is based on even greater reductions in methane and nitrous oxide emissions. **Methane** is 25 times as more climate-potent than carbon dioxide. In terms of carbon dioxide equivalents, 2014 emissions amounted to around 59 million tonnes. That was less than half the 1990 emissions (120 million tonnes), and was mainly due to emission reductions in waste management. The global warming potential of **nitrous oxide** is 298 times higher than that of carbon dioxide. 38 million tonnes of carbon dioxide equivalents were emitted in 2014, i.e. 28 million tonnes less than in 1990. The decrease was mainly due to emission reductions in the chemical industry. **Fully and partly fluorinated hydrocarbons** (PFCs, HFCs) and **sulphur hexafluoride** (SF_6) are emitted in small amounts, but they have an enormous greenhouse potential. In terms of carbon dioxide equivalents, 14.8 million tonnes were emitted in 2014 (1990: 13.1 million tonnes). Due to the reduction of methane and nitrous oxide emissions, the proportion of “F gases” within the total emissions increased.

Carbon dioxide is produced almost exclusively in combustion processes in industrial facilities and engines. In relation to the unit of energy used, emissions are the highest from solid fuels, which predominantly consist of coal. The lowest is for gaseous fuels because of their high hydrogen content. Liquid fuels occupy an intermediate position.

Carbon dioxide emissions have almost continuously decreased since 1990. Between 1990 and 1995, this was mainly due to the reduced use of lignite in the new states (Länder). From the mid-1990s, the active climate protection policy of the Federal Government specifically had an effect in reducing emissions. In addition, weather and business cycle influences also determine the course of emissions. In 2014 they were around 800 million tonnes. Emissions from power generation remained steady, but because of weather conditions, more gas was used for heating houses and flats than in previous years. The increased use of renewable energies dampened the rise in emissions.

Methane emissions were roughly halved between 1990 and 2014. Livestock is a major source of methane, and emissions are also produced by extraction, transport and distribution of fuels (coal mining, gas distribution). Methane production in landfills is another important source.

Emissions decreased particularly strongly in the field of waste disposal from 1990 to 2014. Emissions from the extraction and distribution of fuels decreased sharply due to a decrease in coal production in Germany.

Because livestock was reduced in the new states (Länder), emissions from agriculture also decreased. However, since major savings took place in the other relevant source categories, with 54 %, this sector currently represents the largest source of methane emissions.

Agriculture with 51 % and the chemical industry with 33 % were major **nitrous oxide** (N_2O) emitters in 1990. Emissions from this sector, however, dropped by more than 95 % by 2014. The share of emissions from agriculture increased to 77 %.

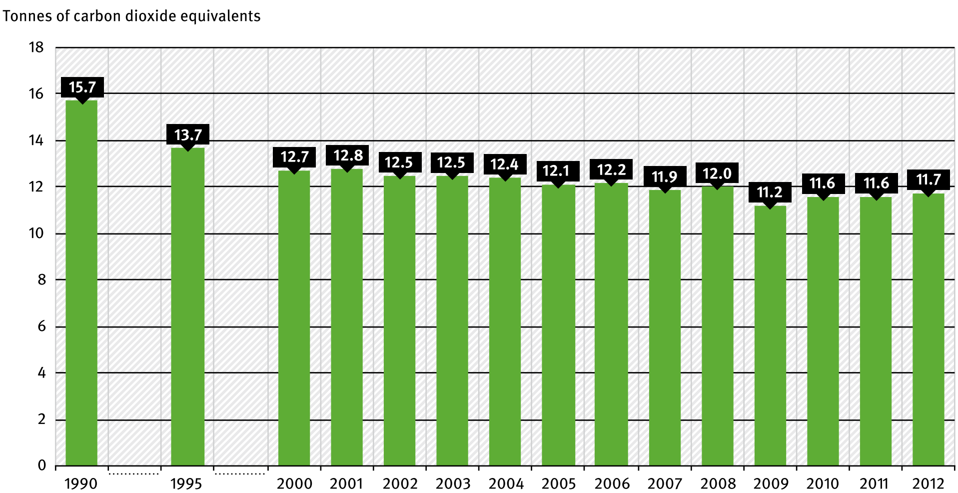
Between 1990 and 2014, emissions of **partly fluorinated hydrocarbons** (HFCs) doubled because their use as refrigerants in refrigerating plants increased and these items were increasingly disposed of. Emission reductions due to the decreased use as polyurethane (PU) foam blowing agents were more than offset.

Emissions of **fully fluorinated hydrocarbons** (PFCs) have decreased by 91 % since 1990. This is mainly due to the efforts of primary aluminium producers and semiconductor manufacturers.

Sulphur hexafluoride emissions were about 12 % lower in 2014 than in 1990. The emissions had risen until 1995, and have been decreasing since then. However, increasing emissions are expected in the coming years.

Per capita emissions

Per capita emissions



Source: Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (eds.) 2014 Climate protection in figures, p. 22

Although greenhouse gas emissions in Germany related to the population are declining, they are still too high. This can be seen by a comparison with the per capita emissions of other Member States of the European Union. Germany scored somewhat higher than the average of around 9 tonnes of carbon dioxide equivalents per person in 2011. The leader was Luxembourg with 23.6 tonnes of carbon dioxide equivalents per capita, Latvia showed the lowest per capita emissions in the Union (5.5 tonnes of carbon dioxide equivalents).

The per capita emissions in Germany related to the emission budget still available to the international community for achieving the 2 degree Celsius target, are also too high. To realise this goal, the industrialised countries must reduce their greenhouse gas emissions by 95 % by 2050. In Germany this corresponds to an annual residual emission of 1 tonne per capita carbon dioxide equivalent from 2050.

Making the best use of all available efficiency potentials in the economic

sectors is the necessary prerequisite to reducing the energy-related emissions to almost zero. This requires the complete changeover of energy production to renewable sources. The Federal Environment Agency (UBA) has shown in its study "Germany 2050 – A Greenhouse Gas-Neutral Country" how this can be achieved technically [UBA 2013a]. However, there is still a considerable research and development need in important sectors such as hydrogen technology.

Nonetheless, technical solutions alone are not enough to reach this goal. One example is the transport sector. Technical improvements to vehicles have to be complemented by traffic avoidance measures and a move to environmentally friendly modes of transport in order to ensure that the decrease in individual-vehicle emissions is not offset by a growth in traffic volumes.

Agriculture provides another example. If the livestock were reduced while maintaining the same meat consumption of the population, greenhouse gas emissions from German agriculture would decrease; but foreign suppliers would fill the supply gap and increase their domestic livestock – a zero sum game in global terms.

This example also shows that no country can act alone in a globalised and economically interdependent world. The "one tonne per capita" target will only succeed in Germany if the EU implements ambitious targets for the reduction of greenhouse gas emissions throughout the European Union and the international community will agree on binding commitments to reduce greenhouse gas emissions.

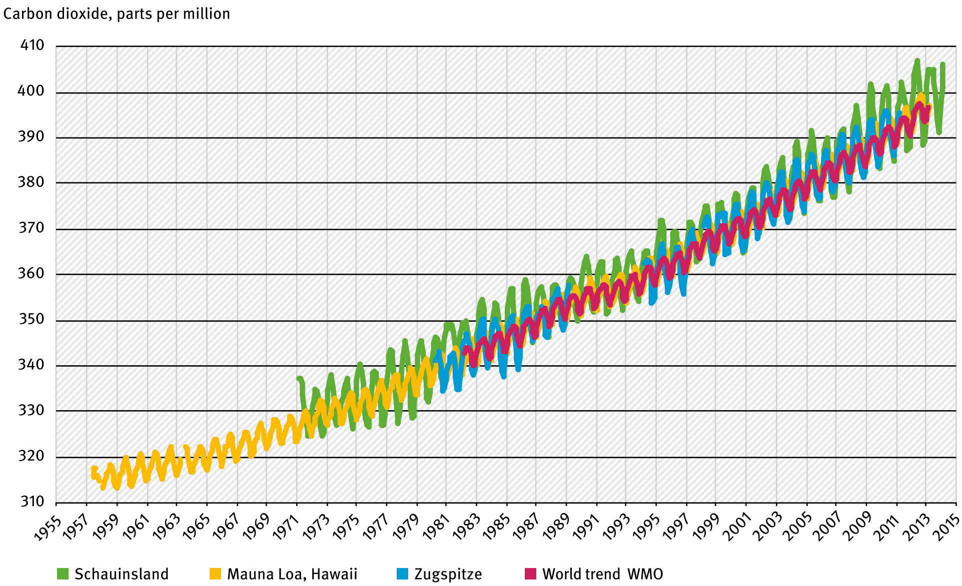
Per capita emissions are decreasing but are still high

Per capita greenhouse gas emissions decreased in Germany between 1990 and 2012 by about 26 % and now stand at 11.7 tonnes. That they remained broadly stable between 2010 and 2012 was mainly due to the population on which the calculation was based: as a result of a census, the population was corrected downward in early 2011. Thus 80.3 million inhabitants were estimated in 2011 (2010: 81.8 million inhabitants).

Even if German total greenhouse gas emissions account for only a small proportion of global emissions (2010: about 2 %), they are much too high relative to the population. Germany was above the EU average of around 9 tonnes of carbon dioxide equivalents per capita in 2011. If the developed countries want to prevent global warming by more than 2 °C above pre-industrial levels, they have to reduce their greenhouse gas emissions to about 1 tonne of carbon dioxide equivalent per capita by 2050. Technically, this is possible, but for this to happen, the final energy consumption in Germany must be decreased as much as possible by exploiting existing efficiency potentials and the remaining energy demand (electricity, heat, fuels) must be covered by renewables. Hydrogen technology plays a key role here, however, intensive research and considerable technical development efforts are still required to achieve this goal.

Carbon dioxide concentrations

Carbon dioxide concentration (monthly averages)



* 1 ppm = 1 part per million = 0,0001 %

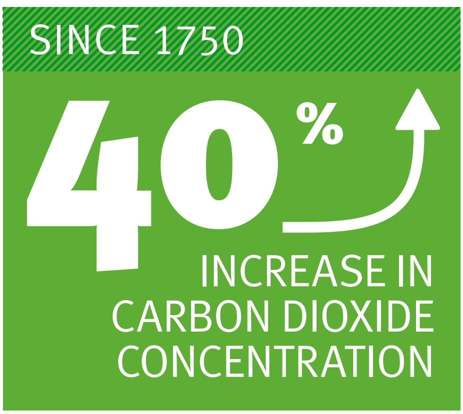
Source: Federal Environment Agency (Schauinsland, Zugspitze), World Data Centre for Greenhouse Gases (Mauna Loa, Hawaii), World Meteorological Organization

Limiting the increase in carbon dioxide concentrations by reducing emissions

Greenhouse gases produced by man are the most important cause of global warming. Due to its high atmospheric concentration, carbon dioxide is the most important greenhouse gas behind water vapour. The global concentration of carbon dioxide has increased by 40 % since the start of the industrial revolution in 1750. By contrast, carbon dioxide concentration was almost constant during the previous 10,000 years. Carbon dioxide is increasing now at a rate about 100 times faster than has ever happened before.

In order to achieve the desired two-degree limit, the total greenhouse gas concentration in the atmosphere needs to be stabilised at about 450 parts per million (parts per million parts, ppm) of carbon dioxide equivalents until the end of the century.

Carbon dioxide accumulates in the atmosphere by burning fossil fuels (such as coal and oil) and large-scale deforestation. Agriculture and livestock farming produce gases such as methane and nitrous oxide (laughing gas). Carbon dioxide, methane and nitrous oxide are gases that have a greenhouse effect. An accumulation of these gases in the atmosphere leads to a warming tendency in the lower atmospheric layers. Human activities have caused a permanent increase in atmospheric concentrations of greenhouse gases since the beginning of industrialisation. This accumulation has been scientifically demonstrated beyond doubt.



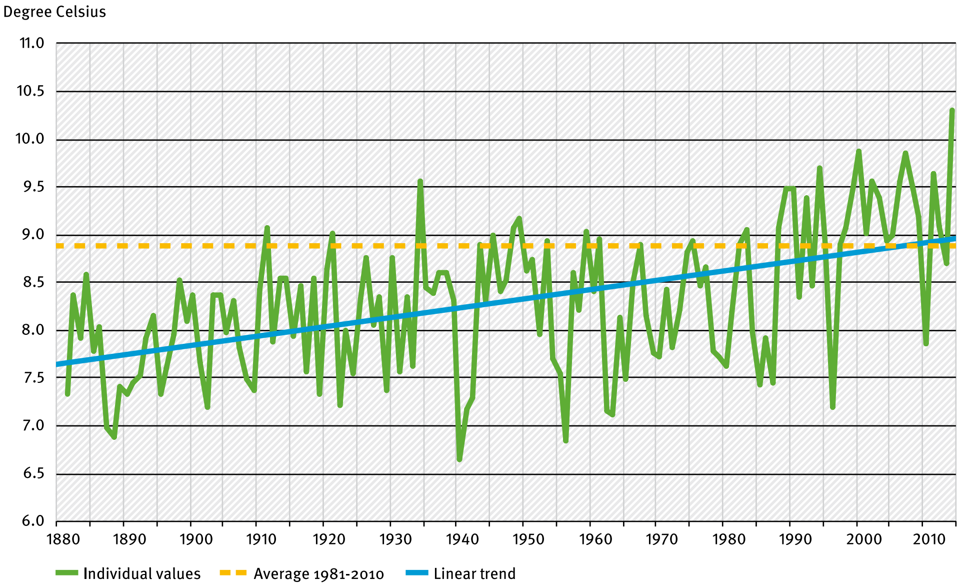
Long measurement series give a reliable measure of the global increase in carbon dioxide concentration in the atmosphere. Thanks to their accuracy, they make it possible to distinguish the effect of fossil fuel burning from natural concentration fluctuations. On this basis climate models can be used to analyse the long-term change in the atmosphere's carbon dioxide supply. While the annual increase on average was 0.55 ppm of carbon dioxide per cubic metre (m^3) air in the 1950s, it has climbed to about 1.9 ppm per year over the past decade. Compared to the 1950s, the global carbon dioxide increase has more than tripled.

The global carbon dioxide concentration is currently just below 400 ppm carbon dioxide. In addition, concentrations of other greenhouse gases also contribute to global climate change.

The total greenhouse gas concentrations (carbon dioxide, methane, nitrous oxide and halogenated gases) in the atmosphere would have to be stabilised at about 450 ppm carbon dioxide equivalents by the end of the century in order to maintain the desired two-degree limit in the atmospheric temperature rise with a probability of at least 66 %. This concentration level can only briefly be exceeded. Global greenhouse gas emissions must be reduced to achieve the desired stabilisation. In most scenarios of the Intergovernmental Panel on Climate Change (IPCC), this corresponds to a worldwide release of greenhouse gas emissions between 30 and 50 billion tonnes of carbon dioxide equivalents in 2030. By 2050, emissions would have to be reduced worldwide between 40 % and 70 % below the 2010 level and decrease to almost zero by the end of the century. This requires binding targets within a global climate protection agreement. The next negotiations will be held at the United Nations Climate Change Conference in Paris in December 2015.

Air temperature trends

Annual average daily mean temperature in Germany 1881-2014



Source: Deutscher Wetterdienst (DWD), release dated 20 April 2015

Climate change is already manifesting itself as slowly rising average temperatures. There is also a change in climate variability, i.e. stronger climate fluctuations and extreme weather events such as storms, droughts and hot summers occur more frequently. The consequences of climate change are diverse and have an impact on our daily lives and upon nature.

Over the long-term, temperature rise in **spring** and **summer**, with 1.3 °C and 1.2 °C, respectively, the temperature has hardly differed from the annual mean trend since 1881, however, the years since the late 1980s have been particularly warm. The four warmest springs were observed in 2014, 2011, 2007 and 2000 – all in the 21st century, while the summer of 2014 does not particularly stand out, being the 25th warmest since 1881.

Autumn has also shown a distinctive, statistically significant temperature increase with 1.2 °C since 1881. However, a large amount of warming occurred as a sudden

jump in the 1920s. Since then, autumn temperatures have remained largely constant. Only the autumn of 2006 stands out as by far the warmest autumn since the late 19th century.

With 1.0 °C, **winter** shows a slightly smaller increase which is currently not statistically significant. The period has been characterised by a number of particularly cold winters and the lack of very mild winters in the mid-20th century. This season has usually been very mild in the years since the late 1980s. Seven of them, in descending order: 2006/2007, 1989/1990, 1988/1989, 2007/2008, 1997/1998, 1994/1995, 1987/1988, are among the ten warmest winters in the last 132 years.

So the years are not only warmer, but the seasonal course of plant and animal development (phenology) has also shifted as a result. For example snowdrops heralding the beginning of early spring, and apple trees that indicate the middle of spring, blossom almost 5 days/decade earlier. Forest trees also bud earlier in many European countries, again about 5 days/decade. This

shows that the altered temperature level has changed the starting time and length of seasons.

The impact of the shift of phenological phases on the animal and plant stocks is complex and its understanding is still in its infancy. Certain bird species respond to the shorter winter with an increased breeding success. A change in timing, however, may adversely affect population trends of plant species and their pollinators or herbivores and predator-prey systems.

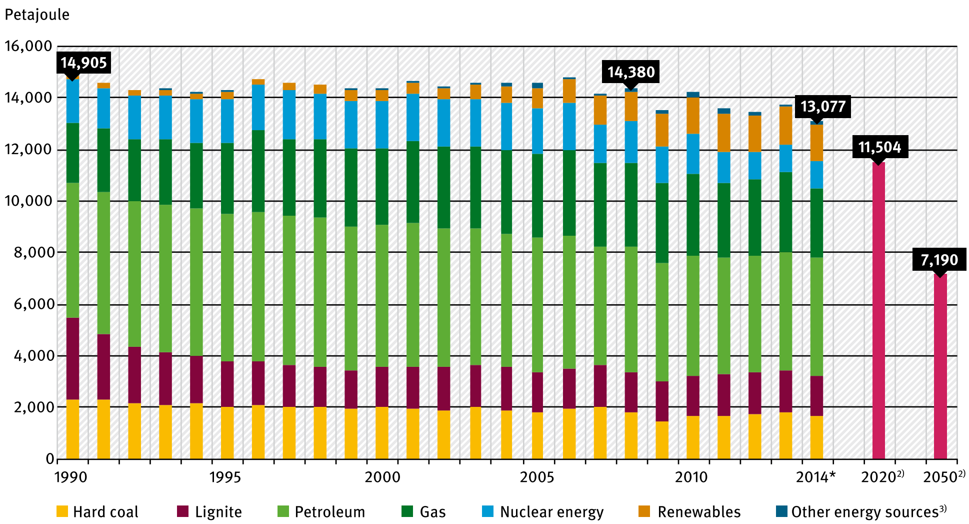
Germany is getting warmer

2014 has been the warmest year globally since 1881 when comprehensive records started. With an average temperature of 10.3 °C it was also the warmest year seen in Germany, with the annual mean temperature reaching a two-digit value for the first time. The first fourteen years of the 21st century were among the fifteen warmest years since 1881 throughout the world and even in Germany these fourteen years were on average warmer than any decade since the beginning of comprehensive records in 1881.

This trend has been detected both for spring and summer. The correlation for winter is weaker and statistically not significant. This has an impact on nature. Climate change in Germany is now so obvious that the initial impacts on fauna and flora can be observed.

Energy consumption and energy transition

Primary Energy Consumption1) in Germany by energy sources with targets



1) Calculations based on the efficiency approach

2) The objectives of the Federal Government's energy concept are: reducing primary energy consumption by 20 % by 2020 and by 50 % by 2050 (baseline year: 2008)

3) Other energy sources: mine gas, non-renewable waste and waste heat as well as electricity exchange balance

* 2014: Preliminary figures

Source: AGEB, Energy Balance Evaluation Tables for the Federal Republic of Germany 1990-2013, as of 09/2014 and Primary Energy Consumption in the Federal Republic of Germany 2013-2014, as of 03/2015

Over the last century, there was an extremely strong increase in worldwide energy consumption and this continues to grow rapidly. The International Energy Agency estimates that global primary energy demand from 2008 to 2035 will increase by another 47 %. Developed countries have a particularly high per capita consumption.

The use of energy is accompanied by a number of adverse effects on the environment. The extraction of fossil fuels often inflicts serious damage on ecosystems and their combustion gives rise to climate-damaging emissions and pollutants harmful to health. Today's excessive use of energy resources limits future generations' options for action.

Two strategies are in particular necessary to reduce the negative impact of energy use: firstly, total energy consumption must be reduced, which primarily requires energy efficiency measures and energy savings. On the other hand, the energy system needs to switch to more environmentally friendly forms of energy such as renewables.

Since 1990, the energy mix in Germany changed dramatically. Lignite use has been halved, gas consumption has considerably increased and renewables have grown massively:

- Petroleum products accounted for a good third of primary energy consumption in Germany in 2014 and natural gas for one-fifth.
- Hard coal, lignite and nuclear energy each covered one-tenth of the primary energy consumption.
- The proportion of renewables in primary energy consumption has significantly increased since 1990: it rose from 1.3 % in 1990 to 11.1 % in 2014.
- A relatively constant proportion of about 7 % of fossil fuels was used for non-energy consumption in 2013, the most important consumer being the petrochemical industry.

The Energy Concept adopted in 2010 describes Germany's energy-policy positioning until 2050. It ushered in the "energy transition", which can be regarded as "an appropriate and necessary step on the way to an industrial society which follows the concept of sustainability" [Coalition Agreement 2013]. Accordingly, primary energy consumption should be reduced by 20 % by 2020 and by 50 % by 2050 compared to the 2008 level. In order to achieve the Federal Government's objectives, ambitious measures are needed for both strategic approaches.

Reducing energy consumption in absolute terms: an important component of energy transition

In addition to the expansion of renewables and increasing energy efficiency, the reduction of primary energy consumption is an important component of energy transition. The German Government specified the objectives in their Energy Concept.

In 2014, primary energy consumption dropped by 12 % compared to 1990, and was also much lower compared to 2013. This effect was mainly due to the warm winter. Renewables had the strongest growth among all energy sources, their share increasing sevenfold since 1990.

The Energy Concept of the Federal Government adopted in 2010 [Federal Government 2010] envisages primary energy consumption being reduced by 20 % by 2020 and by 50 % by 2050 compared to the 2008 consumption. The current trend, however, is not sufficient to reach these goals.

Energy consumption by application

Reducing energy consumption in all areas of application

Final energy consumption can be represented according to its different applications and sources. Transport, industry and private households are responsible for just under 30 % of energy consumption, while the commerce, trade and services sector accounts for 15 %. Final energy consumption has noticeably decreased both in industry and in the commerce, trade and services sector since 1990. In 1990, the industrial sector still consumed by far the largest share of energy. Private households and traffic consumed increasingly more energy in the same period. Total energy consumption decreased slightly by 2 % in 2013 compared to 1990, but there are significant variations between individual years.

Energy consumption can be considered along the energy conversion chain. Primary energy is converted into final energy (e.g. electricity and district heating) while suffering from energy losses. Final energy will be delivered in the form of useful energy to respective terminal equipment with further conversion losses.

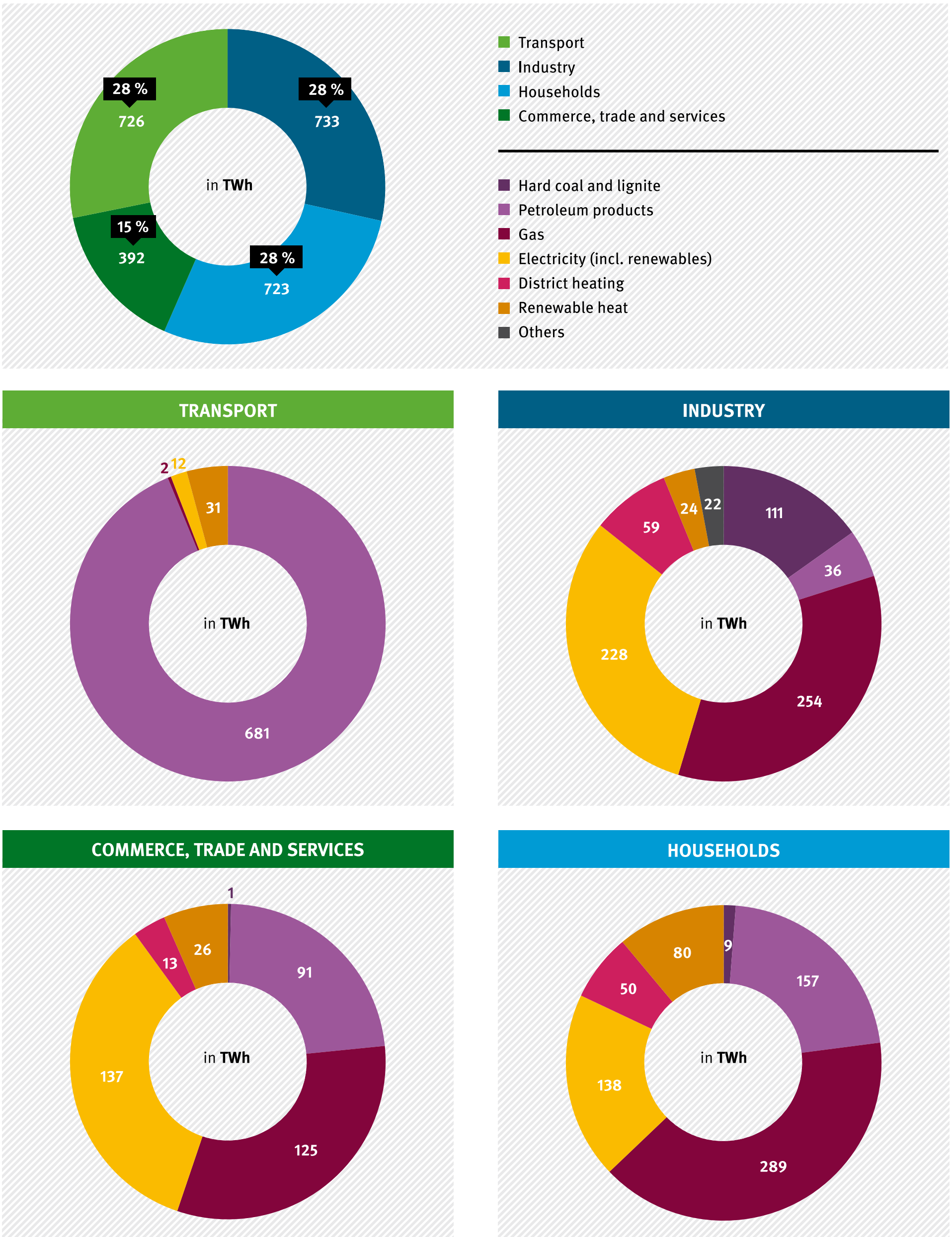
► Optimizing one's data centre helps saving energy by 40 to 50 percent.

Significant sector-specific reductions have been achieved in final energy consumption in industry and the commerce, trade and services sector (GHD) from 1990. However, absolute consumption related to total consumption increased in private households and transport.

In terms of its specific energy application, a 12 % decrease occurred over the same period in heating, which accounted for about half of the total final energy consumption. Consumption of fuels, whose share is about 30 %, increased by 5 % since 1990. Electricity accounts for 20 % of total final energy. Here the consumption increased by 13 % across all sectors.

Final energy consumption in 2013* by sectors and energy sources

Final energy consumption

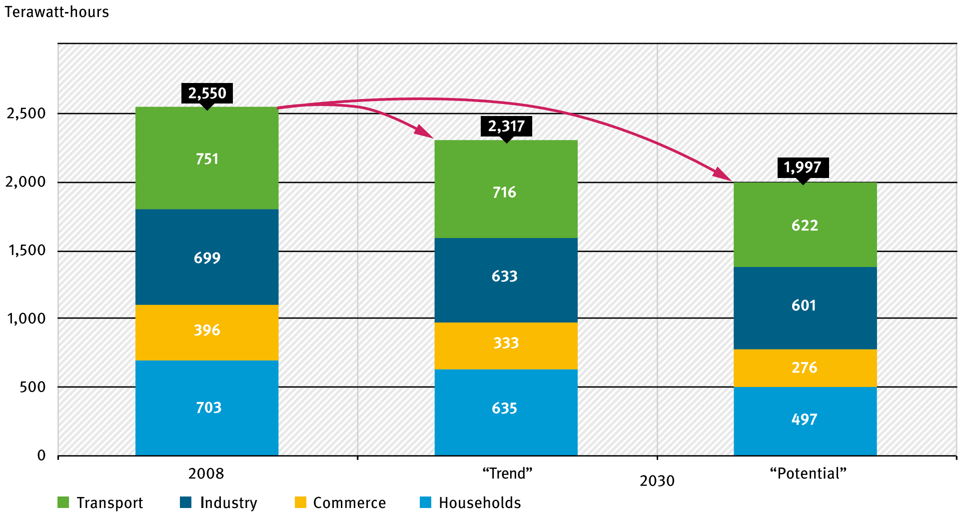


*Preliminary figures

Source: AGEB: Energy Balance Evaluation Tables 1990-2013, as of 09/2014

Energy saving

Scenarios for final energy consumption in Germany in 2008* and 2030



*Historical energy balance data for 2008 are now outdated and have been slightly adjusted.

Source: Matthes et al., Politikszenarien für den Klimaschutz VI, Dessau-Roßlau 2012

How much energy can we save?

There are numerous studies that show energy can be used more economically and efficiently without any loss of comfort. The results, of course, always depend on the assumptions made (on which the calculations are based) and describe only one possible development. The Policy Scenarios for Climate Protection VI study [UBA 2013b] showed that final energy consumption in Germany could be reduced under current conditions by 9 % to 2,317 TWh by 2030 ("trend" or "current policies" scenario). But by making an extra effort, final energy consumption can be reduced by as much as 22 % to 1,997 TWh ("potential" or "energy transition" scenario).

Energy-saving measures must be aimed at all areas of application.

- For **households**, heating performance is crucial. The average per capita living space has increased over the years, room heating now accounts for about three-quarters of energy consumption in households. Natural gas and heating oil show the highest consumption while renewable heating and district heating are increasingly being used in this sector. Incentives to use more efficient heating systems, better building insulation and implementing electricity-saving potentials are therefore important starting points.

- The **Commerce, trade and services sector** is also dominated by heating performance. Room heating accounts for half of the final energy consumption. Also, large amounts of electricity are consumed, which is attributable to the increased use of mechanical energy by electrical equipment, as well as motors and lighting.

- Two-thirds of final energy consumption for **industry** is needed for process heat. Mechanical energy accounts for a quarter of consumption, room heating forms only a small proportion.

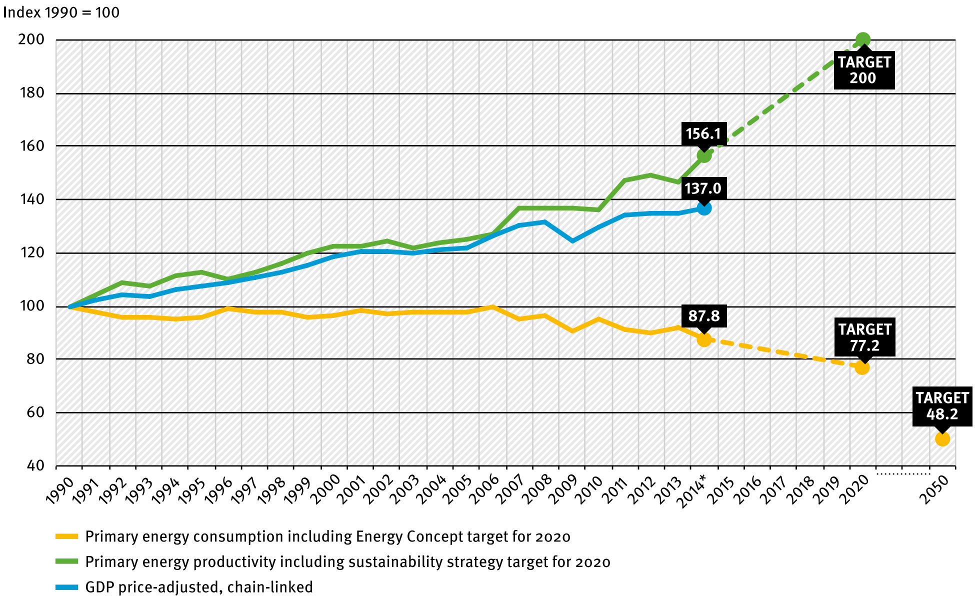
- Petroleum fuels account for more than 90 % of fuels in the **transport** sector. Biofuels and electricity so far only play a marginal role. Almost all energy used in transport is converted into mechanical energy.

The German Government's Energy Concept envisages the reduction of energy consumption in the transport sector by 10 % by 2020 and by 40 % by 2050.

In existing buildings, the Energy Concept's aim is a reduction of primary energy demand in the order of – 80 % by 2050 (climate-neutral building stock) and to reduce heat demand by 20 % by 2020 and double the renovation rate to 2 % per year.

Energy efficiency

Energy productivity



* Preliminary figures

Source: Gross Domestic Product - Federal Statistical Office, Fachserie 18 Reihe 1.5, as of 02/2015; Primary and final energy consumption - AGEB: Energy Balance Evaluation Tables 1990-2013, as of 09/2014; AGEB: Primary Energy Consumption in the Federal Republic of Germany (2013/2014), as of 10/03/2015; Primary Energy Consumption Target in 2020 and 2050 – UBA's calculation based on the Federal Government's energy concept, as of 28.09.2010

The increase in energy productivity (energy efficiency) constitutes an essential element of resource conservation and the fight against global warming. The world's energy consumption will continue to increase with dramatic consequences for the environment unless additional measures to increase energy efficiency are implemented. An increase in efficiency is also economically sound. Greater efficiency means producing the same amount of Gross Domestic Product while consuming fewer resources. This reduces the environmental impact and saves money. The economy benefits from an improved energy efficiency over the long term as energy-efficient products "Made in Germany" are selling well worldwide. With rising energy prices in the future it is all the more worthwhile investing into fuel-efficient technologies today. Even private households can save money if they pay attention to better energy efficiency when buying durable consumer goods for example.

Using energy efficiently

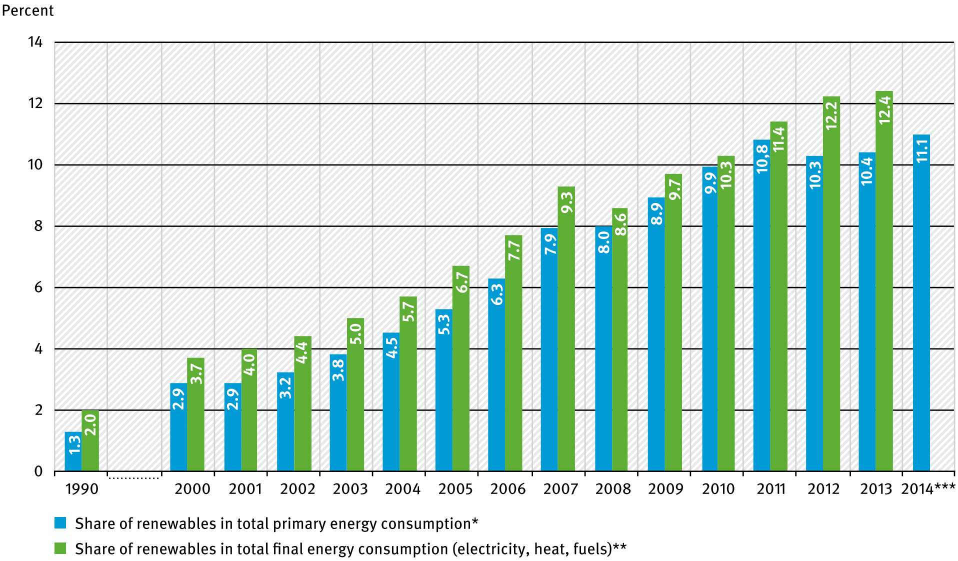
Energy productivity represents the ratio of gross domestic product (GDP) to primary energy consumption. It can serve as a measure of efficiency in the use of energy resources. Energy productivity has increased in Germany by 56 % from 1990 to 2014. Although this increase indicates a more efficient use of energy, it is only associated with a small decrease in primary energy consumption (minus 12 % since 1990). The increase in productivity is therefore mainly due to economic growth of 35 % in this period. Against the background of this long-term development, primary energy consumption drastically decreased by 5 % in the very warm year of 2014, which made productivity skyrocket by 21 % compared to the previous year. The aim of the German Government's sustainability strategy [Federal Government 2002] is to double energy productivity by 2020 compared to 1990. However, considering the development trend of the past five years, this doubling of the target will be difficult to achieve.

Improvements in the infrastructure of power plants (construction and renovation as well as increasing the efficiency) have contributed to increasing energy efficiency. Saving potentials have been exploited and efficiency increased in all sectors including private households. For example, higher standards in the energy quality of new buildings has resulted in energy savings and reduced carbon dioxide emissions in the building sector.

However, Germany can only reach the objective of energy productivity by taking more action in the fields of energy supply and use. Examples are the development of decentralised systems of combined heat and power because they reduce energy conversion losses compared to conventional power plants. Also, energy-efficiency renovation of buildings – supported by tools such as energy performance certificates and heating mirrors – provides further saving potential.

Renewables

Share of renewables in total primary energy consumption and total final energy consumption



* Energy Balances Working Group (AGEB), calculated according to the efficiency approach: as of 02/2015, preliminary figures
** Calculated without taking into account specific computing requirements of the EU Directive 2009/28/EC
*** Share of renewables in total final energy consumption: figures for 2014 are not available

Source: Federal Ministry for Economic Affairs and Energy (eds.): Time series of renewables in Germany, as of 02/2015

Renewable energy sources are wind, solar energy, biomass, geothermal energy and hydropower and they can make a significant contribution to climate protection. They also contribute to security of supply and to avoiding resource conflicts. Germany in particular imports fossil fuels such as oil, gas, coal and uranium so the expansion of renewables helps save energy imports and increases domestic added value.

Both the EU and the German Government have set targets for the expansion of renewables: the share of renewable energy should reach at least 27 % of primary energy consumption throughout Europe by 2030. Binding targets set for Germany include increasing the proportion of renewables in final energy consumption to 18 % by 2020 and to 60 % by 2050.

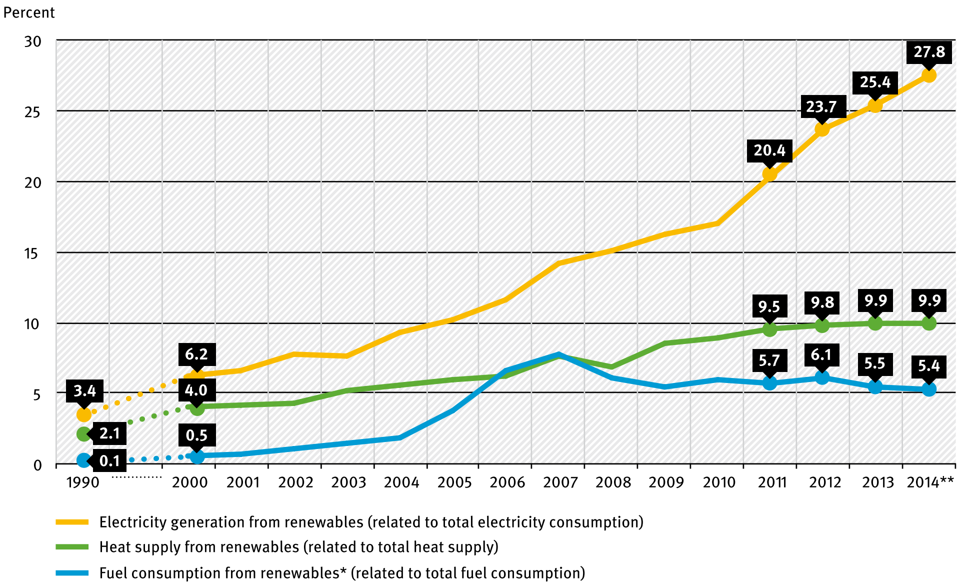
Increasing further the share of renewables in energy consumption

In 2014, 11.1 % of primary energy consumption was covered by renewables – an increase of 0.7 % over the previous year. The share of renewables in final energy consumption increased by 0.2 % compared to 2012 and was 12.4 % in 2013 (figures for 2014 are not available by August 2015). The Federal Government wants to increase this proportion in final energy consumption to 18 % by 2020 and to 60 % by 2050.

The share of renewables in primary and final energy consumption remained almost static in 2013, the reasons being chiefly due to the extremely cold winter in 2013 where the associated high heating demand could not be offset by the use of renewables. In 2014 the share of renewables in primary energy consumption increased again by 0.7 percentage points.

The share of renewables in final energy consumption reflects contrasting developments in 2014: on the one hand, the share of renewables in electricity consumption continued to rise sharply (from 3.4 % in 1990 and 23.7 % in 2012 to 27.8 % in 2014). At the same time, the share of renewables in the heating sector stagnated at 9.9 % of the 2014 heat supply. The share of renewables in the transport sector even fell by 0.1 % to 5.4 % of the total fuel consumption.

Share of renewables in total final energy consumption for electricity, heat and fuels

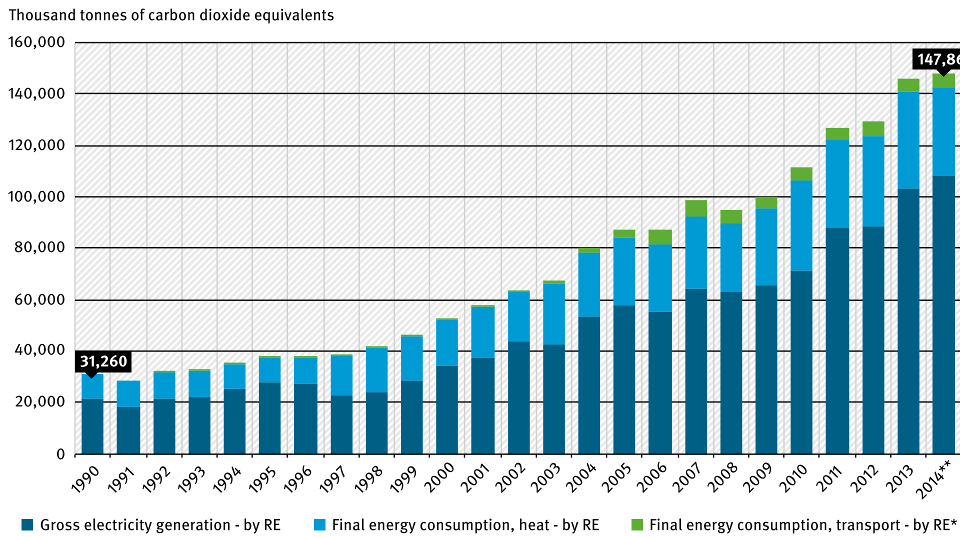


* Reference until 2002: fuel consumption in road transport, from 2003: total motor fuel consumption, without aviation fuel
** preliminary figures

Source: Federal Ministry for Economic Affairs and Energy (eds.): Time series of renewables in Germany using the data of AGEE-Stat, as of 02/2015

Greenhouse gas emissions avoided by the use of renewables

Greenhouse gas emissions avoided by the use of renewables



* Excluding electricity consumption in the transport sector; using the typical GHG values for biofuels by Directive 2009/28/EC
** preliminary figures

Source: Federal Ministry for Economic Affairs and Energy (eds.): Time series for renewables in Germany, as of 02/2015

If the share of renewables in the fields of electricity generation, heat production and transport increases, then the share of fossil fuels decreases as a consequence. The equivalent demand for final energy for electricity, heating and transport can therefore be satisfied at the expense of less harmful emissions. On the other hand, the use of renewable energies is also combined with detrimental emissions that must be considered. For example, wood combustion also releases air pollutants.

Commissioned by the Working Group on Renewable Energy Statistics (AGEE-Stat), UBA periodically calculates and publishes the “Emissions from

Expansion of renewables to achieve climate protection goals

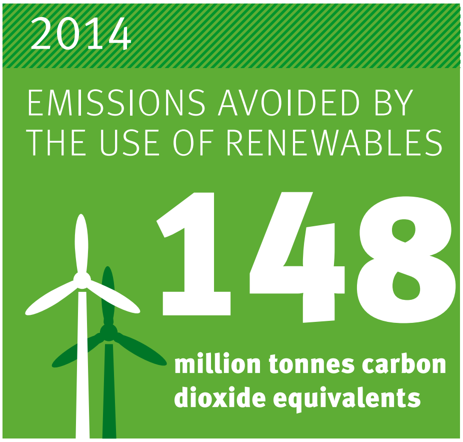
Expanding renewables significantly contributes to achieving Germany's climate protection targets. Fossil fuels are being increasingly replaced with renewables in all sectors of consumption (electricity, heat and transport). Greenhouse gas emissions thereby saved are key components on the way to a greenhouse gas neutral Germany. In 2013, a total of about 146 million tonnes of carbon dioxide equivalents were avoided through the use of renewables, about five times as much as in 1990. Based on initial preliminary estimates on the use of renewables, a greenhouse gas reduction of about 148 million tonnes of carbon dioxide equivalents can be assumed for 2014 [BMWi 2015], thus the trend of increasing emission avoidance continues through the use of renewables. 74 % of these were attributable to electricity supply from renewables. The heating sectors contributed 23 % to emission avoidance, and transport another 3 %.

Increasing energy efficiency also reduces greenhouse gas emissions. However, no comparable valid assessments are currently available on this yet.

renewable energy sources" [UBA 2014a]. This report checks renewables for their greenhouse and air pollution balances. The results show that greenhouse gas emissions of about 148 million tonnes of carbon dioxide equivalents were avoided by the expansion of renewables in 2014. The Federal Environment Agency's calculations show that for 2014 greenhouse gas emissions would have been about 16 % higher without the use of renewables.

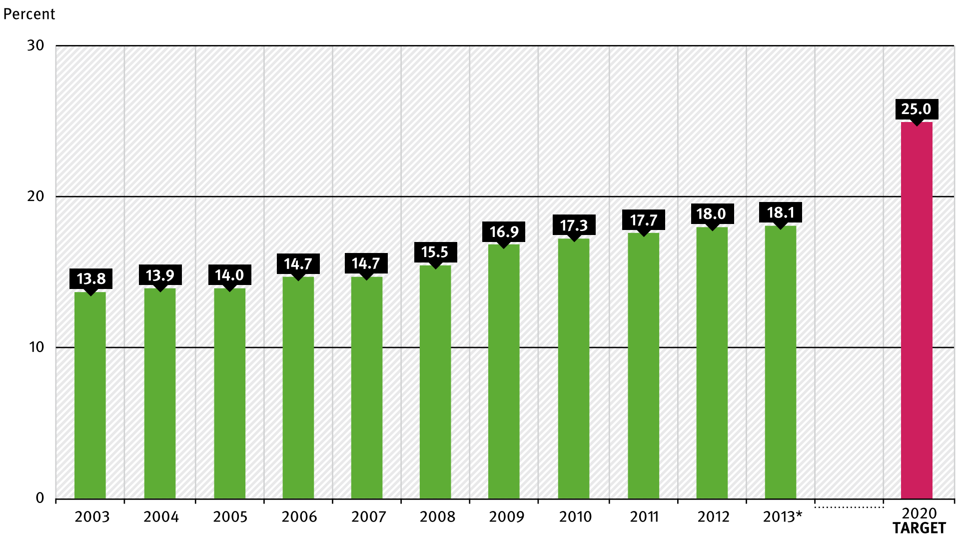
The electricity sector accounted for savings of about 109 million tonnes of carbon dioxide equivalents, 80 million tonnes of which can be attributed to the portion of electricity with EEG (Renewable Energy Sources Act) compensation claim. Greenhouse gases amounting to about 34 million tonnes of carbon dioxide equivalents were avoided by the use of renewables in the heating sector and about 5 million tonnes of carbon dioxide equivalents by the use of biofuels.

In contrast, a study of other air pollutants shows a mixed picture: while pollutants can be avoided to a considerable extent by generating electricity from sun, wind and water, the burning of wood or other biomass leads to high dust emissions. Accompanying measures such as the gradual tightening of standards for tiled stoves and fireplaces are the right and necessary way to make the most from the benefits of renewables.



Combined heat and power

Share of CHP generated electricity in the total net electricity



* Preliminary figures

Source: AGEB: Energy Balance Evaluation Tables 1990-2013, as of 09/2014; BMWi (2014): Monitoring Report on the Energy Transition, p. 46

Combined heat and power plants also utilise the heat produced during electricity generation. CHP plants therefore have a much higher efficiency than power generation in uncoupled systems. Thus up to 90 % of the fuel's energy content can be converted into useful energy. This means that about 25 % of primary energy savings are possible compared to cutting-edge-technology systems that generate electricity and heat separately. Therefore, power and heat generation in CHP plants is accompanied by a much lower environmental impact. CHP has a wide variety of applications, for example there are CHP plants that feed district or local heating networks or those that provide heat for industrial processes. CHP is particularly suitable where there is a uniform and high heat demand throughout the year.

Stronger utilisation of CHP's economic potential is especially relevant for an energy policy aimed at climate protection and resource efficiency. Based on the CHP Act of 2012, a 25 % target has been set for the proportion of CHP within total electricity generation to be reached by 2020.

The CHP Act for fossil-fired CHP plants and the Renewable Energy Sources Act (EEG) for CHP plants powered by

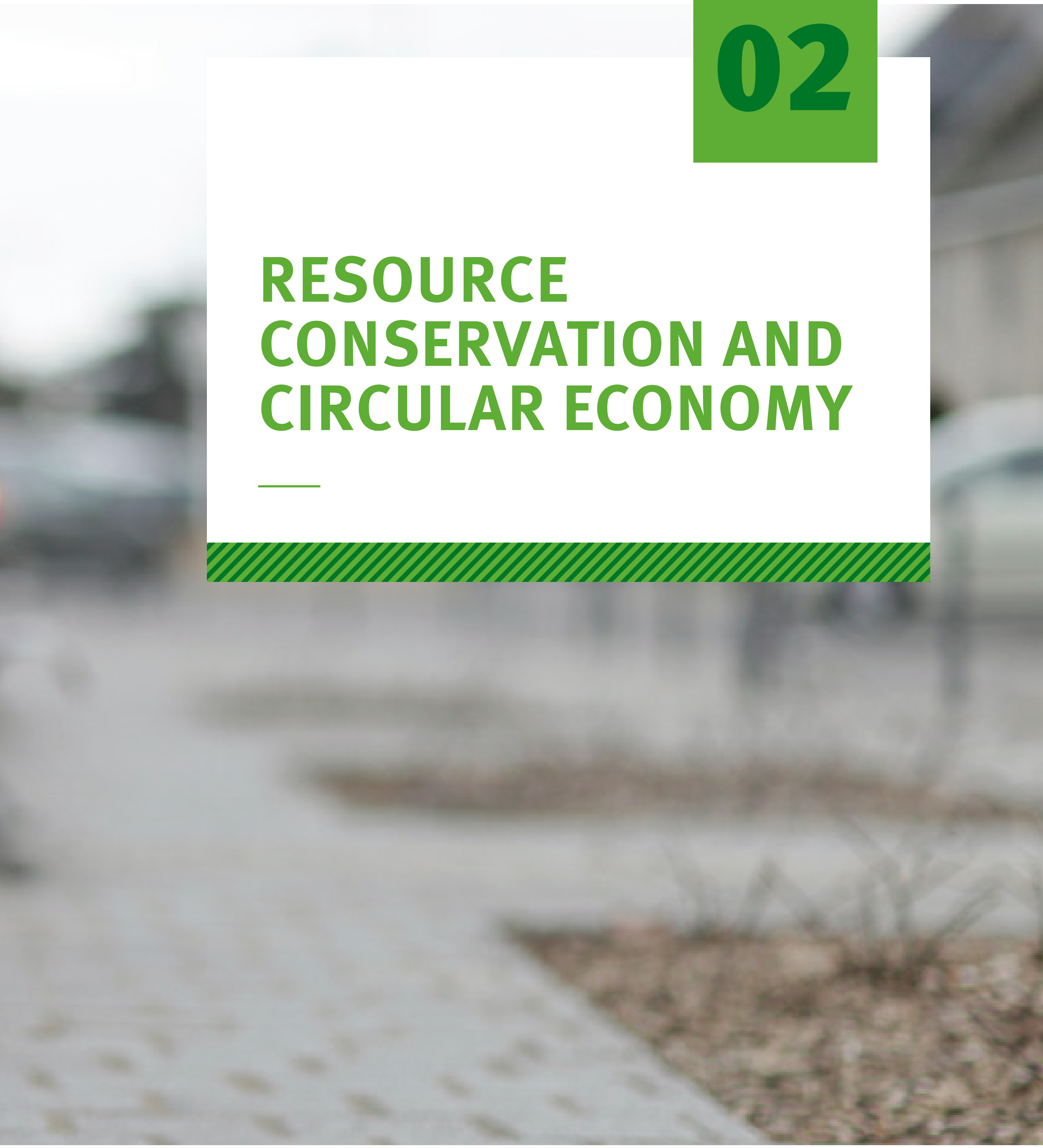
Protecting the environment through the use of waste heat

Electricity produced by combined heat and power (CHP) plants has increased by about 30 TWh from less than 78 terawatt-hours (TWh) to 108 TWh in the 2003 - 2013 period. The share of net CHP electricity in total net electricity has thus slowly but steadily increased in recent years: it was 13.8 % in 2003 and 18.1 % in 2013. This growth is particularly due to the increasing use of biomass and the additional construction of gas-CHPs. Coal- and oil-fired plants, however, showed a decline. The 2020 target for CHP is to achieve 25 % of total net electricity generation.

renewables (in particular biomass) are the two key instruments that encourage electricity generation using CHP plants.

The CHP Act promotes the construction and modernisation of high-efficiency CHP plants through a feed-in tariff for the electricity generated. Construction and expansion of heating and refrigeration networks as well as heat reservoirs and cold accumulators are also supported by an investment subsidy. Overall, the development of combined heat and power is to be supported by an annual maximum fund of 750 million euro, of which a maximum of 150 million euros have been earmarked for the construction of heating and refrigeration networks as well as heat reservoirs and cold accumulators.

In addition, CHP was supported by EEG based on renewables. EEG 2004 and EEG 2009 provided for CHP bonuses to be paid (2 cents per kilowatt-hour (ct/kWh) and 3 ct/kWh for CHP electricity), which ceased in EEG 2012. There are minimum requirements for biogas production with relevance to CHP: each biogas plant must prove either 60 % heat utilisation or 60 % manure use or, alternatively, directly market the electricity (market premium model).

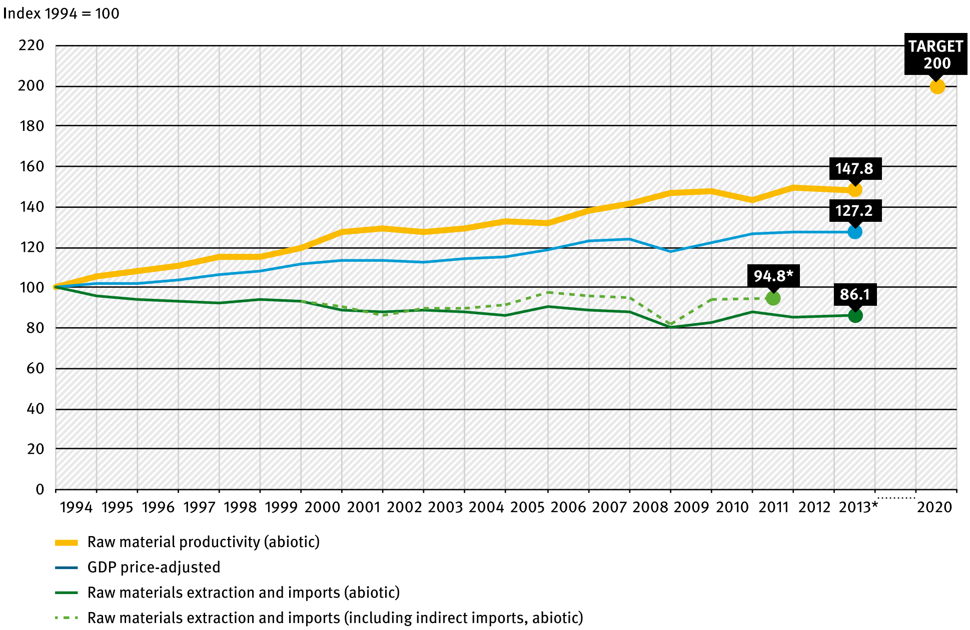


02

RESOURCE CONSERVATION AND CIRCULAR ECONOMY

Raw material productivity

Raw material productivity



* Preliminary figures

Source: Federal Statistical Office (eds.) 2015, Environmental-Economic Accounting, Sustainable Development in Germany, Environmental and Economic Indicators, p.7

Raw material productivity is an important guideline value. Although strictly speaking it only considers non-renewable raw materials and primary materials, conclusions can be drawn about the trend of resource efficiency in the economy over the long term. Thus resource productivity represents the production factor of raw materials analogous to labour and capital productivity.

There were changes in the ratio of domestic raw material extraction to the import of abiotic goods between 1994 and 2012: while domestic extraction of abiotic raw materials declined by 311 million tonnes (- 28 %) in this period, imports of raw materials and semi-finished and finished goods increased by 94 million tonnes (+ 24 %). The share of imported goods among the total non-renewable raw

materials increased from 26 % in 1994 to 38 % in 2012.

Raw material productivity takes into account the direct, but not the so-called "indirect material flows" of imports. This means that those resources that were used for the production of imported goods in other countries beyond the dead weight of imports are not accounted for. If resource-intensive processes are relocated abroad and highly-processed goods are imported instead, raw material productivity may show a progress in productivity.

An additional parameter has been introduced to reflect total raw material extraction in which all raw material used for the imports are accounted for as "raw material equivalents". A raw material equivalent of 2.5 tonnes results on average for each tonne of imported goods which means that 2.5 tonnes of raw material is on average required abroad to produce one tonne of these imported goods. Raw material use including these indirect imports increased by 2.4 % between 2000 and 2011 (see dashed line in the figure).

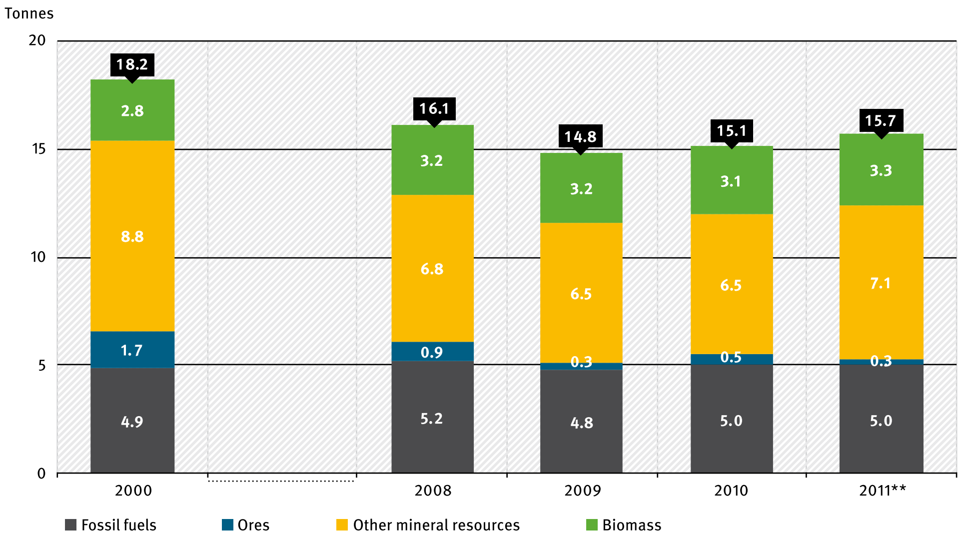
Germany launched an important initiative at the national level in the beginning of 2012 with the German resource efficiency program (ProgRess) [BMU 2012] in order to promote the efficient use of resources in industry – similar to the EU's Roadmap to a Resource Efficient Europe [COM 2011] at the European level in late 2011. German resource efficiency policy is no longer in its infancy. There are already instruments and measures that are currently being developed or implemented. Important areas are public procurement, strengthening resource efficiency in small and medium-sized enterprises and the establishment of the theme of resource conservation in schools, vocational and higher education as well as in further education.

Efficient use of raw materials

Raw material productivity is defined as the ratio of GDP to domestic raw material extraction and imports. It can serve as a measure for the efficiency of raw material use. Resource productivity increased in Germany from 1994 to 2013 by 47.8 %. Raw material use decreased by 13.9 % during this period, while GDP increased by 27.2 %. The trend towards increasing productivity has recently weakened. If the trend of the past five years continues, the goal of sustainability strategy to double resource productivity by 2020 compared to 1994 would be missed and the indicator would only reach about 60 % of the target by 2020.

Per capita raw material consumption in Germany

Final domestic raw material consumption (RMC) per capita*



* Annual average value based on the population projection of earlier censuses.

** Preliminary figures

Source: Federal Statistical Office 2014 (eds.), Raw materials for Germany, demand analysis for consumption, investment and export at macro and meso level, Table volume of project report

Conserving resources – reducing consumption in absolute terms

Raw material consumption provides information about an economy's demand for raw materials taken directly from nature to meet domestic consumption and investment. In Germany, it fell from nearly 1.5 billion tonnes in 2000 to about 1.3 billion tonnes in 2011, an 18 % decrease. This means that on average Germany's population used about 16 tonnes per capita of primary raw materials in 2011. It had been more than 18 tonnes per capita in 2000.

German industry has very strong international connections through foreign trade: it imports and exports large amounts of highly processed semi-finished and finished products. These products often contain only a fraction of the raw materials used in their production. However, all goods can be converted into “raw material equivalents” which represent the extent of primary raw material used and the associated environmental impacts. These take account of all raw materials – other than water – that have been used at home and abroad to produce the goods. The jargon refers to the shares of raw materials used as indirect imports (“backpacks”), not counting the dead weight of imports.

On average, 2.5 tonnes of raw material have been used abroad for each tonne of goods imported by Germany, including biomass. Goods exported by Germany have a raw material equivalent of 3.9 tonnes since exported goods are mostly of higher production complexity than imports.

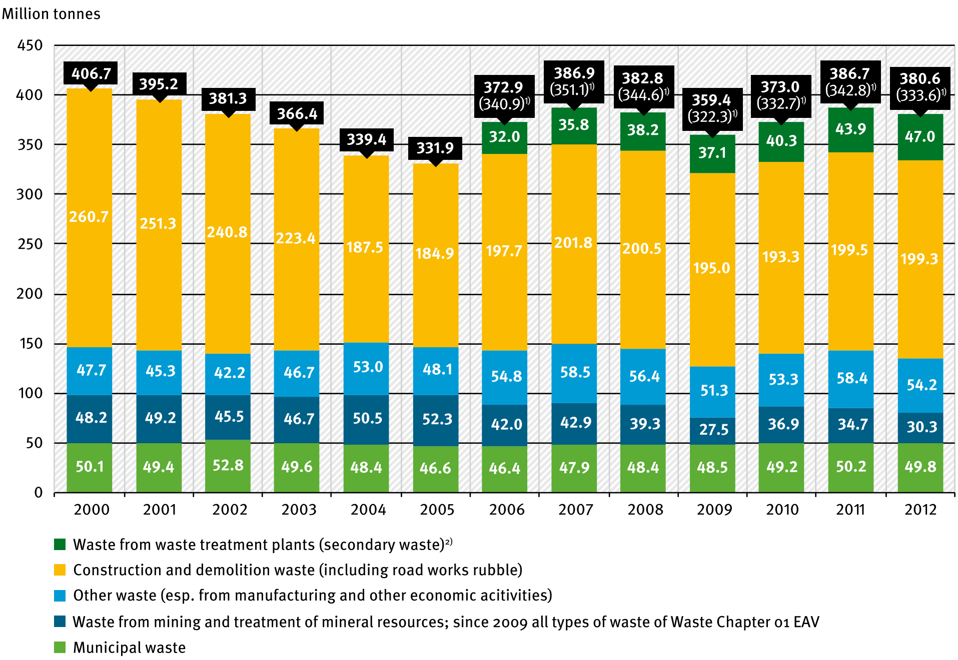
The input indicator “raw material input” (RMI) provides information about Germany’s primary raw material demand for investment, consumption and export. This was about 2.7 billion tonnes in 2010.

Imports take up a significant share of Germany’s primary raw material input. However, a large part of them can again be found in the exported goods. The consumption indicator “raw material consumption” (RMC) can be used to represent the actual primary raw material demand in Germany due to domestic consumption and investment. This takes into account both imports and exports in raw material equivalents. Here, the primary raw material requirement of exports is subtracted from the primary raw material input. The primary raw material effort is thus allocated to the countries that use these raw materials or highly processed goods produced from them in accordance with the 'polluter pays' principle and global responsibility. To allow international comparability, it is useful to normalise the indicator using the number of inhabitants (per capita RMC).

The RMC fell by almost one-fifth (18 %) from nearly 1.5 billion tonnes in 2000 to about 1.3 billion tonnes in 2011. Per capita primary raw material consumption thus decreased from approximately 18 tonnes to about 16 tonnes in only eleven years. After a significant reduction between 2000 and 2009, the domestic primary raw material consumption has slightly increased recently. Both the reduction and the slight increase now observed are largely due to the amounts of investments made. Investment in buildings and equipment and other capital goods has decreased by up to 30 % since 2000. The primary raw material consumption used for domestic consumption was less robust and decreased by about 10 %.

Waste generation

Waste generation (including hazardous waste)



1) Net waste without waste from waste treatment plants; first time recorded as part of waste in 2006.

2) Without waste from sewage treatment plants (EAV 1908), waste from the preparation of water intended for human consumption or water for industrial use (EAV 1909), waste from the remediation of contaminated soil and groundwater (EAV 1913) and secondary wastes that leave the disposal process as raw materials/products.

Source: Federal Statistical Office, Waste balance, Wiesbaden, Various volumes

The total waste generation in Germany amounted to 380.6 million tonnes of waste in 2012. Since 2006, waste statistics have also included waste that only arises during waste treatment, called secondary waste. Subtracting this, 333.6 million tonnes remain. Compared to the waste produced in 2000, it was 18 % less. This decrease was mainly due to the decrease in **construction and demolition waste**, which alone accounted for about half (52.4 %) of the total waste generated in 2012.

Production waste, with a proportion of 14.2 %, made up waste generation's second largest group in 2012.

Municipal waste followed in third place with 13.1 %. This consists of household waste and household-type commercial waste collected by public waste collection services and municipal waste delivered or collected separately (for example glass, paper). The amount of municipal waste remained roughly the same in 2000-2012 and hovered around an annual 50 million tonnes. Household waste and household-type commercial waste made up about 18 million tonnes in 2000 and decreased to about 14 million tonnes by 2012. This was partly due to a switch in statistics. By contrast, the amount of glass, paper and other waste, including waste electrical and electronic equipment, collected separately for recycling increased from 13.5 to 18.5 million tonnes. Again, there was a sharp increase in volume in 2002 due to statistical effects.

Mine waste decreased from 48.2 to 30.3 million tonnes. This waste predominantly originates from hard-coal mining. It is stored almost entirely in waste heaps; only 1 % can be recycled.

All waste types mentioned also contain **hazardous waste** in addition to non-hazardous wastes. These have only been reported for information as part of the waste balance of the Federal Statistical Office [StBA o. J.] since 1999. About 6 % of waste was hazardous waste in 2012, in particular, it was produced in industry and the construction sector.

With the exception of the crisis years 2008 and 2009, economic output rose in Germany during the period considered. At the same time, waste production dropped. This indicates that Germany has successfully started decoupling economic growth and waste production. The ratio of both quantities, i.e. waste intensity, fell by 28.3 % between 2000 and 2012.

In addition to decoupling waste from economic performance, the key future issue will be to return as much as possible raw material and energy contained in the waste to industry. Waste avoidance and resource-efficient recovery of valuable materials constitute a modern circular economy.

Avoiding waste, recovering residues

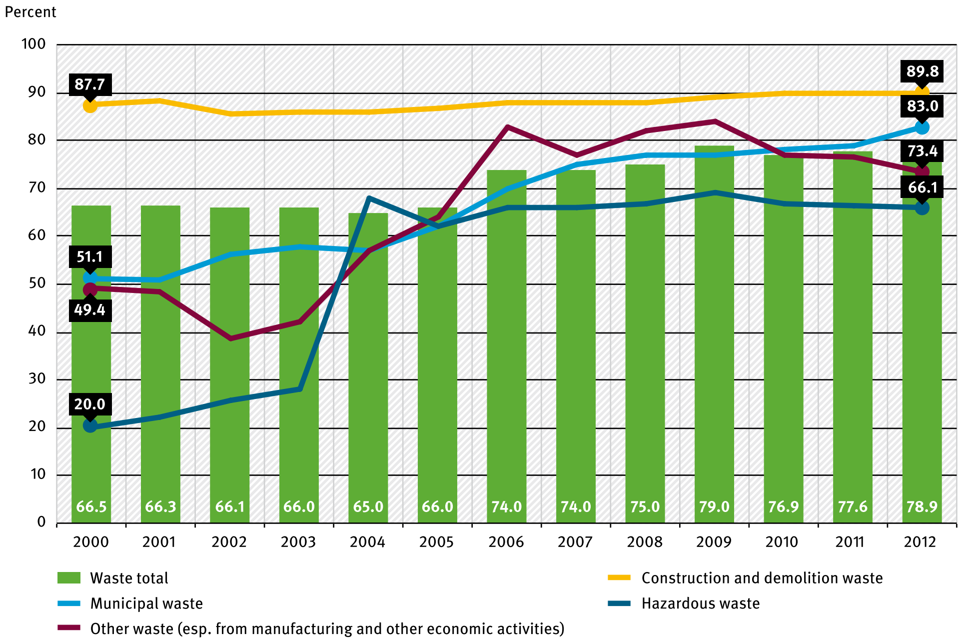
A sustainable policy of conserving natural resources attributes a high importance to the creation of closed substance cycles – from raw material extraction through production, use and consumption to the collection, reuse and possibly high-valued recovery.

Modern closed substance cycle management is an integral part of a sustainable material stream management. Priority goes to as high degree of utilisation of materials extracted from nature as possible in order to save resources and to prevent the generation of waste. The aim is to decouple waste generation from economic growth.

Although the amount of waste has slightly decreased in recent years, still too much waste is being produced. Further efforts are needed in sustainable product design, conscious consumption and thus waste avoidance, particularly regarding municipal waste.

Recovery rates of the main waste streams

Recovery rates of the main waste streams



2000: Hamburg using 1999 data

2002: Introduction of the European Waste Catalogue with shifts between waste not requiring special control and waste requiring special control and within municipal waste.

2006: Switch of waste balance calculation from net principle to gross principle. Hazardous waste: From 2004, including treatment for recycling.

Source: Federal Statistical Office, Waste balance, Wiesbaden, various volumes; Federal Environment Agency's calculations

Sustainable development requires the decoupling of resource use from economic growth. This strategy can only be successful if growing production and higher consumption does not erode efficiency gains achieved through it. In addition to waste avoidance, enhanced recycling of waste is a key solution. Recycling covers all measures for the re-use of useful materials or energy potential contained in the waste. The aim is to promote and develop waste management

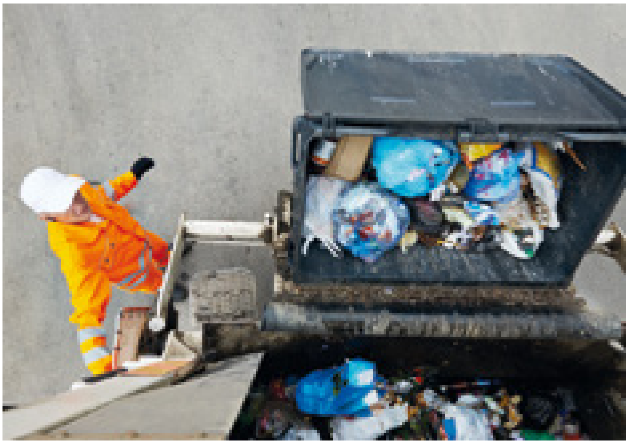
into a source of raw materials and for the production of goods.

This aim has already been achieved to a large extent for **construction and demolition waste**. This makes up about 52 % of the (gross) waste in Germany. Recycling of this waste has been at very high levels for years: 89 % was recycled for materials and 1 % for energy in 2012.

55 % of **production waste** (“other wastes”) was recycled. In addition, 18 % was directed towards energy recovery.

Municipal waste, which is ready for recovery, should if possible, be recycled in terms of material or energy (e.g. bio-waste composting, recycling of glass and paper). Non-recyclable residual waste is mechanically and biologically treated or incinerated. Only waste remaining from this treatment and that already in an inert state is landfilled. Since 1 June 2005 it has been illegal to landfill untreated municipal waste. A total of about 65 % of municipal waste was recycled and another 18 % incinerated in 2012.

The term **“hazardous waste”** describes different types of waste with specified hazard characteristics. They represent a hazard to health and/or the environment. There are specific disposal methods and procedures for hazardous wastes that ensure safe and environmentally friendly destruction of pollutants. 54 % of the substances classified as hazardous waste from all waste streams was recycled and 12 % was incinerated in 2012.



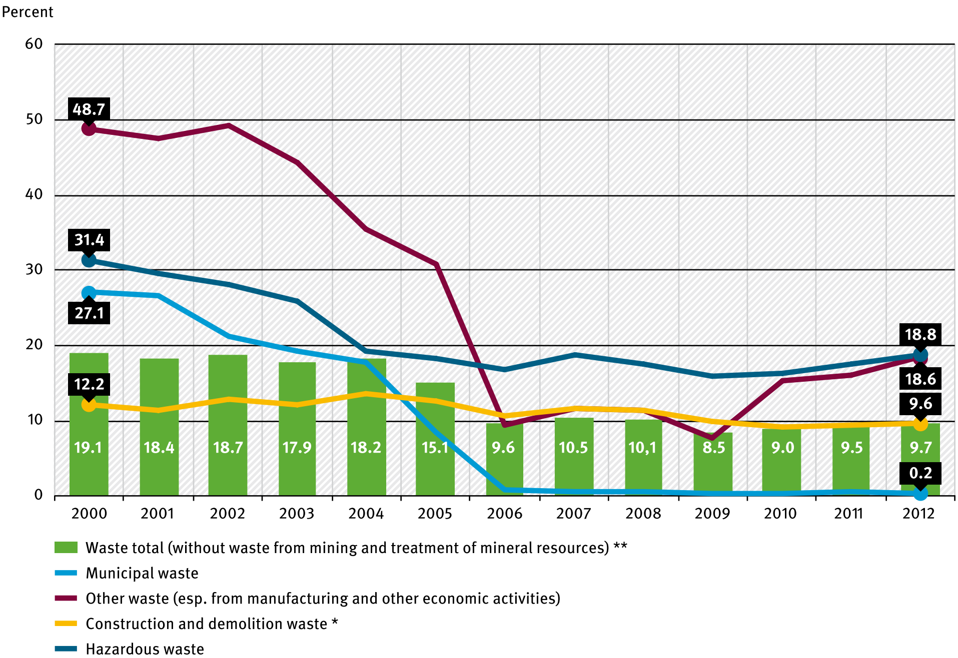
Waste recovery conserves resources and protects the environment

79 % of waste generated in Germany was recovered in 2012. 70 % was channelled to recycling, the remaining 9 % went to energy recovery. Waste with a high calorific value can be used as a substitute for conventional fuels to produce electricity and heat. This helps save fossil fuels and contributes to conserving resources. At the same time waste incineration offers the opportunity to convert waste into inert materials so that harmful substances contained in them do not react with each other or with the environment. The remaining inert slag can be reused in many cases, for example in road construction. Where this is not possible, they must be disposed of in an environmentally sound manner.

However, re-introducing former waste into the economic cycle through recycling is preferable to combustion.

Landfilling rates of the main waste streams

Landfilling rates of the main waste streams



2000: Hamburg using 1999 data

2002: Introduction of the European Waste Catalogue with shifts between waste not requiring special control and waste requiring special control and within municipal waste.

* From 2004, excluding the quantities of excavated soil, demolition and road works rubble in construction and reclamation from public sector projects.

** 98.8 % of waste from extraction and treatment of mineral resources is landfilled.

Source: Federal Statistical Office, Waste balance, Wiesbaden, various volumes; Federal Environment Agency's caclulations

Waste which cannot be recovered must be disposed of to avoid damage to the environment and adverse health effects for citizens. Organic waste must be treated mechanically and biologically or thermally before final disposal in order to prevent chemical reactions and to reduce the release of gases and leachates from landfills.

Landfilling of waste decreased from 28.7 to 16.8 % of total waste in the 2000 - 2012 period. This figure included the disposal of "waste from extraction and treatment of mineral resources" (until 2008: "mine waste"). This category of waste is almost completely landfilled and accounts for the largest portion of the total amount landfilled. Not incorporating this waste in the calculation of the landfill proportion, the proportion landfilled would have only been 19.1 % in 2000 and 9.7 % in 2012.

Since June 2005, municipal waste must be pre-treated prior to disposal if it does not comply with the statutory requirements for landfilling. This resulted in a drastic decline in the landfilling of municipal waste, dropping from 27.1 % to a residue of municipal waste not requiring pre-treatment of only 0.2 % between 2000 and 2012. Landfilling recyclable municipal waste must be largely terminated by 2020 instead waste should be either avoided or recycled. The Circular Economy Act sets the goal of 65 percent recycling for municipal waste by January 2020.

The thermal or mechanical and biological pre-treatment of municipal waste and the reduction of the amount landfilled led to a significant decrease in methane emissions from landfills. Capturing landfill gas and subsequent energy use also provide a contribution to climate protection. The waste sector emitted 23 million tonnes of carbon dioxide equivalents in 2005 and only 15 million tonnes in 2012.

In the period between 2000 and 2012, several changes took place in data collection and allocation of the recorded amounts of individual waste types. This resulted, for example, in shifts in the allocation of waste types within municipal waste and non-hazardous and hazardous wastes in 2002.

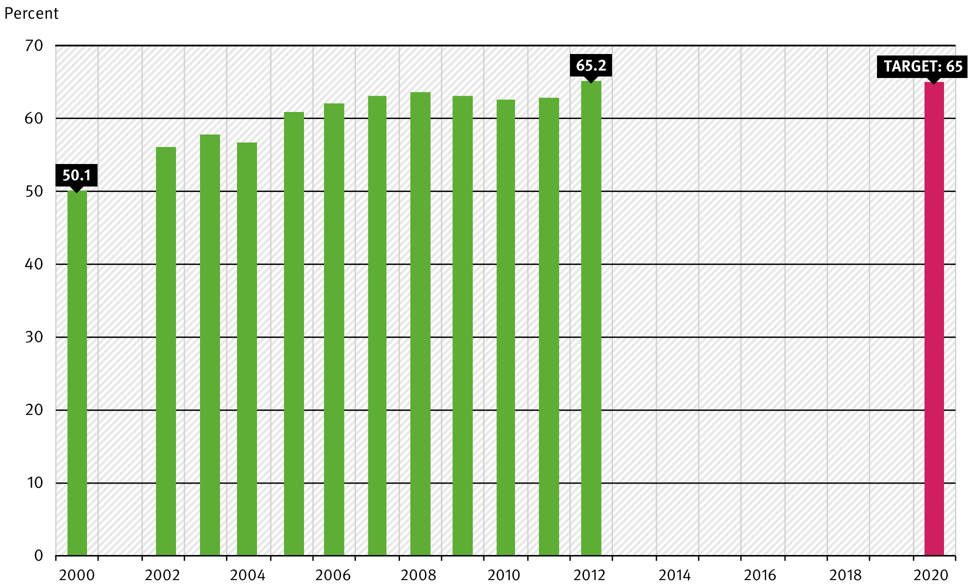
Environmentally friendly disposal of unavoidable residual waste

The Federal Government's waste management policy is aimed at the maximum possible waste avoidance and recycling. Unavoidable residual waste is landfilled in an environmentally sound manner. In Germany, landfilling of wastes has decreased dramatically, and this is particularly evident in the case of municipal waste where landfilling ceased, except for a small remainder, due to legal requirements. Disposal of waste from production and commerce has also fallen drastically in recent years, with a low in 2009, the crisis year. Since then it has risen again, but has not reached the level as seen at the beginning of the century.

About 99 % of waste from the extraction and treatment of mineral resources, especially from hard-coal mining, is landfilled. This is not shown in the diagram.

Recycling rate of municipal waste

Share of treated and recycled municipal waste in total municipal waste



Source: Federal Statistical Office, Waste balance, Wiesbaden, Various volumes

Recycling municipal waste

Statistically, more than 60 % of the recorded municipal waste has been regularly recycled in Germany since 2005. In 2012, the proportion of recycled municipal waste used as material reached 65 % for the first time. The development so far shows that the objective to permanently achieve a 65 % recycling of municipal waste by 2020 using the Circular Economy Act, is within reach.

There is potential for improved collection and recycling of selected waste types, but above all, the emergence of such waste must be avoided, for example through improved product design such as with regard to materials longevity or ease of repair.

Municipal waste includes household waste and similar commercial and industrial waste and waste from public institutions such as schools or hospitals, which are collected together or separately (glass, paper, packaging) by the public waste collection services.

RECYCLED MUNICIPAL WASTE

65 %

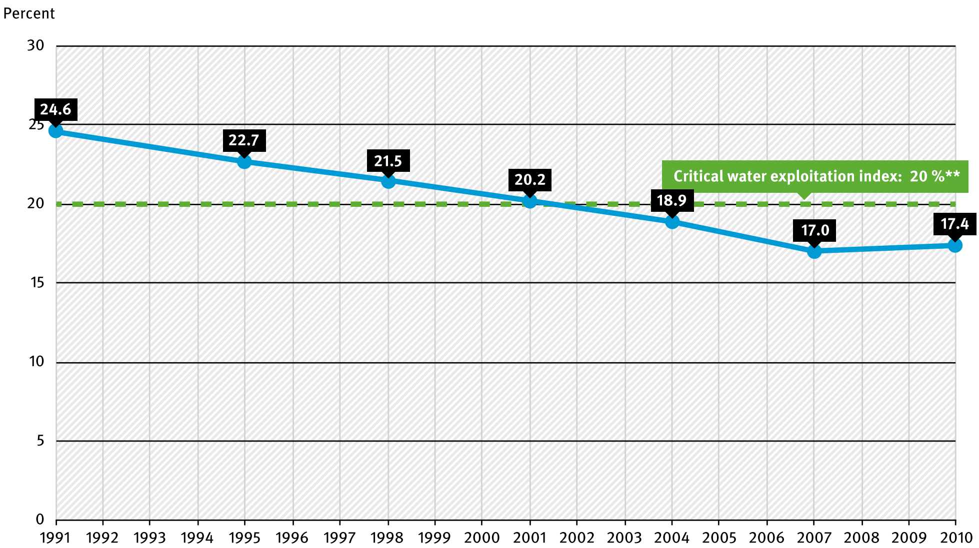
2012

Municipal waste disposal has changed significantly since 2000. Recyclables are increasingly collected separately and the material utilised. This is especially true for the recycling of paper, glass, packaging and bio-waste. This conserves resources, reduces primary energy use and thus reduces carbon dioxide emissions. The ban on landfilling untreated municipal waste also contributed to the reduction of methane emissions from the waste sector.

The quantities of household waste and household-type commercial waste collected jointly by the waste collection services are primarily incinerated, but even here, the proportion of material recycled has increased: 10.0 % of this waste was recycled in 2009 and 15.5 % in 2012.

Water exploitation index

Water exploitation index*



* The water exploitation index is derived from the ratio of total water withdrawal of the given year (since 2007 including irrigation) to the long-term water supply in Germany (188 billion m³).

** A water exploitation index of 20 % is considered as threshold for water stress.

Source: Federal Statistical Office, Fachserie 19, R. 2.1 and 2.2, Wiesbaden, various volumes and Statistical Yearbook 2012, Wiesbaden 2012

Avoiding water stress

In order to assess the effects of water extraction on water bodies, water demand is compared with the total renewable freshwater resources ("available water supply"). The result is referred to as water exploitation index. If extraction exceeds 20 % of the available water supply, this is a sign of water stress. Germany's water exploitation index has been below the critical level since 2004.

Water extraction for public water supply, industry, thermal power plants and agriculture are Germany's most important water uses. These four user groups together have taken 32.8 billion m3 of water from groundwater and surface waters in 2010 according to the Federal Statistical Office. Private households and other small consumers used 15.6 % of this water and 84.4 % was used for the non-public sector. Thermal power stations used more than 75 % of this amount mainly for cooling purposes. Mining and manufacturing sectors consumed the remaining one quarter of non-public water extraction for their processes.

Water extraction by industry and public water suppliers has been declining since 1991. Extraction by thermal power stations also fell compared with 1991, but rose again slightly in 2010.

Germany's water extraction is covered by a potential supply of 188 billion m^3 of water, which means that Germany is a water-rich country. Water supply is calculated as a long-term statistical average for a period of thirty years based on renewable water resources, which are determined from the annual water balance. Water balance is obtained from two quantities: firstly from the inflows from neighbouring countries minus the outflows to neighbouring countries and to the North Sea and Baltic Sea and secondly from the difference between precipitation and evapotranspiration from the ground and plant cover.

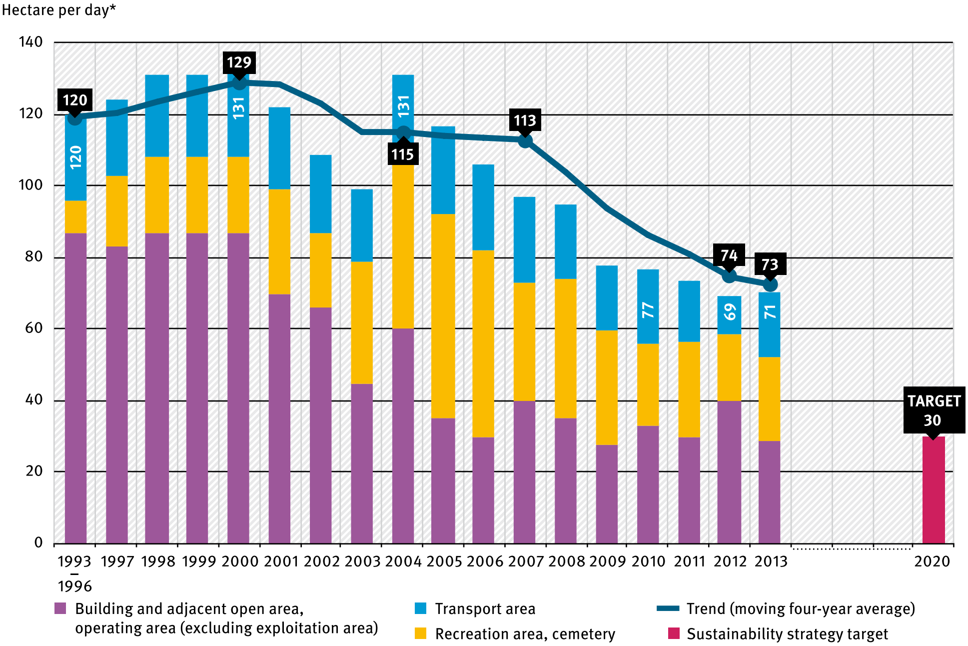
Although total water extraction increased slightly in 2010 compared to previous years due to an increase in energy production, critical levels have not yet been reached. The total volume of extraction is 17.4 % of the potential water supply, thus more than 80 % of domestic water resources remains currently unexploited. It should also be noted that the water volumes extracted for power plant cooling are usually returned to the water bodies with only minor evaporation losses. If the volumes of cooling water had not been included, only 10 % of the potential water supply would have been used in 2010.

International comparisons refer to water stress if the exploitation ratio of the available water supply exceeds 20 %. This can lead to environmental problems such as too low water flow in rivers due to overuse, salinisation of freshwater resources in coastal areas or the loss of wetlands and biodiversity.

As a whole, Germany is not affected by water stress. It has succeeded in decoupling the total water consumption from the growing economic performance and to use water more efficiently. Regional and seasonal shortages can be compensated for by water supply through long – distance pipelines to ensure water uses and to relieve water-dependent ecosystems.

Land-take for settlements and transport

Land-take for settlements and transport infrastructure



* Land use survey is based on the evaluation of the states' (Länder) land registry. Data on increase in land use have been distorted from 2004 due to a change-over in land registries (recoding land use types in course of digitalisation).

Source: Federal Statistical Office 2014, Federal Office for Building and Regional Planning 2009

Undeveloped land is a valuable resource and agriculture, forestry, construction, transport, nature conservation, energy supply and the raw materials industry compete daily for its use [StBA 2014]. Through this competition undeveloped areas are exposed to high usage and development pressures. Therefore in recent decades, considerable change in land-use took place and areas for settlement and transport infrastructure increased.

This has been accompanied with numerous environmental impacts. Loss of natural soil functions, loss of fertile agricultural land and loss of nature protection areas (e.g. valuable grassland sites) count as the main environmental impacts associated with the land-take

for settlement and transport purposes. Small-scale climatic changes that may occur in urban areas due to increasing soil sealing are also significant. There are also other consequences such as increased material consumption for the maintenance of new housing and roads, or increased energy consumption for the operation of new buildings and infrastructure. Newly developed housing areas and transport infrastructures around cities also generate additional traffic, which in turn causes noise and leads to pollutions.

Given the problems outlined, the German Government is aiming to curb the expansion of settlement and transport areas. The aim is to reduce land-take to 30 ha per day by 2020. In addition, the German Council for Sustainable Development (RNE), the German Advisory Council on the Environment (SRU) and the Nature and Biodiversity Conservation Union Germany (NABU) all call for a reduction of land-take to zero by 2050.

Previous measures proposed are focused on minimising the expansion of settlement areas and the associated development of transport infrastructure, using the existing settlement areas in an environmentally friendly manner and minimising the need for new trunkroads and highways. A sensible interior development of existing settlement areas with better use of brownfield sites is the key planning instrument for the reduction of land-take in the municipalities. Looking ahead, focused planning, legal and economic instruments should be further developed.

Currently, a new innovative tool for land conservation is being tested in a Federal Environment Agency pilot project: similar to the trade of carbon dioxide emission allowances, land certificate trading is supposed to raise financial incentives for communities that want to intensify internal development and save land.

Curbing the land-take for human settlements and the transport infrastructure

Land use for human settlements and transport infrastructure is expanding in Germany: between 2000 and 2013 it has increased by 10.3 % from 43,939 square kilometres (km^2) to 48,482 km^2. In 2013, the land-take was 71 hectares (ha) daily for new areas for settlements and transport, which makes them unavailable for other uses. This growth took place mainly at the expense of agricultural land.

As part of its sustainability strategy [Federal Government 2002], the German Government has set itself the aim to reduce the land-take for settlements and transport to 30 ha per day by 2020 and it has achieved considerable success in this respect. While the average daily land-take was 129 ha between 1997 and 2000, the four-year-average decreased to 73 ha in the period 2010 to 2013. Even the figures of the individual years up to 2012 show a discernible downward trend. Sluggish construction activity and low expansion of transport infrastructures, in 2012, for the first time resulted in a daily land-take of less than 70 ha. With the current economic upswing, however, more land is being converted into new building land. In 2013 the land-take for residential, commercial and transport purposes again exceeded 70 ha per day.

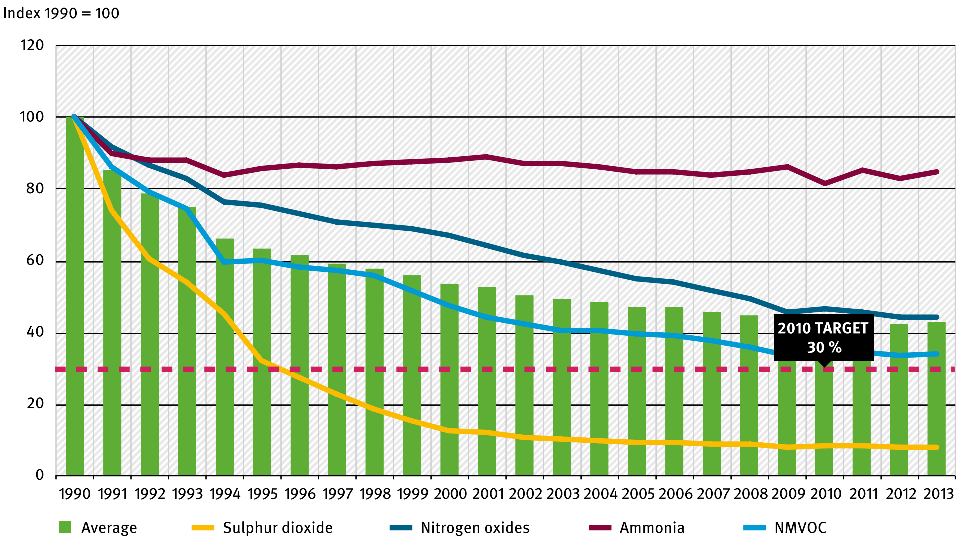
Should this trend continue, the reduction target of German Government cannot be achieved.

03

PROTECTION OF NATURAL RESOURCES

Emission of air pollutants

Air pollutant index of emissions



Air pollution: sulphur dioxide, nitrogen oxides, ammonia and volatile organic compounds without methane, averaged index of statistics

Source: Federal Environment Agency, National trend tables for reporting German atmospheric emissions since 1990, Emissions from 1990 to 2013 (as of 03/2015)

Achieving emission reduction targets

Visible progress has been made in reducing emissions of "classical" air pollutants since 1990. On average, the emissions decreased by about 58 %.

A decline in sulphur dioxide (SO_2) emissions is particularly obvious and emissions of non-methane volatile organic compounds (NMVOC) and nitrogen oxides (NO_x) also decreased significantly. Continuously high ammonia (NH_3) emissions, which mainly come from agriculture, remain problematic. The strongest reduction successes were achieved in the first half of the 1990s as a result of restructuring industry in the new states (Länder).

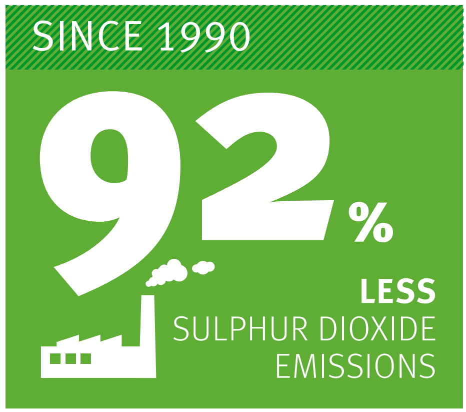
In its sustainability strategy the German Government [Federal Government 2002] set the aim of reducing the average emissions of the four air pollutants sulphur dioxide, nitrogen oxides, ammonia and NMVOC by 70 % compared to the 1990 base level by 2010. This target has been missed. Emissions continued to fall by 2013, but were still above the target, achieving a reduction of 57,5 %.

Emissions of air pollutants presented here affect air quality and thus human health, contribute to the formation of particulate matter and ozone and can damage ecosystems through acidification and eutrophication.

Sulphur dioxide is mainly produced by burning fuels containing sulphur. Emissions here have fallen by 92.2 % since 1990. This is mainly due to the closure of combustion installations and industrial plants in the new states (Länder) and the use of sophisticated emission control technologies. The use of fuels with lower sulphur content also had a significant influence. The EU Directive on National Emission Ceilings (NEC Directive) specified a maximum of 520,000 tonnes of sulphur dioxide for Germany in 2010. This goal was met back in 2004 and emissions have always been well below since then.

Nitrogen oxides are primarily formed through combustion processes in installations and engines and, to a lesser extent, in industrial processes and agriculture. A 56.1 % emission reduction was recorded from 1990 to 2013. The decrease in traffic is the most obvious reason behind this reduction, but despite this, the transport sector is still by far the largest emitter of nitrogen oxide emissions with a proportion of 40.7 %. The NEC Directive allows Germany a maximum output of 1,051,000 tonnes in 2010. This figure was still exceeded in 2013 and further emission reduction measures are therefore urgently required.

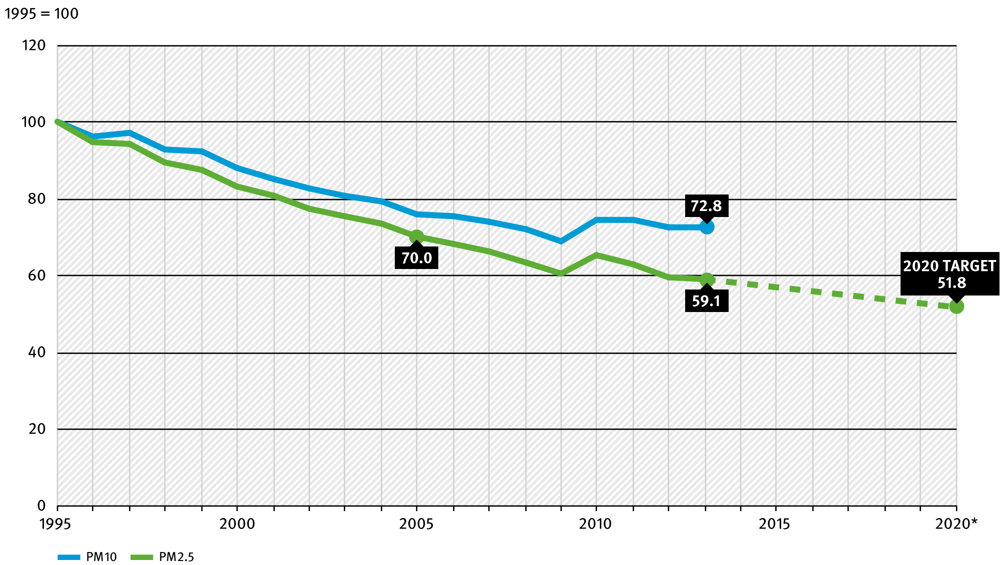
Ammonia emissions fell by 122,000 tonnes or 15.3 % from 1990 to 2013. This is mainly due to the reduction of livestock in the new states (Länder) immediately after reunification. Emission reductions stagnated in all other areas. Ammonia emissions have been about 100,000 tonnes above the NEC Directive's annual emission ceiling of 550,000 tonnes for many years.



Emissions of **non-methane volatile organic compounds** mainly arise from the use of solvents and solvent-based products. Earlier, transport was also a significant source of emissions, but today it produces only a little more than 8.6 % of NMVOC emissions in Germany. Private households and small consumers, volatile fuel emissions and industrial processes are other relevant emission sources. Between 1990 and 2013, emissions have been reduced by 66.5 %. The NMVOC emissions only just exceeded the NEC Directive's allowed emission ceiling of 995,000 tonnes in Germany in 2010, but they were well below the emission ceiling in subsequent years (2013: 929,100 tonnes).

Particulate matter emissions

Emission of particulate matter (PM10 and PM2.5)



*Gothenburg Protocol target: -26 % PM2.5 by 2020, compared to 2005

Source: Federal Environment Agency, National trend tables for reporting on German atmospheric emissions since 1990, Emissions from 1990 to 2013 (as of 03/2015)

Reducing emissions of particulate matter

Particulate matter emissions (PM10 and PM2.5) dropped significantly from 1995 to 2013: PM10 was more than a quarter lower and PM2.5 more than 40 % lower than in 1995. In the crisis year 2009, emissions decreased slightly, but rose again in 2010.

Further measures on air pollution need to be taken in order to achieve the objective of the amended Gothenburg Protocol of the Geneva Convention on Long-Range Transboundary Air Pollution (reduction of particulate matter emissions by 26 % over the period 2005 - 2020).

Tighter emission limits for power plants and industrial installation as well as heaters and stoves will lead to a reduction in particulate matter emissions in the coming years. Moreover modern vehicles that meet the Euro 6/VI emission standards, emit less particulate matter. Measures in agriculture such as exhaust air-cleaning systems in large stables and the rapid incorporation of manure and other organic fertilisers into the fields also contribute to reducing particulate matter emissions.

Particulate matter can be divided into different fractions according to its size. Particles with a diameter of less than 10 micrometres (µm) (PM10) make up a large part. Particulate matter with a diameter less than 2.5 µm (PM2.5) is a health risk, mainly due to its small size. The fine particles can penetrate deeper into the respiratory system, remain there longer and cause respiratory and cardiovascular diseases.

The term particulate matter summarises primarily emitted and secondarily formed particles. Primary particulate matter is released immediately from the source, for example in combustion processes. Secondary particulate matter is when particles emerge from gaseous precursors such as sulphur and nitrogen oxides and ammonia.

SINCE 1995

41 %

LESS

PM2.5 EMISSIONS

Particulate matter emissions have declined substantially in Germany since 1995.

PM10 emissions decreased from 313,000 tonnes in 1995 to 228,000 tonnes in 2013 (-27 %). Slightly more than one-third of PM10 emissions (39 %) comes from production processes, mainly from bulk material handling and the production of mineral products. Bulk materials can for example be sand, coal or grain. Private Households and small consumers (especially from stoves and fireplaces) and road transport (including tyre wear and other mobile sources) each cause about 15 % of PM10 emissions. A little more, 22 %, comes from agriculture.

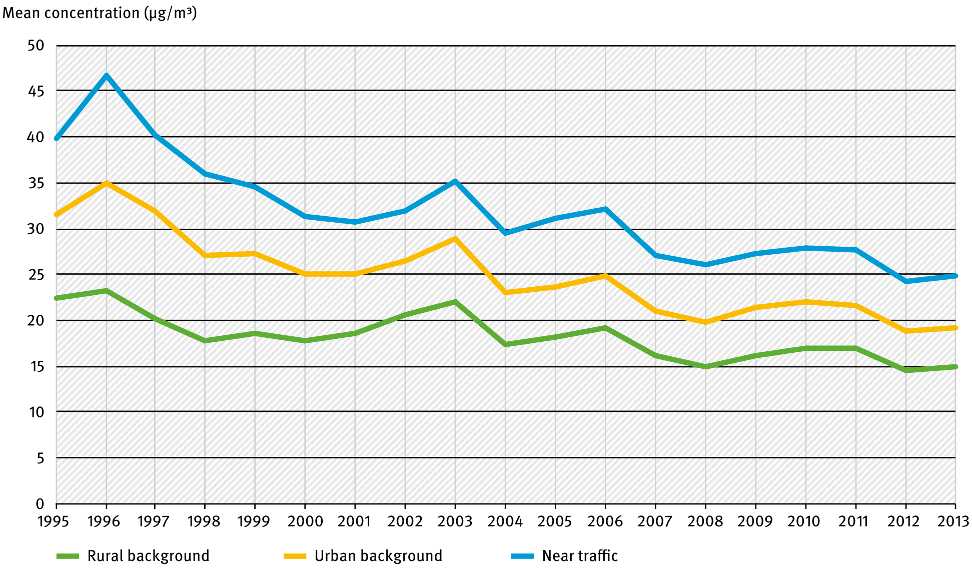
PM2.5 emissions decreased from 191,000 tonnes in 1995 to 113,000 tonnes in 2013 (-41 %). About two-thirds of the emissions result from combustion processes, with residential and commercial combustion as well as road transport having the largest shares. Other relevant amounts of PM2.5 particulate matter originate from production processes (especially from bulk material handling), use of solvent-based products and agriculture.

Particulate matter emissions must be reduced to diminish negative effects on human health. The parties of the Geneva Convention on Long-Range Transboundary Air Pollution (including the EU and its Member States, Eastern European and Asian countries as well as the USA and Canada) have therefore decided to adopt the Gothenburg Protocol (also Multi-Component Protocol) whose May 2012 amendment contains reduction commitments for particulate matter (PM2.5) emissions.

Germany must reduce its PM2.5 emissions by 26 % by 2020 compared to 2005. The 2020 emissions accordingly may only be about 92,000 tonnes or 51.8 % of the 1995 emissions.

Trends in air quality

Trend in annual mean PM10 concentration



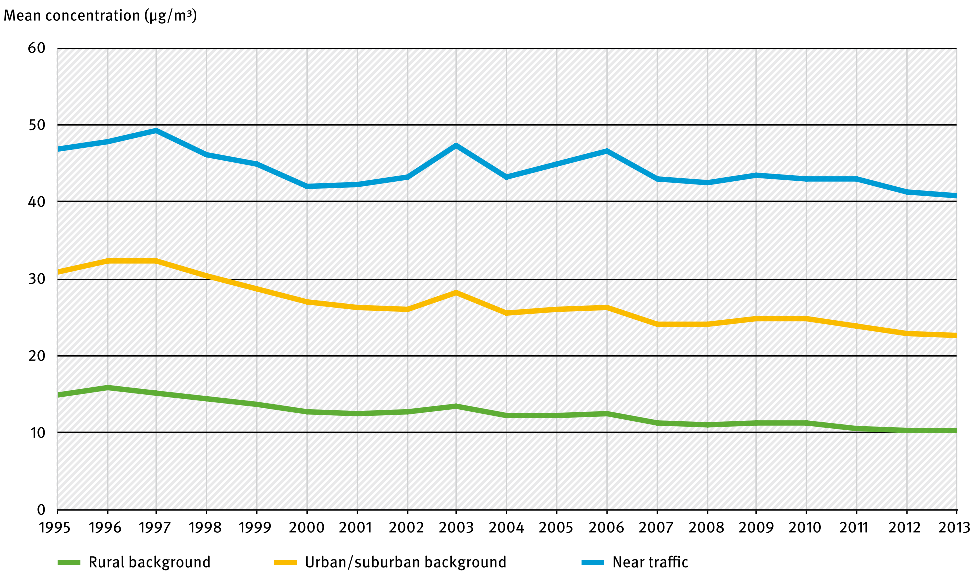
Source: Federal Environment Agency 2015

Minimal reduction of pollution in the last 10 years

Air pollution levels decreased considerably in the 1990s in Germany, but since 2000, there has been no discernible reduction in the concentrations of the health related pollutants particulate matter, nitrogen dioxide (NO_2) and ozone (O_3) despite the fact that emissions have been continually reduced.

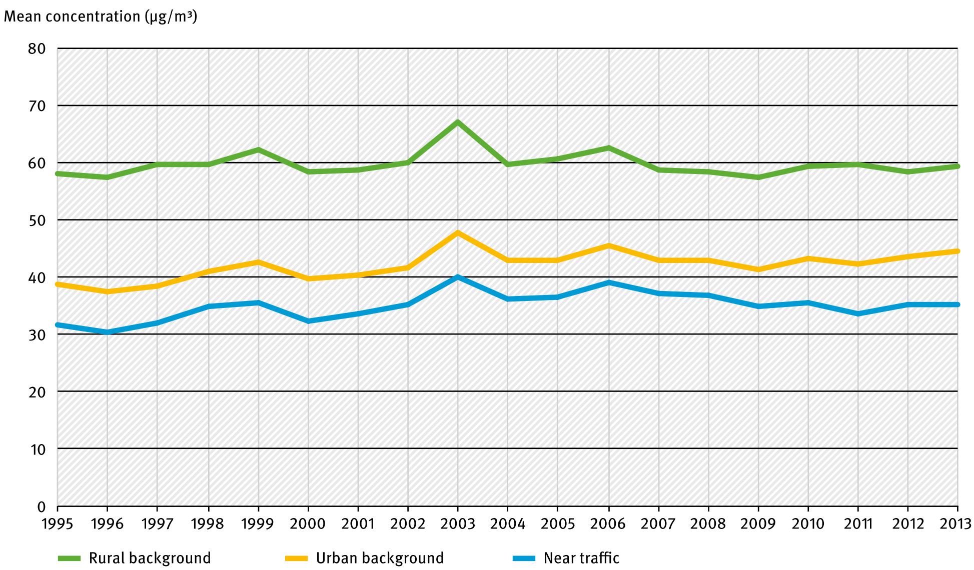
Air quality in Germany currently shows more or less strong inter-annual fluctuations, which are dependent above all on weather conditions. Both particulate matter (PM10) and nitrogen dioxide show a marked decline in medium concentrations in ambient air from towns and cities to rural regions. The highest concentrations occur near the place of origin, in conurbations and in areas with heavy traffic. This is different for ozone. Formed by chemical reactions of the ozone precursors nitrogen oxides and volatile hydrocarbons, the highest concentrations mainly occur outside of conurbations and at some distance from the source.

Trend in annual mean NO_2 concentration



Source: Federal Environment Agency 2015

Trend in annual mean O_3 concentration



Source: Federal Environment Agency 2015

▸ Air monitoring site with different measuring devices

While annual mean **PM10** concentrations at the beginning of the 1990s were around 50 microgram per cubic metre (µg/m³) over large areas, today they range between 20 and 30 µg/m³. The monitoring stations located in rural areas of the UBA monitoring network, which record the air pollution farther from the sources, have registered significantly lower values. The marked reduction in sulphur dioxide emissions and the reduction of primary PM10 emissions during the period from 1995 to 2000 was accompanied by a decrease in PM10 concentrations in ambient air during the same period. Since then there have been no clear, observable reductions in the concentration over time. The development of PM10 concentrations over time is masked by weather-related fluctuations between the individual years. Occasionally values exceeding the limit value of 40 µg/m³ set for a calendar year have been recorded locally and exclusively at those stations in conurbations influenced by traffic.

Annual mean concentrations of **nitrogen dioxide** fell until the end of the 1990s; since then they have stagnated. At far more than half of the stations near traffic, the measured concentration of nitrogen dioxide has exceeded the limit value, which is in place since 2010. Conurbations and cities are affected by heavier pollution as emissions there are higher than in surrounding areas. Depending on the location of the monitoring station, annual mean concentrations range between 30

and 60 µg/m³ and are as high as around 100 µg/m³ in individual cases. For the protection of human health, EU Directive 2008/50/EG – implemented into German law under 39. BImSchV – stipulated an annual limit value of 40 µg/m³, which has been in force since 2010. In 2013, this limit value was exceeded at 65 % of the monitoring stations near traffic. Approximately 500 monitoring stations in Germany currently measure nitrogen dioxide. In rural areas, the concentration rarely exceeds a value of 30 µg/m³. In areas located far away from emission sources, the concentration may even be below 10 µg/m³.

There was a slight increase in annual mean **ozone** concentrations from 1990 to 2013. On the one hand, peak ozone concentrations fell significantly on account of measures taken to reduce nitrogen dioxide and NMVOC emissions in Germany. On the other hand, the resulting reduction in the titration effect (ozone depletion by nitrogen monoxide (NO)) led to an increase in medium ozone concentrations, which is visible in the annual averages. Moreover, intercontinental (hemispheric) transport is believed to play a growing role for ozone pollution in Germany and Europe because of the industrial emissions originating in Asia and North America. As opposed to particulate matter and nitrogen dioxide, the highest annual average values for ozone are not measured in urban areas but in the rural background.

Exceedances of limit/target values in conurbations

Monitoring stations in conurbations where reference values have been exceeded

Source: Federal Environment Agency 2015

The parameter used here to evaluate the long-term development of air quality is the share of stations in conurbations where defined air pollution values (**reference values**) have been exceeded.

Due to their health risks, the air pollutants particulate matter (PM 2.5), nitrogen dioxide and ozone are considered.

The figure "Monitoring stations in conurbations where reference values have been exceeded" shows that a large number of stations exceed the reference values given in the legend. For ozone, this is up to one-half of the stations in the 1990s, thereafter the share fell below 20 % starting at the end of the 1990s. An exception to this is the hot summer of 2003, which had an influence on the years 2003–2005 through the three-year average. For nitrogen dioxide, the share of stations exceeding an annual average of 40 µg/m³ was between 23 and 62 %. There is no clear visible trend that can be observed. For particulate matter (PM 2.5), only the period 2010–2013 is shown since the pollutant PM 2.5 has been measured throughout Germany only since 2008 and can only be considered from 2010 onwards due to the required averaging over three years. The share of stations that exceeded the reference value of 14 µg/m³ was between 58 and 90 %.

Increased air pollutant concentrations affect many people

Compared to other areas in Germany, conurbations are characterised by a variety of human activities (industry, commerce, transport) and are most affected by air pollution. Approximately 35 % of people in Germany live in conurbations and are therefore exposed to increased health risks due to air pollution.

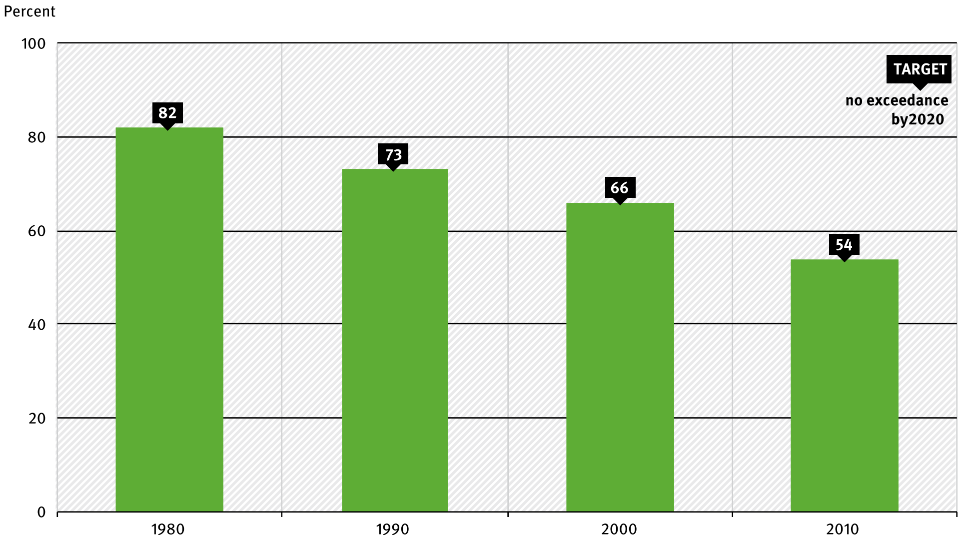
The "Average Exposure Indicator" (AEI) is used for particulate matter (PM 2.5) throughout Europe. This indicator refers to urban background stations and is used to calculate the national exposure reduction targets. According to the initial calculation, the national average value in Germany must not exceed 14 µg/m³ by 2020. Therefore, the **reference value** used here **for particulate matter (PM 2.5)** is 14 µg/m3, as annual mean averaged over three years and measured at selected urban background stations in conurbations.

As the **reference value for nitrogen dioxide**, the limit value applicable in Europe is used, which is 40 µg/m³ as annual average.

As the **reference value for ozone**, the target value applicable in Europe is used, which is 120 µg/m³, as 8-hour average, which must not be exceeded more than 25 times per calendar year averaged over a three-year period.

Ecosystem area at risk of eutrophication

Ecosystem area at risk of eutrophication



Source: European Environment Agency (EEA), Technical Report No.11, 2014

Exceeding the critical loads for eutrophication

Despite the decline in nitrogen deposition, the critical loads were exceeded on 54 % of the area of sensitive ecosystems in 2010. The exceedances of the critical loads are particularly pronounced in parts of Northwest Germany, due to intensive livestock farming on sensitive soils and high nitrogen loads resulting from the regional agricultural industry. Further eutrophication of semi-natural ecosystems due to the insufficient decrease in ammonia emissions (mainly from livestock farming) is expected for the coming years.

The EU's long-term objective and that of the Geneva Convention on Long-Range Transboundary Air Pollution is for the deposition of eutrophying pollutants to completely and permanently fall below the critical loads. The German National Strategy for Biodiversity also includes the objective of meeting critical loads by 2020. This objective will not, however, be achievable without additional measures.

The current high nitrogen deposition in natural and semi-natural terrestrial ecosystems is the result of the emission of chemically and biologically reactive nitrogen compounds originating from agriculture and combustion processes. The air pollution is deposited into terrestrial ecosystems via rainfall, fog, hoarfrost and the deposition of gases and particles from the atmosphere.

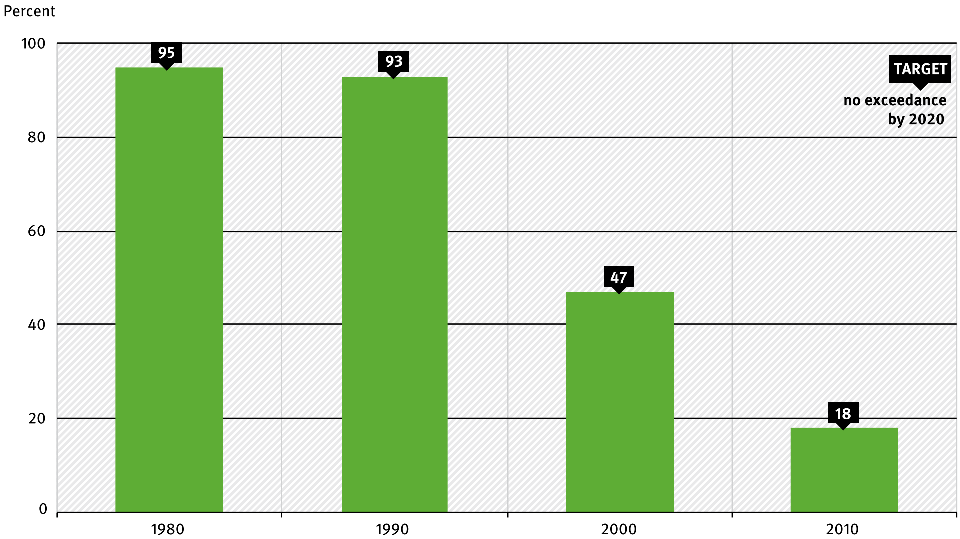
If nitrogen compounds are deposited into terrestrial ecosystems excessively, negative impacts on the environment, which can include nutrient imbalances and shifts in species composition towards nitrophilous species may be the consequence. Over-fertilisation that results from nitrogen input is a primary cause of the loss of biodiversity. Nearly half of the ferns and flowering plants that are listed in the red list in Germany are endangered by nitrogen deposition. Moreover many plants become more vulnerable to frost, drought and pests [SRU 2015].

For the assessment of nitrogen deposition, the ecological threshold value must be determined. If the deposition rate exceeds the so-called “critical load”, it cannot be ruled out that there may be long-term adverse changes to the structure and function of the ecosystem. Critical loads are therefore a good measure of the sensitivity of an ecosystem and allow for a spatially differentiated comparison of the load capacity of an ecosystem and the current deposition rate of air pollutants.

In order to further reduce atmospheric nitrogen deposition in future, emission reduction targets for nitrogen compounds, to be achieved by 2020, were agreed for all Member States in the revised Gothenburg Protocol to Abate Acidification, Eutrophication and Ground-level Ozone to the Geneva Convention on Long-range Transboundary Air Pollution. The target for Germany is to reduce ammonia emissions by 5 % and nitrogen dioxide emissions by 39 % by 2020 compared with 2005 levels. In addition, the EU is planning to update the National Emissions Ceilings Directive (NEC Directive).

Ecosystem area at risk of acidification

Ecosystem area at risk of acidification



Source: European Environment Agency (EEA), Technical Report No. 11, 2014

Exceeding the critical loads for acidification

In recent years, the deposition of airborne acidifying sulphur and nitrogen compounds into terrestrial ecosystems has decreased sharply. In 2010 critical loads were exceeded on 18 % of the area of sensitive ecosystems. The reason for this are no longer high loads of sulphur compounds, as was the case in the 1980s, but rather high ammonium nitrogen deposition from agriculture (particularly from livestock farming).

The comprehensive protection of ecosystems against acidification is an important goal of German and European environmental policy. The German Biodiversity Strategy also states the objective of meeting critical loads by 2020. However, this goal will not be achievable without targeting emission reduction measures on ammonia emitters.

► Monitoring site for atmospheric pollutants in a beech forest. Bayerischer Wald nature reserve

In Germany, the main sources of the deposition of acidifying nitrogen and sulphur compounds in terrestrial ecosystems are emissions from agriculture, energy production and industry. The air pollution is carried into terrestrial ecosystems via rainfall, fog, hoarfrost and the deposition of gases and particles from the atmosphere.

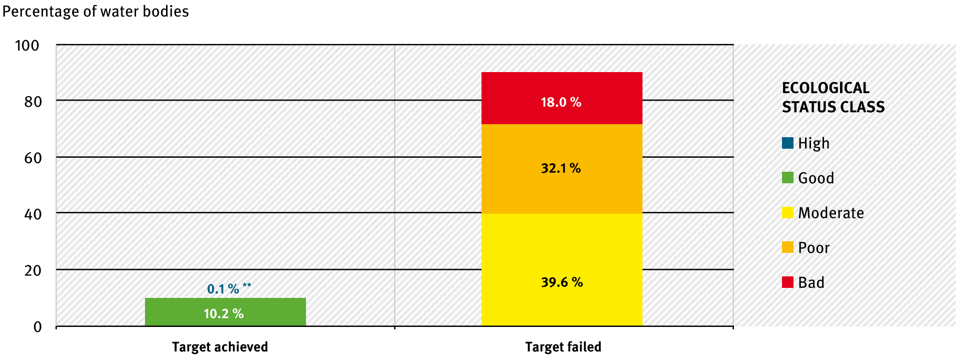
Acidifying nitrogen and sulphur compounds cause pH levels in an ecosystem to drop. The continuing acidification causes a change in nutrient availability for vegetation. Long periods of acid stress lead to a reduced vitality of plants and to a limited defence against natural stress factors. Visible forest damage such as crown thinning can be a result of acidification.

For the assessment of acid deposition, critical loads are determined for airborne nitrogen and sulphur deposition. If these limits are exceeded, sensitive ecosystems such as forests, heaths and marshes (and also surface waters and groundwater) can be damaged. The amount of tolerable deposition depends on the characteristics of the ecosystem under consideration.

In order to further reduce acidifying inputs of air pollutants, emission reduction targets for sulphur and nitrogen compounds (SO_2, NH_x, NO_x) were agreed for all member states in the revised Gothenburg Protocol to Abate Acidification, Eutrophication and Ground-level Ozone to the Geneva Convention on Long-range Transboundary Air Pollution. The target for Germany is to reduce ammonia emissions by 5 %, nitrogen oxide emissions by 39 % and sulphur dioxide emissions by 21 % by 2020 compared to 2005 levels. In addition, the EU is planning to update the National Emissions Ceilings Directive (NEC Directive).

Ecological status of rivers

Share of natural rivers that have reached the goal of good or high ecological status*



* Percentage of water bodies with an ecological status of "high or good" in the total number of flowing water bodies rated compared to the proportion of flowing water bodies that have not yet reached the target (worse than good ecological status)

**Percentage of river water bodies rated "high"

Source: Federal Environment Agency, Report portal WasserBLIcK/ Federal Institute of Hydrology 2015, 2nd draft management plans

German rivers do not have "good" ecological status

The EU has pursued a comprehensive protection and use concept for European waters with the EU Water Framework Directive 2000/60/EU (WFD) from 2000. Rivers, lakes, transitional and coastal waters should achieve the ecological status of "good" or "high" by at least 2015, or the latest by 2027.

In the 2015 draft river basin management plans, only about 10 % of German rivers were ranked at a "good" or "high" ecological status. Most frequently, "good" or "high" ecological status has failed to be achieved when watercourse structures have been altered by e.g. straightening or riverbank construction. River continuity was lacking and the nutrient load in flowing water was too high.

More than half of watercourses are "heavily modified" or "artificial". These are watercourses whose structure has been physically transformed for land drainage, navigation, water storage or hydropower to an extent that their original status can no longer be applied as assessment yardstick, or they are man-made (e.g. canals). The objective for these watercourses is to achieve "good" or "high" ecological potential. About 3 % have achieved this objective.

Thus it is foreseeable that a large number of rivers in Germany will not achieve the "good" ecological status in the coming years.

The ecological condition of surface water is assessed based on biological, chemical, physico-chemical and hydromorphological quality elements of the water bodies. In order to classify them, the organisms living in the water are compared with the population that should normally be present under natural conditions. Freshwater biologists concentrate on four groups of organisms: microalgae (phytoplankton), macroalgae and flowering plants (macrophytes), invertebrates living on the riverbed (macrozoobenthos) and fish. The species composition and frequency is determined and compared with the natural condition of that type of water. The classification is set out in the Surface Water Ordinance (OGewV) [BMUB 2014a].

According to the degree of deviation from the natural state of the water type, the responsible federal state (Land) authority will assess the state of a body of water into the classes “high”, “good”, “moderate”, “poor” or “bad”. A “worst-case scenario” has been applied in the classification: the biological quality component with the worst assessment determines the final class. If the national environmental quality standard (EQS) of a pollutant relevant to the river basin is exceeded, the ecological state can be assessed as “moderate” at best.

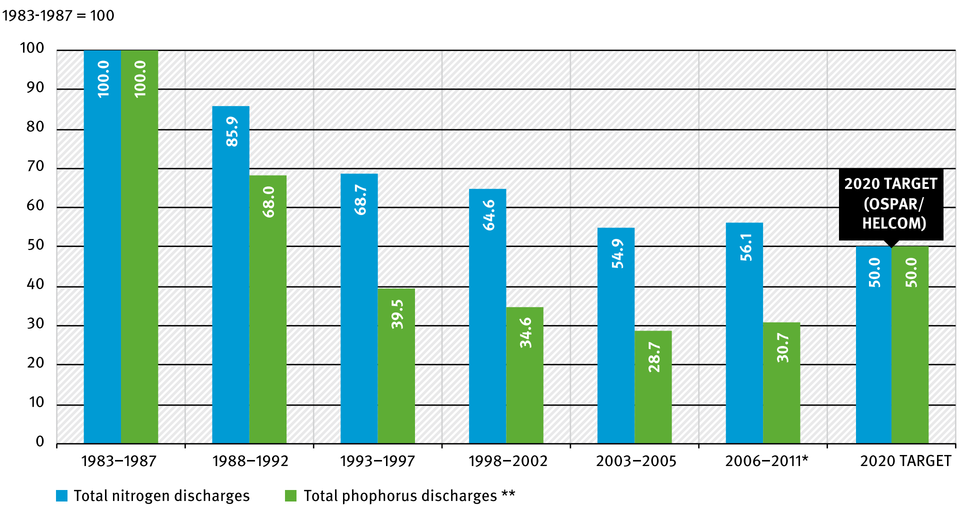
The EU Member States document the ecological state of the waters on a regular basis in river basin management plans, which are based on the six-year management cycle set out in the Water Framework Directive. The first management cycle began in 2009 and ends in 2015. During this period, a section of the waters is tested at least once. Two further cycles will then follow.

Prior to the first management cycle, the ecological quality of all waters was classified and an initial management plan and a first programme of measures on the improvement of the state were drafted. The deadline for this ended on 22 December 2009. Germany submitted its plans and programmes to the EU Commission in a timely manner. These are summarised in the brochure “Water Framework Directive – The way towards healthy waters” [UBA 2010].

To improve the ecological condition of rivers in Germany, the programmes contain a series of environmental protection and reclamation measures. These include reducing nutrient in-take from agriculture, removing structural interventions and restoring semi-natural courses of rivers and floodplains.

Nutrient discharges into surface waters

Nitrogen and phosphorus discharges into rivers from point and diffuse sources
Average annual values for consecutive 5-year periods



* New database for the period 2006-2011
** Target already achieved for total phosphorus discharges

Source: Federal Environment Agency 2014

Nutrients (nitrogen and phosphorus) can migrate from communities, agriculture, industry and the atmosphere into streams, rivers and lakes where they exert adverse environmental impacts and can lead to algal blooms and upset the oxygen balance of waters.

The volume of nutrients discharged into surface waters is calculated using the MoRE and MONERIS balance model. The results show a significant decrease in discharges over recent decades. This can be attributed mainly to the introduction of phosphate-free detergent, ceasing production in the new states (Länder), the construction and modernisation of municipal and industrial sewage treatment plants as well as a higher residential connection rate to wastewater treatment.

Agriculture is currently the main source of nutrient discharge into surface waters. During land management and livestock farming, nutrients travel via surface-water

run-off and erosion of soil particles from farmland into water bodies. Accordingly, high nutrient discharges occur where large herds are kept and intensive farming is operated on soils that are somewhat permeable or vulnerable to erosion. This is particularly the case in areas with sandy and peaty soils as in north-western Germany. The nutrient discharges from agriculture were hardly reduced over recent decades.

So-called point sources (e.g. municipal sewage treatment plants, power plants, industrial direct dischargers) are also important. These represent the dominant discharge pathway for phosphorus, but not for nitrogen.

The measures arising from the implementation of the WFD are decisive for the protection of surface waters. The main objective of the WFD is to strictly adopt water policies designed for environmentally friendly water use. The states (Länder) are responsible for the implementation of water law and water protection measures.

Future efforts to minimise nutrient discharges and water pollution must primarily be aimed at reducing the burden caused by diffuse sources; agriculture is particularly targeted in this respect. Therefore, the Federal Environment Agency recommends measures that will help ensure that farmers comply with the Codes of Good Practice in agriculture and soil conservation. In order to reduce nitrogen discharges from agriculture, the Federal Environmental Agency also advocates a tightening of the fertiliser ordinance. Other potential measures to improve water quality include the formulation of new requirements for water pollution control, the expansion of sewage treatment plants with an improved cleaning technique, regular monitoring of water quality and close cooperation between the countries in river basins within the framework of internationally binding agreements [BMUB 2014a].

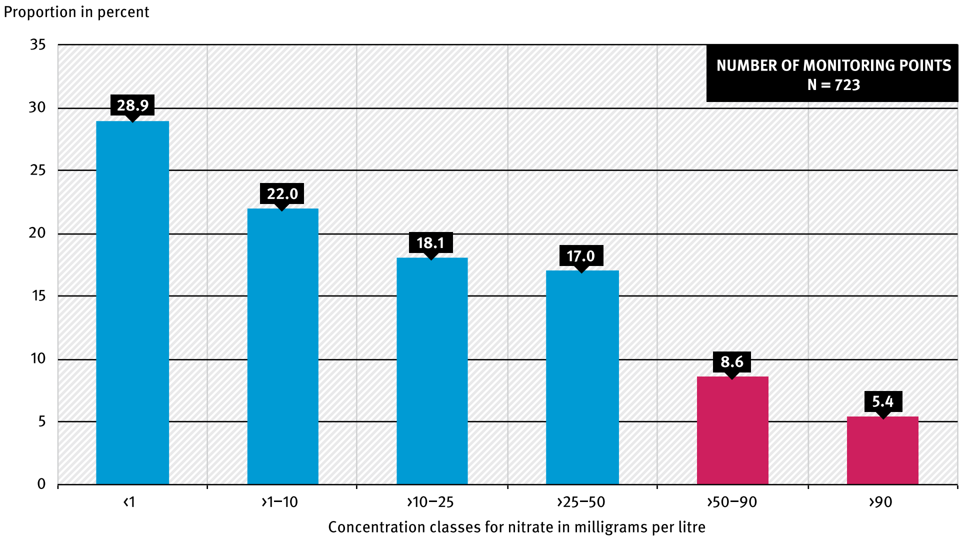
Further reducing the discharges of nutrients from agriculture

Models have shown that an average of 580,000 tonnes of nitrogen per year was discharged into surface waters between 2006 and 2011. This is around 44 % less on average than between 1983 and 1987. Phosphorus discharges measured an average of 25,000 tonnes per year between 2006 and 2011. This represents a decrease of 69 % compared to the average values between 1983 and 1987. However, it must be noted that the balance model and collection of the input data has been marginally modified for the period between 2006 and 2011.

Through the Water Framework Directive (WFD), the EU has set itself the aim to significantly reduce the discharges of nutrients into waters. In addition, some nutrients are subject to objectives set out by the International Convention for the Protection of the marine Environment of the North-East Atlantic (OSPAR) and the Baltic Sea (HELCOM). The environmental policies in the international conventions aim to decrease the discharge of nitrogen and phosphorus into surface waters by half by 2020 compared to 1985. Regarding phosphorus, this goal was achieved between 1993 and 1997, but regarding nitrogen, further measures are still required

Nitrate in groundwater

Distribution of nitrate concentrations in the EEA groundwater monitoring network 2010



Source: Federal Environment Agency 2013 according to the German Working Group on Water Issues (LAWA)

Groundwater is part of the hydrological cycle and an essential element of the ecosystem. It originates mainly from rainwater that seeps through the soil and subsoil into the aquifer. In Germany, groundwater is the most important resource for drinking water, approximately 74 % of drinking water being taken from national groundwater resources [BMUB 2014b].

Elevated nitrate levels in groundwater represent a risk to humans and the environment. High nitrate concentrations affect the ecology of waters, drinking water quality and can affect human health.

The main reason for the partially high nitrate concentrations in German groundwater is diffuse nutrient discharges from agriculture, predominantly discharges of nitrogenous fertilisers, which contribute to nitrate pollution in groundwater. As part of agricultural use, fertilisers are often not distributed on the land in an appropriate fashion or location and therefore can seep into the groundwater. Nitrogen surplus is an indicator of the degree of pollution. In 2012, the annual nitrogen surplus was 98 kilograms per hectare (kg/ha) in the total balance for Germany.

For precautionary groundwater protection, the federal states (Länder) and other institutions operate a large number of monitoring sites where the quality of groundwater is being monitored. In order to facilitate regular reporting of German groundwater conditions to the European Environment Agency (EEA), representative monitoring sites were selected from the states and summarised for the EEA groundwater monitoring network. The states transmit data from this monitoring network annually to the Federal Environment Agency, which in turn reports to the EEA.

In order to protect the groundwater from high nitrate pollution, the European Union (EU) passed guidelines for the protection of groundwater, which must be implemented by Member States into their national law:

- The EU adopted the Nitrates Directive as early as 1991, which aims to prevent the contamination of ground- and surface waters with nitrates from agriculture. With this Directive, the EU stipulates compliance with the "Codes of Good Practice" in agriculture and other reduction measures in action programmes. This requires that farmers should consistently adhere to the Fertiliser Ordinance.

- The EU set a compulsory limit of 50 mg/l for nitrates in drinking water in 1998 in the EU Drinking Water Directive.

- The EU Groundwater Directive (GWD) of 2006 (amended in 2014) supplements the EU Water Framework Directive (WFD) of 2000. It also provides a threshold of 50 mg/l for nitrate, above which a "good" chemical groundwater condition no longer exists and so countermeasures must be taken.

In order to achieve the WFD objectives, management plans will be launched in Germany in a 6-year cycle, which include programmes for measures to reduce nitrate pollution and groundwater pollution.

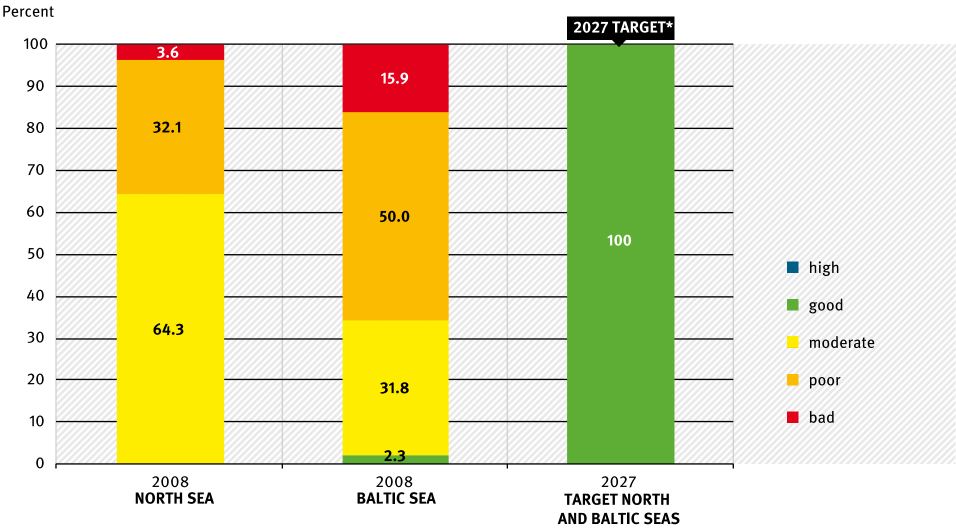
Nitrate content in groundwater

Nitrates may affect the quality of groundwater. The federal states (Länder) use their own monitoring networks to monitor the condition of the groundwater in Germany in order to identify threats to groundwater early on. The nitrate content of groundwater is also regularly monitored in these measurements.

The German Environment Agency received the nitrate concentrations from 723 groundwater monitoring sites of the representative EEA groundwater monitoring network for 2010. The measurements show that 50.9 % of the sites show no or very low nitrate loads of less than 10 milligrams per litre (mg/l). Nitrate concentrations were between 10 and 50 mg/l at 35.1 % of the monitoring sites meaning that the groundwater at these sites was clearly or severely burdened by nitrates. The remaining 14.0 % of monitoring sites had high nitrate concentrations above 50 mg/l. This groundwater cannot be used as drinking water without further processing or blending with uncontaminated water because it exceeds the 50 mg/l nitrate limit of the Drinking Water Ordinance 2001 (TrinkwV 2001).

Ecological status of coastal waters of the North and Baltic Seas

Ecological status of the assessed transitional and coastal waters



*Target of the Water Framework Directive (WFD): all water bodies in at least a "good" status by 2015; extension until 2027

Source: Assessment of the ecological status of German transitional and coastal waters 2009

Ecological status of coastal waters of the North and Baltic Seas

The ecological status of the transitional and coastal waters of the North and Baltic Seas was assessed in 2009. This assessment revealed that almost all German coastal water bodies of the North and Baltic Seas are in a "moderate" to "bad" status. Only one of the 72 investigated water bodies reached the "good" ecological status. The poor results originate from excessive nutrient discharges by rivers contributing to the eutrophication of the coastal areas.

Mainly the degree of pollution of the North and Baltic Seas is differing. While 15.9 % of the coastal water bodies of the Baltic Sea were in a "bad" status, this was true for only 3.6 % of the coastal waters of the North Sea [Voß et al. 2010].

The aim of the EC Water Framework Directive is to reach by 2027 at the latest the "good" ecological status for all coastal and transitional waters. This goal will not be reached without significant reduction in nutrient discharges from the river basins.

The coastal waters of the North and Baltic Seas are endangered by human activities. Excessive discharges of nutrients and contaminants through rivers cause the eutrophication and pollution of coastal ecosystems. As a result, the ecological balance of the marine environment is impaired and there is a change in the species composition in coastal waters.

With the implementation of the Water Framework Directive (WFD), the EU has created the basis for a water protection concept that provides a holistic view of the groundwater, rivers, lakes and coastal waters. An important objective of the WFD is to reach the "good" ecological status for the coastal waters of the North and Baltic Seas by 2015 (or in the case of an extension by 2027). The ecological status of the coastal waters is measured mainly by the existence of biocoenoses typical for the particular area. The assessment is based on the biological quality elements phytoplankton (microalgae), macrophytes (macroalgae and flowering plants), macrozoobenthos (ground-dwelling invertebrates) and fish. Morphological and physicochemical features support this assessment. The biological quality element reaching the worst assessment result is decisive for the classification. Water bodies significantly altered as a result of hydromorphological modifications were assessed on the basis of their ecological potential.

The requirements of the WFD are addressed in several steps. After the Directive was implemented into national law in 2003, the state authorities of Schleswig-Holstein, Lower Saxony, Bremen, Hamburg and Mecklenburg-Western Pomerania in 2004 compiled an inventory of the German transitional and coastal waters. This inventory was based on a preliminary assessment of the ecological status as many assessment procedures were still under development. In 2009, management plans and programmes of measures were established to improve the status of waters. The ecological status of the German transitional and coastal waters of the North and Baltic Seas was also assessed to aid the drafting of management plans.

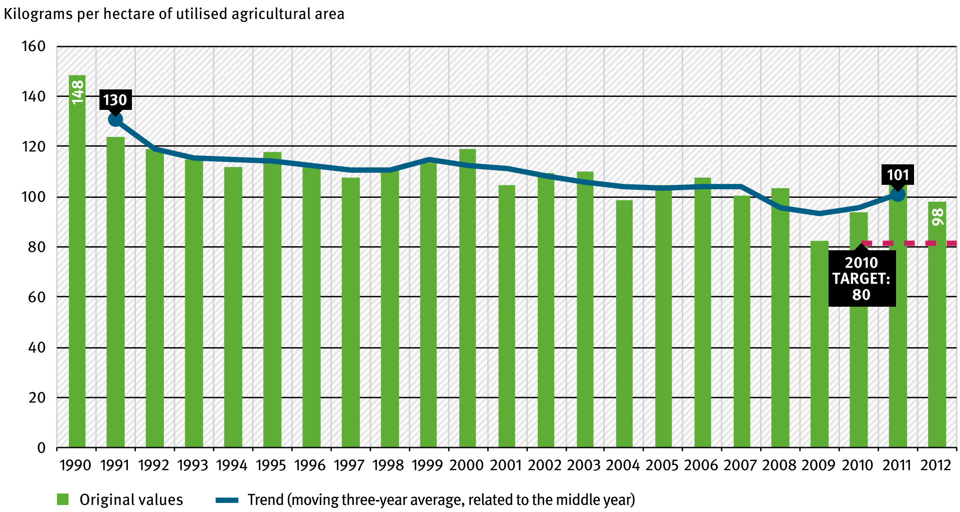
In 2014, the coastal and transitional waters were subsequently assessed in accordance with the WFD. The preliminary results indicate that the ecological status has not fundamentally improved compared to 2009. The reasons are due to the fact that the measures taken so far to reduce nutrient discharges are insufficient and that the transitional and coastal waters only respond with considerable delay to a reduction in nutrient discharges.

04

AGRICULTURE AND FORESTRY

Nitrogen surplus in agriculture

Nitrogen surplus in agriculture (overall balance)



Source: Institute for Crop and Soil Science, Julius Kühn Institute (JKI), Braunschweig and Institute of Landscape Ecology and Resources Management (ILR), University of Gießen, 2014

Reducing nitrogen surplus in agriculture

Between 1991 and 2011, the nitrogen surplus in agriculture declined from 130 kilograms per hectare per year (kg/ha*a) to 101 kg/ha*a in the moving 3-year average. This corresponds to a decline of around 22 %. The decrease in the nitrogen surplus at the beginning of the 1990s can be attributed largely to the reduction of livestock in the new states (Länder). Since 1993, the average annual decline in the balance has been approximately 1 % due to a slight decline in the use of mineral fertiliser and reliance on efficiency gains in the use of nitrogen as a result of yield increases in crop production and a higher feed conversion ratio in livestock farming.

The German Government's aim was to reduce the nitrogen surplus in agriculture in the overall balance from 130 to 80 kg/ha*a by 2010 [Federal Government 2002]. A further reduction was set out for 2015 [BMU 2007]. The target has not been met. In 2011, the target value was exceeded by 21 kg/ha*a (moving 3-year average), or by roughly 26 % and the German Government has not yet established a new target. The Federal Environment Agency recommends that the nitrogen surplus in the overall balance should be reduced to 50 kg/ha*a by 2040 [UBA 2014b]. In addition, the Agency supports a tightening and better implementation of the Fertiliser Ordinance requirements.

Nitrogen is an essential nutrient for all live. In agriculture, nitrogen is used as a fertiliser to compensate for nutrient losses during production, to increase crop yields and to improve soil fertility. However, if introduced in excess into the environment, nitrogen can have a serious impact on the ecosystem. If the nitrogen surplus is not absorbed by plants, it can get into the surrounding water or air. The most significant consequences of high nitrogen input include the pollution of groundwater with nitrates, the eutrophication of ecosystems and the acidification of ecosystems which leads to reduced biodiversity.

A measure for the potential nitrogen discharges from agriculture into groundwater, surface waters and air is the nitrogen surplus that is determined from the total nitrogen balance. The nitrogen balance in agriculture results from the comparison of nitrogen intake and output. Sources of nitrogen intake are fertilisers, non-agricultural emissions, biological nitrogen fixation, seeds and seedlings and fodder. The nitrogen output is calculated from the amount of nitrogen contained in the agricultural products. The balance is calculated according to the field-stable balance. It is assumed that the amount of nitrogen calculated in the balance remains on agricultural land and in the environment.

As such, in 2010, 50 % of the nitrogen intake in the German agricultural sector came from mineral fertilisers, 22 % from domestic animal feed and 12 % from fodder imports. An additional 7 % was caused by the biological nitrogen fixation of legumes; 5 % was conveyed by air from non-agricultural sources and 1 % stemmed from seeds and seedlings. Nitrogen outputs are plant and animal products.

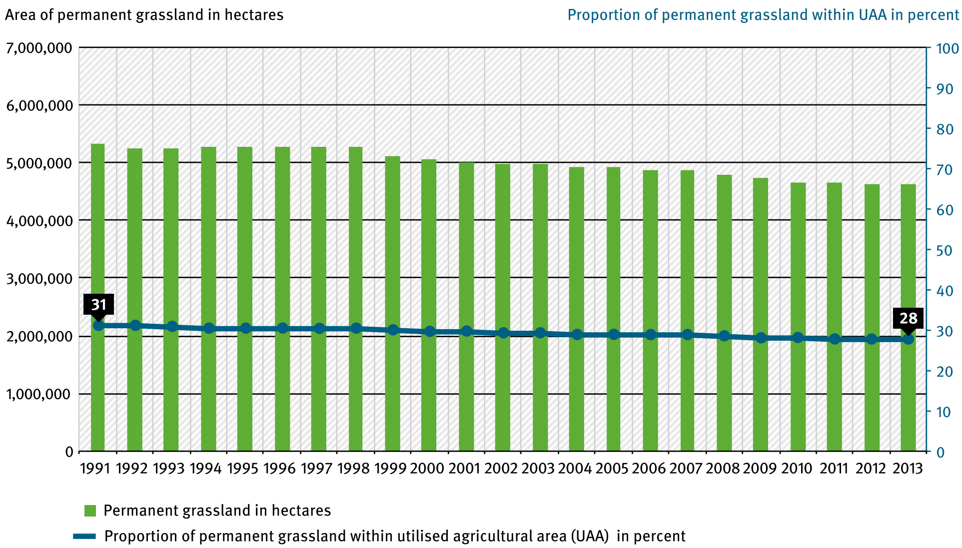
The results indicate that in spite of the tendential decrease in recent years, excessive nitrogen surpluses still occur today. The reasons are mainly poorly controlled fertilisation and excessive concentration of livestock. Diffuse nutrient discharges in rivers and groundwater reach their maximum where excessive livestock are kept on locations with nutrient discharge potential. This is the case across the entire northwest of Germany and in the Alpine foothills.

The Fertiliser Ordinance was adopted in 1996 in order to achieve a reduction in the nitrogen surplus. The Fertiliser Ordinance stipulates that farmers are only allowed to fertilise according to the nutritional needs of plants. Since 2007, the nitrogen surplus of individual farms (calculated at the field surface) must not exceed a statutory limit. This maximum value (averaged over three years) was gradually reduced from 90 kg/ha*a to 60 kg/ha*a. Values of this surface balance are about 30 kg/ha*a lower than values of the total or field-stable balance because they do not contain nitrogen which escapes into the air from stables or the treatment of manure and manure storage.

Studies show that high nitrogen surpluses occur especially in farms with a high livestock density. There is a potential for reduction: the efficiency of nitrogen use could be improved, for example through optimising farm nutrient management, location coordinated management, appropriate crop varieties and smaller livestock numbers [UBA 2011].

Ploughing up grassland

Permanent grassland - total area and proportion within utilised agricultural area (UAA)



Source: Federal Ministry of Food and Agriculture (BMEL) 2014, Statistics and reports

Preservation of permanent pastures

Grasslands are communities of plants such as grasses and herbaceous plants that have arisen naturally or through human use. Areas of grassland include important nature conservation areas such as wetlands, neglected grassland and orchards as well as meadows and pastures, which are used for food and fodder production and biomass production. Extensively managed grassland areas in particular contain a wide variety of species [BfN 2014].

In Germany, grassland has been subject to strong environmental pressure in recent years. During 1991 more than 5.3 million hectare of agricultural land were cultivated as permanent pasture and decreased to only 4.6 million hectares of permanent pasture in 2013. Thus, the total area of permanent pasture declined during this period by roughly 0.7 million hectare.

The aim of the German and European agricultural policy is to maintain grassland areas in the future and prevent further ploughing up of grasslands.

Grassland fulfils various functions in the agricultural landscape and is of great value to nature conservation. Grassland areas are home to over half of all species occurring in Germany. Extensively cultivated grasslands are an important habitat for plant communities that prefer nutrient-poor soils and are rare in the agricultural landscape. The same applies to endangered animal species adapted to such places. Moreover, grasslands are important for soil and water conservation and as carbon sinks they contribute to climate protection.

The decrease of grassland is a result of a more intensive agriculture and related changes in land-use. The trigger was and is the high demand for certain agricultural products such as maize for animal feed, aggravated by biomass production for energy recovery. Pastures and meadows are thereby increasingly used regionally for cultivating energy crops. An analysis of data from 2009 for several states (Länder) shows that the cultivation of corn represents more than 50 % of the dominant land-use after grassland conversion to farmland. The intensification of dairy farming and low milk prices also encourage the ploughing up of grassland because farmers keep cows all year-round in barns and increasingly feed them with concentrated fodder (e.g. maize, rapeseed meal and soybean), instead of habitually keeping them on the pasture. Furthermore, grassland serves as a "land reserve" in cases of changes in land-use. New land-take for residential and transport land-use in Germany consists of about 70 hectares every day. The consequent loss of arable land tends to be compensated for by grassland.

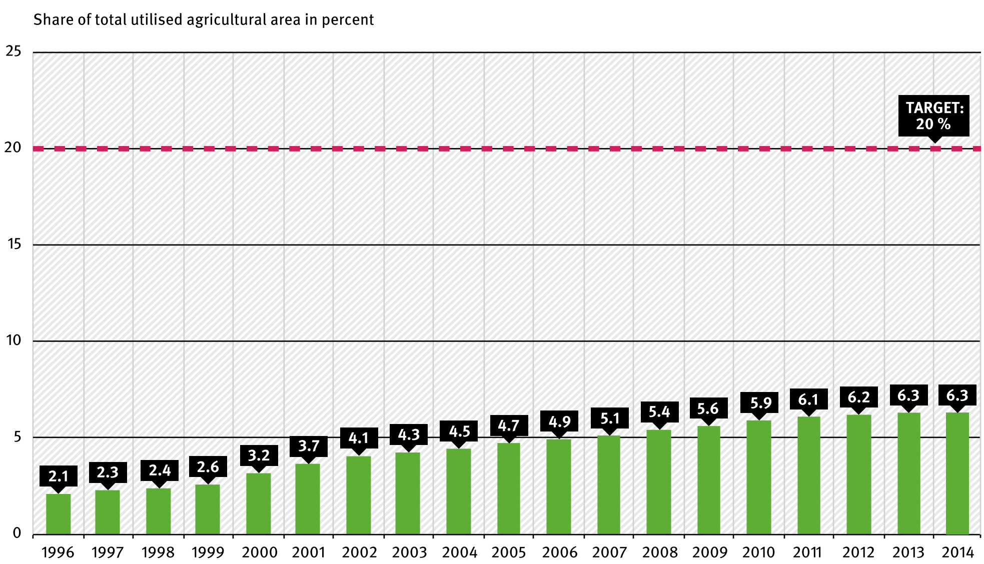
From a nature conservation and climate protection perspective it is alarming that the ploughing up of grassland also occurs on ecologically valuable sites such as semi-dry grasslands and wetlands (fen and half-bog sites). Intensive agriculture on these lands can have serious consequences for the environment (loss of species, nitrate leaching, greenhouse gas emissions, erosion risk).

The EU formulated a permanent grassland conservation order in 2005 in order to protect permanent pastures through the conditionality of direct payments (Cross Compliance) for farmers benefiting from income support through direct payments. Furthermore, the reform of the EU Common Agricultural Policy (CAP) provided new provisions for environmental protection requirements for the funding period 2014-2020. In the future, 30 % of direct payments will depend on compliance with the so-called "Greening" (crop diversification, retention of permanent grassland, provision of ecological focus areas). Grassland preservation needs will no longer be met at the state (Land) level, but be carried out by individual farms. At a state (Land) level, grassland areas may not decrease by more than 5 % in relation to the area of arable land compared to 2012. An additional future conversion and ploughing ban will apply to sensitive permanent grassland in areas of flora-fauna rich habitat.

Whether these requirements are sufficient to adequately protect the grassland in scope and quality will be reflected in the mid-term review of the new CAP in 2017/2018. The opportunity to intervene through corrective action if necessary should then be unquestionably used.

Organic farming

Share of organic farming within the utilised agricultural area



Source: Federal Ministry of Food and Agriculture (ed.), Statistical yearbook on nutrition, agriculture and forestry, Münster-Hiltrup, various volumes; http://www.bmel.de (inspected on 12.09.2014) and communication as of July 2015

Organic farming is a particularly resource-saving, environmentally and animal-friendly form of agriculture. Farms that operate according to the principles of organic farming renounce mineral fertilisers and synthetic chemical pesticides and provide a number of positive environmental services. The number of animals is limited depending on the area of holding. The principles of this farming system are preferably closed nutrient cycles, a diverse crop rotation and animal-friendly livestock management. Organic farming is therefore an essential element in an agricultural policy relying on the exemplary principles of sustainability. It plays a pioneering role in sustainable land management.

In 2014, 23,398 agricultural holdings (8.2 % of all farms) farmed an agricultural area of 1,047,633 hectares in Germany according to the rules of organic farming. The number of enterprises increased during the previous year by about 0.5 %, while the area of organic farming in

Germany grew by about 0.3 % (BMEL 2015).

Most ecological/organic farming enterprises in Germany are organised in associations. The guidelines of the German farming associations meet the criteria of, and go a few points beyond, the EC Eco-Regulations. Most of these farming associations are associated to the Federation of the Organic Food Industry e. V. (BÖLW) which acts as the umbrella organisation of all German organic sectors.

Organic products are enjoying a growing popularity in Germany since it is the largest market and the largest organic producer in Europe. In 2014 an estimated turnover of 7.91 billion euro was achieved [BÖLW 2015]. This represents an increase of around 5 % compared to the previous year (2013: 7.55 billion euro). Based on the total food market, the organic share increased to about 4 %. Demand for organic products still exceeds the supply significantly. A part of these imports could actually be produced in Germany, however, the willingness of farmers to convert to organic farming requires a financial planning security and reliability. The aim of the Federal Government's National Sustainability Strategy to achieve a proportion of 20 % of organically cultivated areas in Germany depends crucially on ensuring sufficient funds for organic farming. It is therefore in the hands of European and German agriculture ministers to allocate adequate funding for the second pillar of agricultural policy and to encourage corresponding funds in the federal and state (Länder) budget in order to strongly support the requirements of environmental protection in agriculture and to appropriately promote organic farming.

Increasing the proportion of organic farming areas in Germany

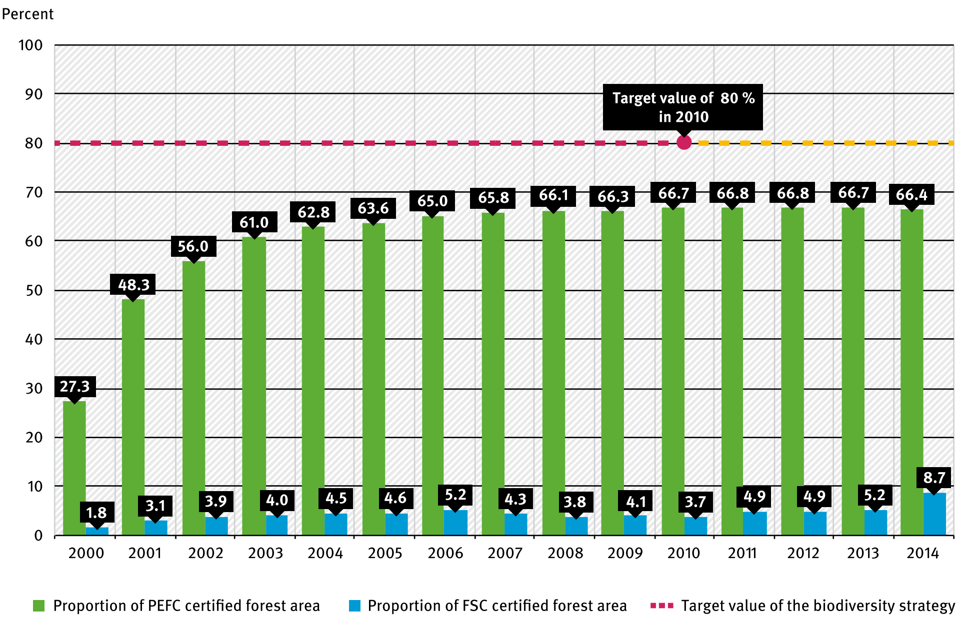
According to the Federal Ministry of Food and Agriculture (BMEL) around 6.3 % of the total agricultural land in Germany was cultivated in accordance with the principles of organic agriculture in 2014 [BMEL 2015]. Between 1996 and 2014, the proportion of organically cultivated area rose by 4.2 percentage points.

The aim of the Federal Government is to further strengthen organic farming in Germany. For this purpose, the government aims to increase the proportion of organically cultivated areas within the total utilised agricultural area in Germany to 20 %.

It is foreseeable that the goal of the Federal Government will not be achieved in the next few years. Further efforts are therefore needed to increase the share of organically cultivated area in the future.

Sustainable forestry

Proportion of PEFC and FSC respectively certified forest area



Source: PEFC Germany (2014), FSC Germany (2014), Federal Agency for Nature Conservation (2014)

Share of certified forest areas in Germany is stagnating

Central to the protection of forests and the preservation of their performance is a more sustainable and efficient use of wood as a raw material. Demanding certification systems for sustainable forest management and the use of certified woods are important tools for this purpose. In 2014, the proportion of PEFC certified forest area was 66.4 %, while the proportion of FSC certified forest area was 8.7 %. The proportion of certified forest areas in the total forest area has greatly increased between 2000 and 2003. Since 2004, however, only a small annual increase of certified forest areas has been recorded.

The "National Biodiversity Strategy" sets the goal that 80 % of forest areas in Germany would be certified according to high-quality environmental standards by 2010. The target was only narrowly missed with a proportion of about 70 % of forest areas being certified.

Certification is a voluntary commitment of forestry companies to comply with standards in ecological, economic and social fields beyond the legal requirements. Through certification following a demanding accreditation system, forest owners document their willingness to consider going beyond the legally prescribed standards of sustainability and nature and species protection in the management of their land.

THE FOLLOWING FOREST CERTIFICATION SYSTEMS WERE ESTABLISHED IN GERMANY:

- Programme for the Endorsement of Forest Certification Schemes (PEFC),
- Forest Stewardship Council (FSC),
- “Naturland”-certificate.

The PEFC was initiated in 1999 and is based on the decisions of the 1992 Rio de Janeiro Earth Summit follow-up conferences. The introduction of the certification system is based on a Scandinavian, French, German and Austrian forests properties initiative. The primary goal of the PEFC is to document and improve sustainable forest management in terms of economic, ecological and social standards. With an area of about 7.36 million hectares, the PEFC is the system with the largest certified area in Germany [PEFC 2014].

The FSC was introduced in 1993 and is an internationally recognised forest certification system. However, the FSC Germany has only been in existence since 1997 as a national initiative. The FSC was founded with the aspiration to promote environmentally appropriate, socially beneficial and economically viable management of forests. The FSC certification system is supported by most environmental and nature conservation organisations. By the end of 2014, about 965,000 hectares of forests were cultivated in Germany in accordance with the FSC [FSC 2014] standards.

The Naturland-certificate was developed in 1995 by Naturland, Greenpeace, the Federation for Environment and Nature Conservation Germany (BUND), the World Wide Fund for Nature (WWF) and Robin Wood. The aim of Naturland is an ecologically and socially responsible use of forests. Germany currently holds about 54,000 hectares certified by Naturland criteria for ecological forest use [Naturland 2014].

The share of PEFC and FSC certified forest areas is used as an indicator of the National Biodiversity Strategy. However, it must be noted that forest areas can be certified by both PEFC and FSC and the extent of the overlap cannot be precisely determined. In addition, forest areas certified by Naturland are included in the figures of FSC.

05

ENVIRONMENT AND ECONOMY

Environmental industry and green markets of the future

Production of potential environmental protection goods in Germany by environmental fields

ENVIRONMENTAL FIELD	PRODUCTION IN BILLION EUROS			CHANGE IN PERCENT		
	2009	2010	2011	2009/10	2010/11	2009/11
Waste	7.8	8.9	10.2	13.2	15.7	31.0
Waste water	14.0	14.6	16.2	4.5	10.6	15.5
Noise	3.6	4.3	5.3	17.3	25.7	47.4
Air	5.2	6.2	7.5	19.9	21.2	45.3
Measurement, control and regulation technology (MSR)	5.2	6.0	6.7	15.8	11.6	29.3
Climate protection	30.2	34.3	37.5	13.7	9.2	24.1
among this:						
Goods for the efficient use of energy	14.7	16.3	17.9	10.9	9.4	21.3
Goods for the efficient conversion of energy	2.3	2.7	2.7	17.6	-0.3	17.2
Goods for the use of renewable energy sources	13.1	15.2	16.8	16.2	10.6	28.5
Total environmental protection goods*	**67.7**	**76.2**	**84.8**	**12.6**	**11.2**	**25.2**
for notification: Total manufactured production	1,065	1,231	1,366	15.6	10.9	28.2

* Includes groups of goods that could not be attributed for secrecy reasons

Source: Federal Statistical Office, Calculations by the NIW based on the new list of potential environmental protection goods 2013, see also Gehrke, Schasse, Ostertag (2013), p. 23

Environmental protection strengthens Germany as business location: production of environmental protection goods

The environmental industry is cross-sectoral, covering all companies that provide environmental protection goods and services.

In 2011, potential environmental and climate protection goods worth nearly 85 billion euros were produced in Germany. This corresponds to 6.2 % of the value of the total industrial production. Between 2009 and 2011 the production value increased by 25 %. Overall, the production of potential environmental and climate protection goods, on the upswing after the crisis of 2009 with a value of 13 %, did not increase quite as strongly as industrial production as a whole (+ 16 %). This is mainly related to the fact that total industrial production in 2009 took a bigger hit than the production of potential environmental and climate protection goods [Gehrke 2014].

The statistically established "potential environmental and climate protection goods" include items such as air and wastewater filters or rotor blades for wind turbines, which are used exclusively for environmental protection purposes. Furthermore, goods that can be used both in environmental protection and for other purposes, such as pumps, pipes or measurement and control technologies are also included. Economic research institutes in collaboration with the Federal Statistical Office developed the concept of potential environmental and climate protection goods.

The production of environmental and climate protection goods is not only making a contribution to improving the environment, but also plays an important role as an economic factor. Environmental protection is also increasingly becoming a core issue in the "traditional" economic sectors such as the automotive industry or mechanical engineering. The use of environmental and efficiency technologies gains in importance and has a decisive impact on the competitiveness of enterprises.

Research shows that German enterprises have a strong position on the so-called global "green markets of the future". These are predicted to have an average annual growth of the global market volume of 6.5 % by 2025 [BMUB 2014c].

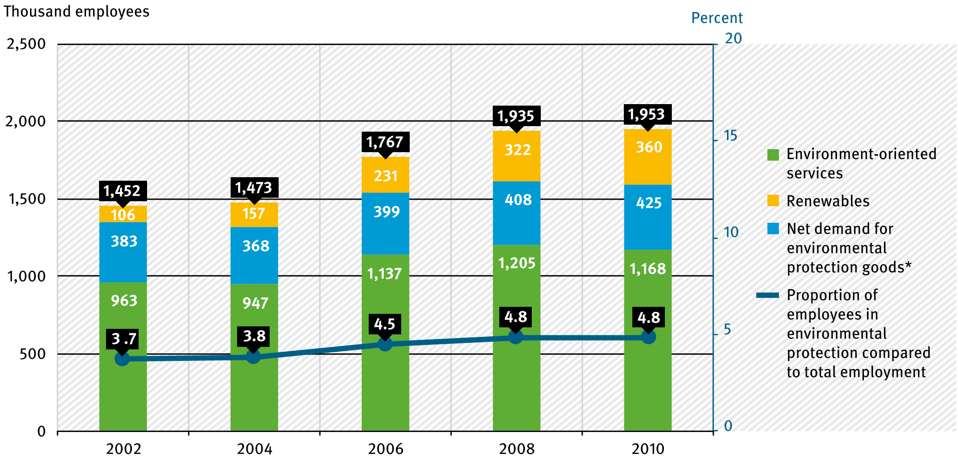
GREEN MARKETS OF THE FUTURE ARE:

- Environmentally friendly production, storage and distribution of energy,
- Energy efficiency,
- Resource and material efficiency,
- Sustainable mobility,
- Sustainable water management,
- Waste and recycling management.

In 2013, Germany's participation in the world market exceeded 10 % in all six business lines. Germany had a particularly high share, with 17 % each, in the areas of "environmentally friendly production, storage and distribution of energy", "waste and recycling management" and "sustainable mobility". Green markets of the future play a key role in maintaining the livelihood of humanity and the fulfilment of their basic needs. They are also economically very important.

Overall employment in environmental protection

Employment in environmental protection



The 2010 estimate of environment-oriented services is only conditionally comparable to the previous years' estimates due to methodological changes

* Net: adjusted for double counting. Includes employment due to energy efficiency renovation of buildings.

Source: Edler, D., Blazejczak, J. (2014): Beschäftigungswirkungen des Umweltschutzes in Deutschland im Jahr 2010. In: Federal Environment Agency, Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (eds.): Reihe Umwelt, Innovation, Beschäftigung 02/14.

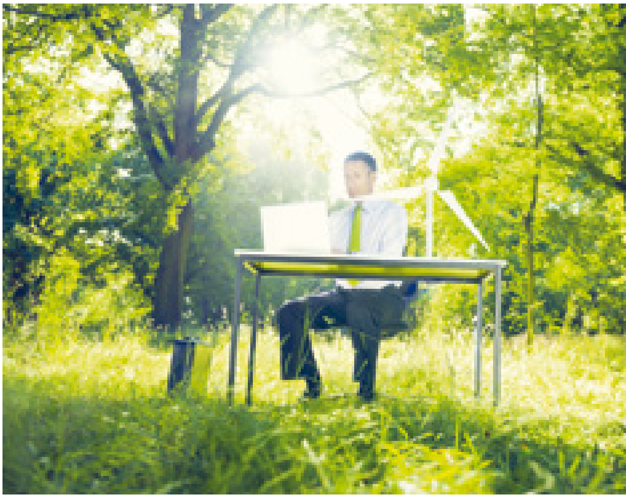
Environmental protection is important for a variety of professions. The scope of environmental professions ranges from street cleaner to the specialist in environmental medicine, from environmental engineer to chimney sweep, from energy adviser to the assistant in environmental administration.

The number of employees in environmental protection cannot be captured statistically because of the variety of occupations and activities. To show the importance of environmental protection for the labour market, the Federal Environment Agency therefore regularly commissions research projects that estimate the number of employees in environmental protection based on an internationally recognised method. The main categories for employment in environmental protection are environment oriented services, the production of goods for environmental protection, and investment into and operation of renewable energy installations. Since the field of renewables has developed

dynamically in recent years, sophisticated studies have been conducted on this theme whose results are presented in the next section.

Available 2010 data clearly show which (gross) employment effects can be encountered in environmental protection. In a net approach it is necessary to deduct any potential job losses from these employment figures – e.g. those due to displacement effects, cost, price and competition effects However, these net employment effects cannot be determined empirically. This is only possible using models or scenario analyses that determine the impact of a measure on employment.

However, it should be noted for all scenario analyses that the aim of environmental protection is not primarily to create as many jobs as possible, but to efficiently achieve environmental quality objectives - that is, at the least economic cost. That environmental protection also creates jobs in net terms in many cases, is among other things due to the fact that labour-intensive sectors benefit more than average. Therefore, a shift of funds to environmental protection results in increased employment in many cases, not only in gross terms but also in net terms. In addition, environmental protection measures replace imports in part with domestic added value such as energy-saving investments which reduce the consumption of fossil fuels such as oil or gas.



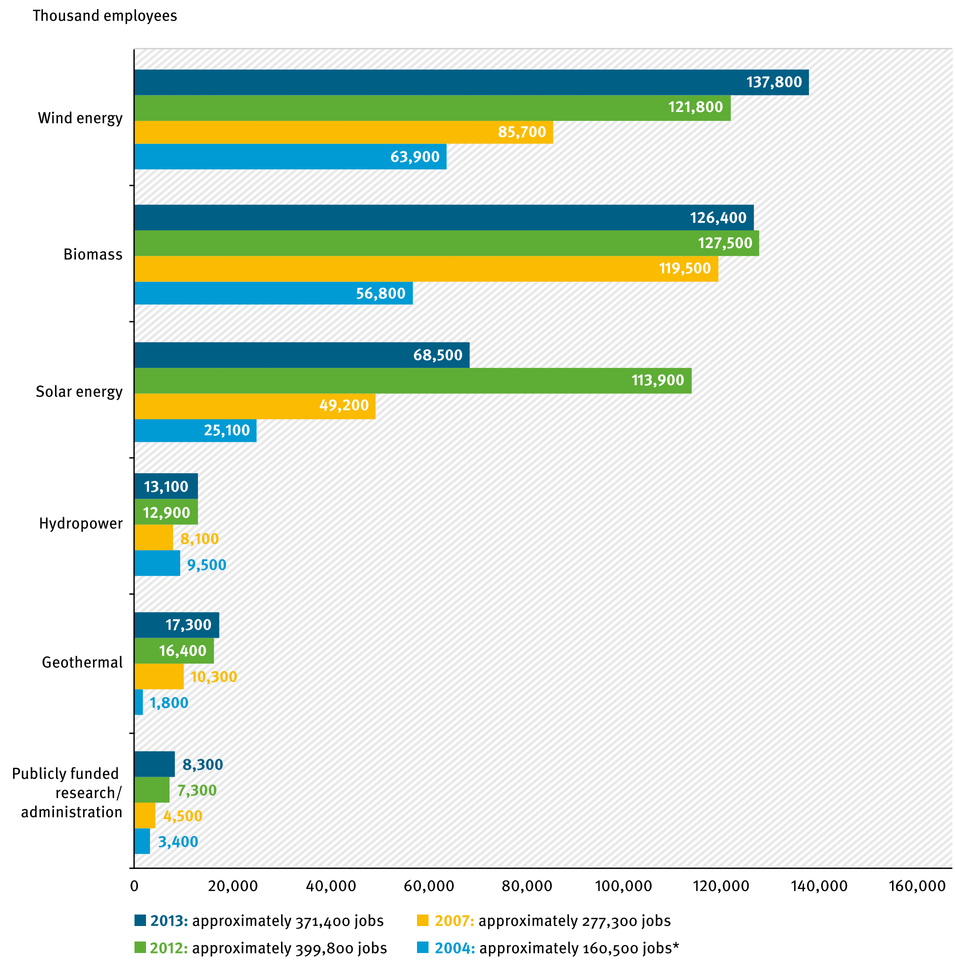
Environmental protection creates jobs

Environmental protection is an important factor for Germany's labour market: 2 million people owed their jobs to environmental protection in 2010 (these are the latest data available). This corresponds to approximately 4.8 % of the total employment in Germany, and about 60 % of these jobs are in environmentally related services, for example energy saving consultation [Edler 2014]. In recent years, employment in environmental protection has steadily increased and has now stabilised at a high level.

The reported number of employees includes the jobs that are generally necessary for producing environmental goods and services (called gross employment effects). Environmental goods are manufactured in a number of traditional industries such as steel production, mechanical and automotive engineering, electronic industries and the building sector. Therefore, employment effects of environmental protection are not limited to individual sectors of the economy, but have an effect across all sectors.

Employment through renewables

Employment effects of renewables



* Estimate

Source: O'Sullivan et al. (2014): Gross employment in renewable energy in Germany in 2013 - an initial assessment, Research project, Federal Ministry for Economic Affairs and Energy, Berlin.

In the “renewables” labour market, mainly technical professions such as engineers, technicians and craftsmen are needed. There is a huge demand for skilled workers for service and installation. The training market reacted to the increased demand for skilled workers. The number of university courses dealing with renewables, for example, more than doubled from 144 in 2007 to 300 in 2010.

The employment numbers shown here refer to what is called gross employment effects. The figures indicate the total number of people employed in the renewables sector. The extension of renewable energies however induces displacements in other power production systems thus job reductions elsewhere in industry. Modelling and scenario analyses show that the increase in electricity and heat production from renewables has had a net positive effect on the labour market. The employment in such scenarios is also higher than in scenarios with power supplies that largely refrain from the use of renewables. The models have concluded that in addition to the expansion of renewables, increasing energy efficiency has also positively influenced employment [GWS 2013].

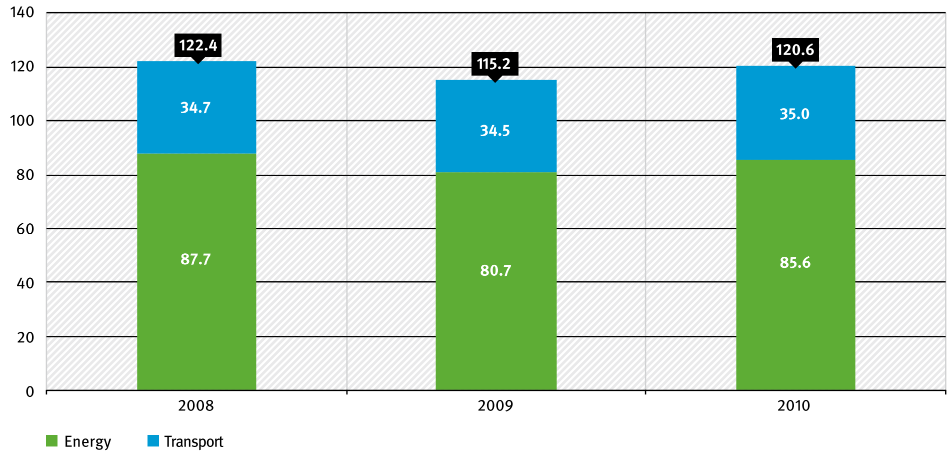
Long-term positive employment effects through the development of renewables

A total of 371,400 people worked in the renewable energy sector in 2013. They were engaged in building and operating facilities or in research and administration. Wind energy formed the largest share, followed by biomass and solar energy. The number of employees compared to 2004 more than doubled over the long term. From 2012 to 2013, however, the number of jobs declined by 7 %. This negative trend over the previous year is almost exclusively due to cuts in the solar energy sector, where employment fell by almost 45,000 people within one year. This was mainly due to the sharp decline in the installation of new solar systems in Germany. In the wind energy sector, however, the opposite trend can be observed: 16,000 additional jobs were created there within a year. Other areas of renewables (biomass, hydropower, geothermal) show only very slight changes in comparison to 2012 [O'Sullivan 2014].

Costs of the society due to environmental pollution

Environmental costs of energy and transport

Environmental costs of power and heat production and road transport (greenhouse gases and air pollutants) in billion euros*



* Based on 2010 purchasing power

Source: Federal Environment Agency's own calculations based on data of AGEB, Working Group on Renewable Energy Statistics, TREMOD - Transport Emission Model, Renewables in figures, Methodological convention for the estimation of environmental costs 2.0

Environmental costs are in the hundreds of billions

Environmental costs are economically strongly relevant. Economist Nicholas Stern showed this in his Review on the Economics of Climate Change in 2006. In his so-called "Stern Report" he figured the costs incurred only by climate change in a year to be up to 20 % of global gross domestic product. Estimates related to Germany also emphasise the economic significance of environmental costs. Thus, Germany's energy related environmental costs of electricity and heat production as well as transport are estimated to be an annual 120 billion euros.

The environmental costs of energy production from fossil fuels such as coal and lignite are significantly in excess of the environmental costs incurred by the use of renewables such as wind power and solar energy. Not only emissions but also social follow-up costs can thus be saved through energy savings and an increased use of renewables.

Not only do pollutant discharges into the environment contaminate the ecosystems and the atmosphere, they also cause damage to human health and property. Therefore economic costs such as the expenditure necessary to remediate storm damage or the charges to treat environmental diseases also often occur. Damage to human health and the environment mainly arises from the combustion of fossil fuel. Release of air pollutants such as particulate matter and nitrogen oxides causes an increase in respiratory illnesses (asthma, cough or bronchitis), damage to buildings (façade soiling) and the greenhouse gases emitted contribute to climate change.

Climate impacts and health effects caused by air pollutants from fossil fuels such as coal, oil and gas account for about 90 % of quantifiable damage. Other categories are material damage to buildings, crop failure and water contamination.

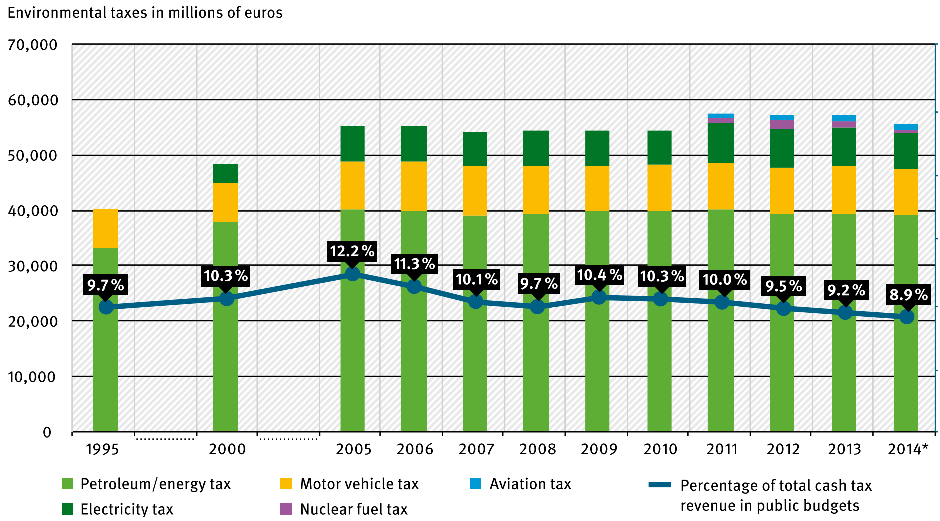
Estimates of environmental costs can be used in various ways. They show how costly the omission of environmental protection really is, and they support the economic necessity of demanding environmental objectives. With their help, costs and benefits of environmental and climate policy can be better assessed. For example, not only do they reveal the benefits of energy saving measures in terms of energy cost savings, but also in avoided environmental and health damage.

The estimate of these costs requires complex methodology. The Federal Environment Agency, together with professionals from several research institutes, has developed the Methodological Convention 2.0 to estimate environmental costs [UBA 2013c]. The convention takes into account the current state of the art in research and helps specify the cost for the use of the environment based on uniform and transparent criteria. It provides best

practice cost rates for environmental costs due to greenhouse gas emissions, air pollutants and noise or also per kilowatt-hour generated electricity and per kilometre travelled. Environmental costs that arise in power and heat production and in the transport sector can be estimated based on these cost rates.

Environmental taxes

Environmental taxes in Germany



Source: Federal Statistical Office 2015, environmental-economic accounting, environmental protection measures

Environmental taxes only account for 9 percent of tax revenues

In 2014, revenue from environmental taxes amounted to 57.3 billion euros. Energy tax (the former mineral oil tax) at 39.8 billion euros formed the largest share of this, followed by motor vehicle tax (8.5 billion euros) and electricity tax (6.6 billion euros).

Environmental taxes increased by 18.9 % from 2000 to 2014, but total taxes rose by 37.7 %. Therefore, the proportion of environmental taxes in total tax revenue only amounts to 8.9 %. This has been the lowest figure since 1995.

Compared to other European countries (EU 28 average), environmental taxes in Germany constitute a lower proportion in total taxes and social contributions. Also in terms of GDP, the share is below the EU-average.

With the introduction of the ecological tax reform in 1999, revenues from environmental taxes and charges in Germany increased sharply. Petroleum and electricity tax rates went through a multi-stage increase up to 2003. But the revenue from environmental taxes declined slightly up to 2010. This was in a large part due to the fact that the ecological tax reform was successful in its control effect on climate protection and led to a more efficient use of energy and electricity. Tax rates, however, were not increased accordingly. The newly introduced nuclear fuel tax and aviation tax provided an increase in 2011. In terms of the share of total tax revenue, environmental taxes now only make up 8.9 %. This is less than before the introduction of the ecological tax reform.

The introduction of environmental taxes has effectively helped to deal with environmental challenges that arise, for example, from energy and resource consumption: a higher price stimulates companies and households to incorporate environmental costs of products in their production and purchasing decisions. In addition, companies are motivated to develop new environmentally friendly technologies and thereby have the opportunity to improve their international competitiveness.

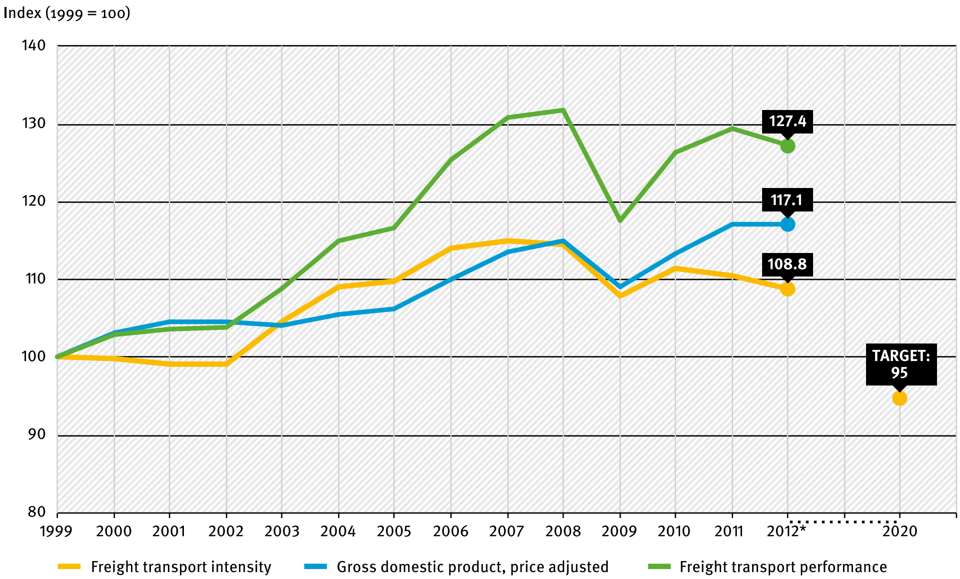
The concept of statistics about environmental taxes was developed by OECD and the Statistical Office of the European Communities (Eurostat) at the international level. Compared to other European countries (EU 28 average), environmental taxes in Germany constitute a lower share in total taxes and social contributions. The share is also below the average in terms of GDP [Eurostat 2014].

06

ENVIRONMENT AND TRANSPORT

Freight transport intensity

Freight transport intensity



* Preliminary figures

Source: Federal Statistical Office (ed.) 2015, Environmental-economic accounting, Sustainable development in Germany, Indicators on the environment and economy, p. 20

Increasing freight transport can have significantly detrimental effects on humans and the environment. This happens primarily through the consumption of fossil fuels, the resulting greenhouse gas emissions, air pollutants, noise and through the fragmentation of land and landscapes.

Overall, the domestic freight transport performance (the mileage in kilometres multiplied by the transported tonnes, measured in tonne-kilometres, tkm) increased by 27.4 % between 1999 and 2012.

In order to avoid further increases in freight transport performance and to prevent negative environmental effects, measures must be taken to avoid traffic and achieve a modal shift of freight transport towards rail and shipping. Traffic avoidance measures are examined, such as more efficient logistics within the operational environmental management or, beyond individual operations, within

Decoupling economic performance from freight transport

Freight transport should be handled as efficiently as possible. To measure this, the freight transport performance is set in proportion to the gross domestic product - GDP. The result is the freight transport intensity. In its sustainability strategy, the German Government aims to reduce the intensity of freight transport by 5 % compared to the 1999 status. This should be achieved by 2020. The aim is to decouple the economic performance from freight transport.

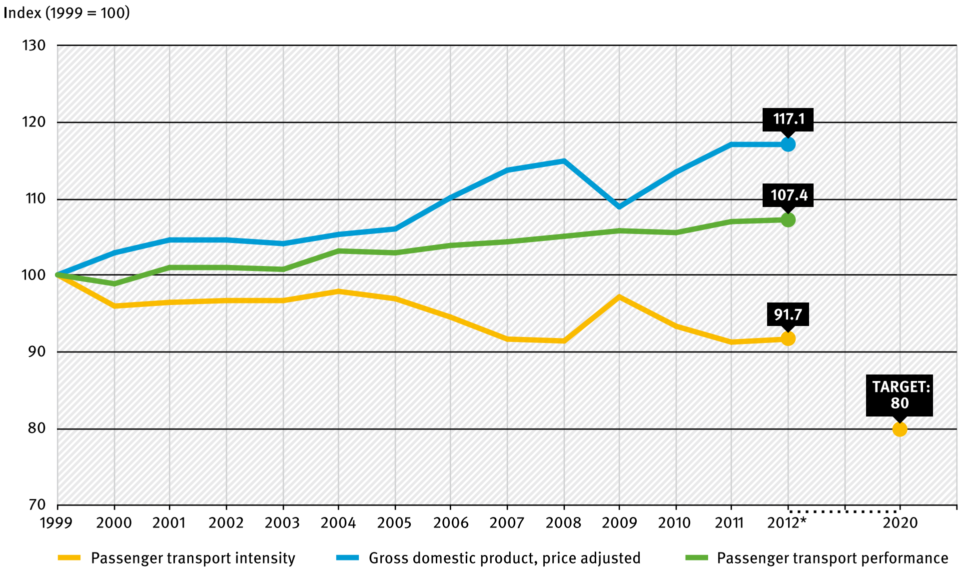
Freight transport intensity initially developed in opposition to the desired direction. It reached its peak in 2007, and then declined only to rise with the resurgent economy and to decline again since 2011. In order to achieve the goal of the German Government, increased efforts are necessary in order to save on freight transport. It is also important from an environmental perspective, to operate with more environmentally friendly modes such as rail or shipping.

freight exchanges and city logistics models and economic instruments. Better spacial planning and higher transport costs will support location decisions for traffic avoidance by companies in the long-term. Shifting transport from road to rail or waterway can be promoted through the establishment of fair cost structures (for example, an HGV toll), measures for intermodal freight transport and networked freight distribution centres as well as through the establishment of a pan-European integrated transport system.

The indicator "freight transport intensity" reflects the situation of freight transport in Germany. However, it cannot adequately capture the integration of the German economy with the world market and the associated traffic flows abroad. According to the Federal Statistical Office [StBA 2014] the freight transport performance for German imports and exports of goods abroad constituted around 3,031 billion tonne-kilometres in 2010. In the same year, the domestic transport performance amounted to 628 billion tonne-kilometres.

Passenger transport intensity

Passenger transport intensity



* Partially preliminary figures

Source: Federal Statistical Office (ed.) 2015, Environmental-economic accounting, Sustainable development in Germany, Indicators on the environment and economy, p. 20

Efficient and environmentally sound mobility

Sufficient and affordable mobility for citizens is not least an expression of personal freedom. Therefore, the central task of a sustainable, environmentally oriented transport policy is to maintain mobility and make it as environmentally friendly as possible. The decoupling of passenger transport from economic performance provides an indication of efficient and thus comparatively environmentally friendly execution of passenger transport. It is measured using passenger transport intensity (the mileage in kilometres multiplied by number of the passengers transported, in relation to gross domestic product). A decreasing intensity indicates movement in the desired direction.

The German Government's sustainability strategy [Federal Government 2002] aims to reduce the passenger transport intensity to 80 % of the 1999 value by 2020. Between 1999 and 2008, the passenger transport intensity was moving in the right direction. After an increase in 2009 - which can be attributed to the decline in the GDP - it dropped back to the level of 2008. However, considerable efforts are still required in order to achieve the target on time.

The prevention of unnecessary routes and transports, transferring traffic to more environmentally friendly modes of transport and the improvement of applied technologies are central to sustainable mobility. Passenger transport needs to focus on the strengthening of local and long distance public transport and on non-motorised cycling and walking.

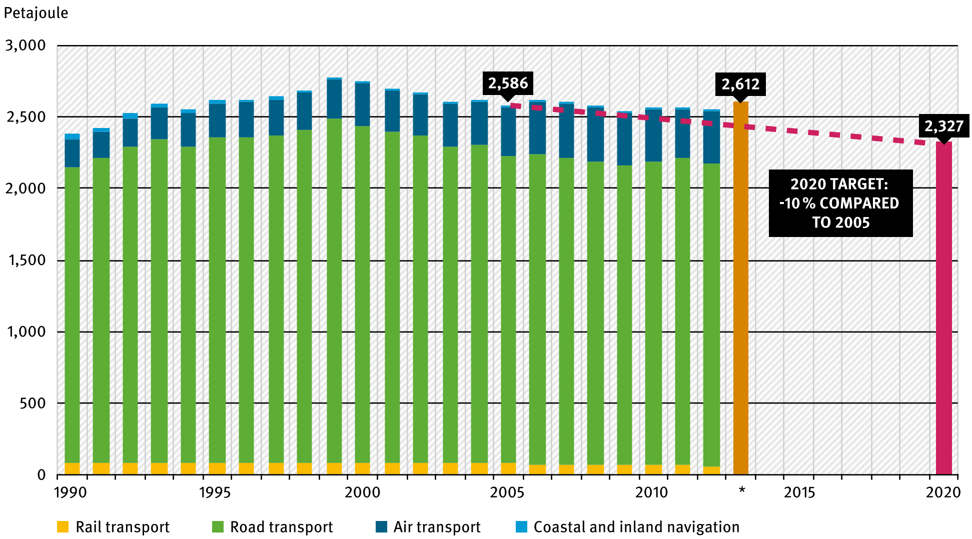
Transport performance in passenger transport increased between 1999 and 2012 by roughly 7 %. Motorised private transport increased by about 5 % thus maintaining its dominant position: Its share in the total passenger transport performance barely decreased from 1999 (82.0 %) to 2012 (80.5 %). The share of public road transport and railways remained nearly constant between 1999 and 2012 (1999: 14.2 %, 2012: 14.5 %). Passenger transport performance of these comparatively less environmentally damaging modes of transport increased in this period by 10 %, and this increase can be traced back mainly to the development of rail transport (+ 20 %). The second highest growth rates (16 %) are recorded in domestic air transport. Its share of the total passenger transport performance is around 1 %.

Figures are not very different even if non-motorised passenger transport (pedestrian, bicycle) is included in the transport performance: motorised passenger transport dominated 2011 with a proportion of around 76 % and was clearly ahead of ecomobility (pedestrian, cyclist, rail and public transport) by a total of around 20 %.

Traffic-avoiding urban development and transport planning can support the strengthening of ecomobility in passenger transport. A “city of short distances” has compact building structures and apartments close to supply, service and recreational amenities. This facilitates short daily travel distances, which can be covered on foot or by bike.

Energy consumption of transport

Final energy consumption of transport



* Preliminary figures, 2013 only for overall transport

Source: AGEB, Energy balance, various volumes

Transport requires energy. Approximately 98 % of the total final energy consumption is accounted for by fuels and 2 % by electricity. The consumption of fuel in 2012 was divided into 29.5 % from petrol, 49.7 % from diesel, 14.8 % from aviation fuel and 1.4 % from liquefied gas and natural gas. 98 % of the energy source in rail transport is electric power.

Between 2005 and 2012 rail transport saved slightly more than a quarter of energy (-26 %), while inland navigation energy savings amounted to 10 %. However, rail and shipping made up only a small part of the total final energy consumption of transport in 2012 with a share of 2.3 % (rail) and 0.5 % (shipping). Air transport showed growing energy consumption by roughly 8 % in the same period with a share of 14.5 % in the total consumption in 2012.

Road transport has a share of 83 % (2012) and consumes by far the most energy in the transport sector. Consumption decreased by almost 2 % between 2005 and 2012.

Apart from the actual consumption data, the environmentally friendly satisfaction of the transport energy demand is also

relevant to the environment. The use of renewable energy source materials is an important option in this case.

Since 1995, biofuels have increasingly been used in road transport. Currently, these are mainly biodiesel, vegetable oil and bioethanol. Their share of the total fuel consumption in 2013 was 5.3 %. The share of renewable energies in the entire transport sector of the EU Member States is expected to increase to 10 % by 2020. This statement primarily targets biofuels, but includes the possibility of the production and marketing of synthetic fuels amongst others, with renewable energies such as wind power. Unlike the use of fossil fuels, biofuels may reduce the development of greenhouse gas emissions. In Germany, companies that market petrol and diesel fuels are obliged to reduce the annual greenhouse gas emissions of fuels through the use of biofuels by 2020. In addition, this saves fossil fuels, thereby contributing to the reduction of German energy imports.

Electric vehicles provide another way to efficiently use renewable energy in road transport since the vehicle battery can be charged with electricity from solar energy, wind or waterpower. The proportion of renewable energies in the German electricity mix was approximately 25.4 % in 2013. While the range of purely electric vehicles is still limited, so-called plug-in hybrid vehicles (PHEVs) already offer the same everyday capability as conventional vehicles. Besides an electric drive – its battery usually has a range between 20 and 80 kilometres. PHEVs also have an internal combustion engine so daily trips to work or shopping can be efficiently covered with the electric drive. The internal combustion engine starts in the case of longer trips – during a vacation for example.

Reducing energy consumption, strengthening renewable energies

The total final energy consumption of transport amounted in 2012 to 2,559 petajoules (PJ). This was about 1 % less than in 2005, with 2,586 PJ. According to preliminary figures, energy consumption increased again in 2013 to 2,612 PJ.

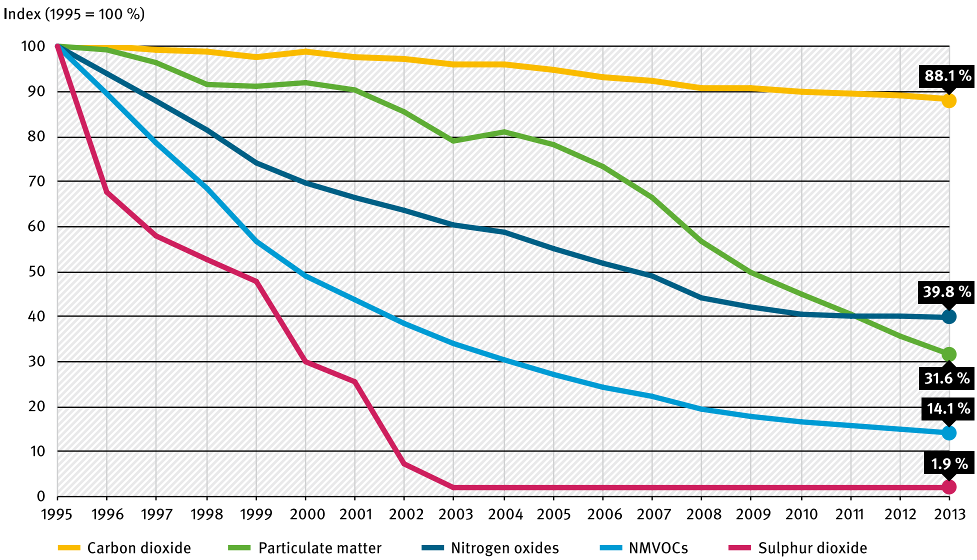
Compared to the peak of 2,781 PJ in 1999, transport-related energy consumption dropped by 8 % by 2012. Simultaneously, the passenger transport performance increased by roughly 7 % and freight transport performance by about 27 %. This demonstrates increasing energy efficiency in transport. However, from an environmental perspective this is not enough. The energy consumption of the transport sector must also decrease in absolute figures.

Through the energy concept of 2010 [Federal Government 2010], the German Government set the goal of reducing the total final energy consumption in transport by 10 % by 2020 and by 40 % by 2050 compared to 2005. A reduction of 1.1 % was achieved in the seven years leading up to 2012. In order to meet the target in 2020, the total transport final energy consumption must decline annually by 29 PJ or 1.1 % from 2012 onwards.

In addition, the energy requirement of transport should be covered mainly by renewable sources. This conserves natural resources and can reduce greenhouse gas and air pollutant emissions from transport.

Car specific emissions

Car specific emissions (direct car emissions/car transport performance)



Source: Federal Environment Agency, TREMOD data and calculation model - Transport Emission Model, 5.53 version (11/2014)

Making car traffic more climate and environmentally friendly

If the total distance travelled by cars in a year is multiplied by the number of passengers, the result is the transport performance measured in passenger kilometres (Pkm). The specific emissions of car traffic provide a measure for the ratio of air pollutant emissions from the car fleet to the passenger kilometres driven. The lower the result, the better for the environment.

Since 1995, technical improvements to vehicles and improved fuel quality have led to impressive declines in specific emissions of "classic" air pollutants. However, specific emissions of the greenhouse gas carbon dioxide still need to catch up. In this respect, the transport sector must make a substantial contribution for the Federal Government to achieve its climate target by 2020.

On average, a car causes less damage to the environment and climate today than back in 1995. This is mainly due to three reasons. Firstly, the legislator has gradually tightened emission standards for newly registered cars, prompting carmakers to technically improve their engines. Secondly, the legislator demanded that existing cars be partially retrofitted with catalytic converters or particle filters to reduce emissions. And thirdly, it compelled refineries to improve fuel quality. The result is that specific emissions of pollutants and carbon dioxide per passenger kilometres dropped compared to 1995.

As such, by 2013 specific emissions of sulphur dioxide decreased by around 98 % compared to the initial level and emissions of volatile organic compounds without methane by about 86 %. Exhaust levels of nitrogen oxides decreased in the same period by 60 %, particulate matter emissions by 68 %. However, carbon dioxide emissions decreased by only 12 %. The reduction of nitrogen oxide emissions is mainly due to significant improvements in petrol cars with the introduction of the regulated catalytic converter. However, nitrogen oxide emissions from diesel cars were not sufficiently reduced despite the technical developments.

Extra traffic also impedes improvements in climate and environmental protection. Car traffic between 1995 and 2013 has increased by 11 %. In detail:

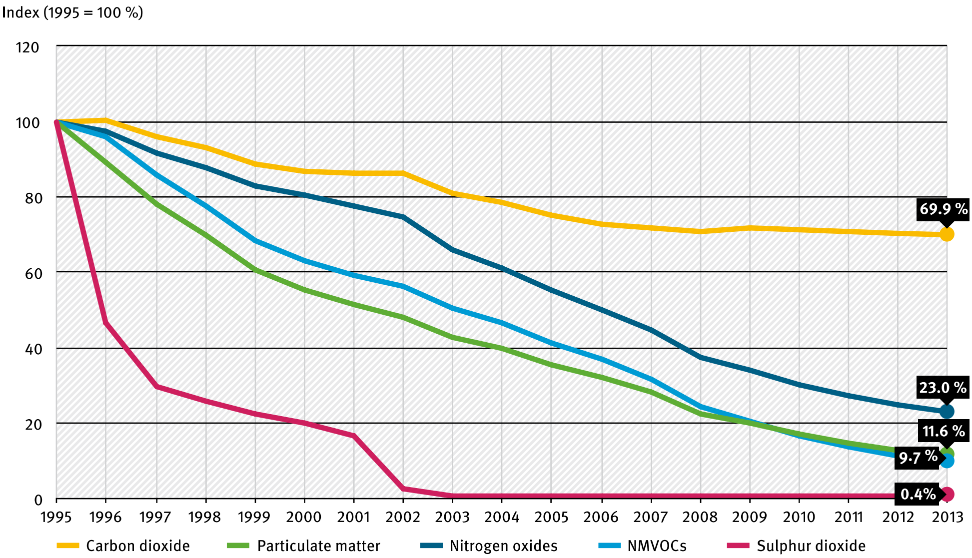
- Between 1995 and 2003 total carbon dioxide emissions from car traffic declined by only 2 %, while specific emissions decreased by 12 %.
- Total nitrogen oxide emissions from cars fell from 1995 to 2013 by 56 %, however, specific nitrogen oxide emissions fell by 60 %.
- Particle emissions from cars showed a reduction by 65 % in the total emissions while declining by 68 % regarding specific emissions.

The reason behind this is that the mileage of cars with diesel engines has increased by approximately 160 % since 1995. Due to this development, further significant reductions in emissions are necessary in the coming years – of particulates yes, but especially regarding nitrogen oxides.

Ultimately, environmental and climate relief in passenger transport cannot be achieved solely by improvements of the vehicle. This challenge can only be solved by a combination of measures such as an increase in transport efficiency or an improved modal choice.

HGV specific emissions

HGV specific emissions (direct HGV emissions/HGV transport performance)



Source: Federal Environment Agency, TREMOD data and calculation model - Transport Emission Model, 5.53 version (11/2014)

In HGV transport, specific emissions per transport performance have fallen since 1995 due to better engines and better fuel quality. Transport performance is measured in tonne-kilometres (tkm) and for this purpose, the number of kilometres is multiplied by the amount of carried goods.

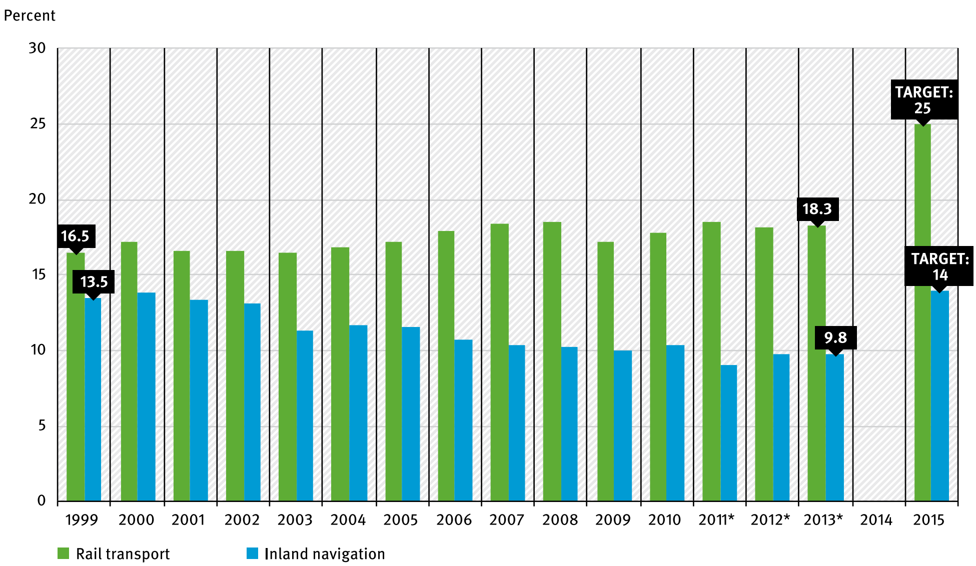
Sulphur dioxide emissions decreased by more than 99 % compared to the initial level, while carbon dioxide emissions fell by only 30 %. In terms of total emissions from road freight transport, technology dependent reductions per tkm were partly offset due to the increased transport performance. Reductions of carbon emissions were yet overcompensated. Absolute carbon dioxide emissions in road freight transport increased between 1995 and 2013, despite technical improvements, from 34.2 to 38.7 million tonnes, i.e. by 13 %.

Reducing carbon dioxide emissions from HGV traffic

Specific emissions from HGV traffic in Germany have significantly decreased between 1995 and 2013. Sulphur dioxide emissions were reduced to nearly zero. The smallest emission reduction was with the greenhouse gas carbon dioxide. The increasing HGV traffic on German roads seemed to counteract emission reductions even in the light of technical improvements to the vehicles, meaning that improvements in this area are still required.

Environmentally friendly freight transport

Shares of rail transport and inland navigation in freight transport performance



Excluding German HGV local transport (up to 50 km).
* Partially preliminary figures

Source: Federal Statistical Office (edsa.), Sustainable Development in Germany, 2014 and Federal Ministry of Transport and Digital Infrastructure, Verkehr in Zahlen 2014/2015

One of the key pillars of sustainable mobility is shifting transport towards more environmentally friendly modes. In the field of freight transport, these are the railways and inland waterways. It must be remembered however that maintenance and extension of railway lines and the development of rivers into waterways have a significant environmental impact. Environmental compatibility of railways and barge transport therefore can only be reasonably assessed in relation to other modes of transport.

For example, various transport modes emit different amounts of greenhouse gases, nitrogen oxides and particulate matter. Railway and ship transport offer themselves as relatively low-emission alternatives.

Environmentally friendly freight transport

At least 25 % of freight should be transported by rail and another 14 % by inland waterways by 2015 according to the German Government. These objectives are based on the sustainability strategy.

Freight transport by rail has developed broadly in the right direction between 1999 and 2013 (+ 1.8 %), with a slump in the crisis year 2009. The recovery that started after 2009, however, is not sufficient to reach the objective in time.

The trend in the use of inland waterways is opposite to the Federal Government's objective: its market share in freight transport decreased by 3.7 % between 1999 and 2013.

Emissions by transport modes in grams per tonne-kilometre (g/tkm)

	GREENHOUSE GASES AS CARBON DIOXIDE EQUIVALENTS	NITROGEN OXIDES (NO_X)	PARTICULATE MATTER
HGVs*	101.76	0.42	0.007
Railway	24.20	0.07	0.002
Inland navigation	30.90	0.44	0.011
Aviation	1,612.18**	3.86	0.028

Greenhouse gases include: carbon dioxide, methane and nitrous oxide (CO_2, CH_4 and N_2O)
* HGVs from 3.5 t (including articulated lorry and truck-trailer combination)
** Taking into account all climate-relevant effects of aviation

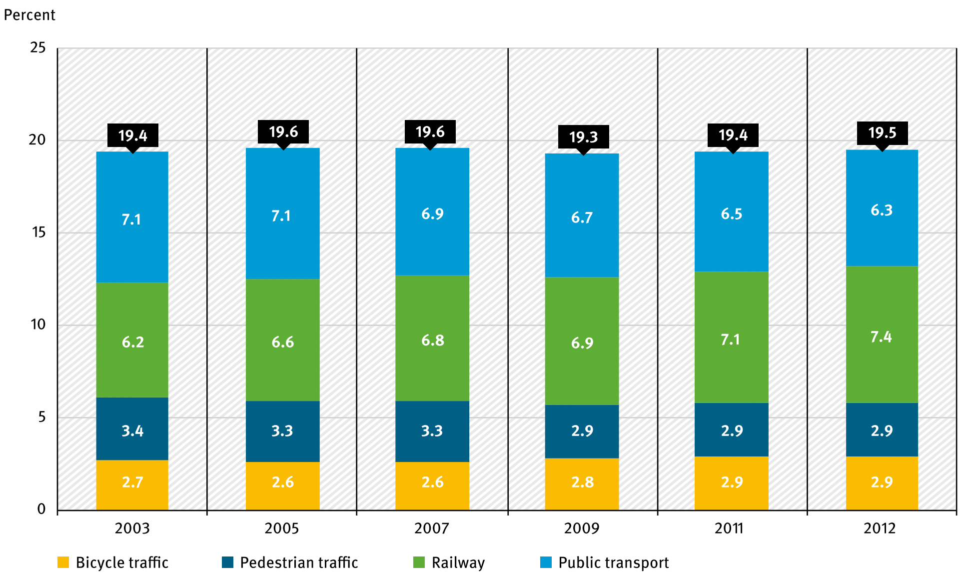
Source: Federal Environment Agency, TREMOD - Transport Emission Model Version 5.53 (11/2014)

The transport performance of freight transport by rail increased between 1999 and 2013 from 76.8 to 112.6 billion tonne-kilometres (+31.8 %). At the same time transport performance on inland waterways fell from 62.7 to 60.1 billion tonne-kilometres (-4.2 %).

The Federal Government supports German industry in the creation of "green", environmentally friendly and resource-efficient logistics. The shift of freight from road to rail or waterways is to be supported by the establishment of fair cost structures (for example, HGV toll), combined freight transport and networked goods distribution centres. Furthermore, the cooperation of railway companies in Europe must be better coordinated and become more attractive.

Environmentally friendly passenger transport

Share of environmentally friendly means of transport in overall passenger transport performance



Source: Federal Ministry of Transport and Digital Infrastructure (eds.), Transport in figures 2014/2015, p. 224/225

German citizens are mobile: passenger transport performance, which is the mileage multiplied by the number of passengers transported, grew by around 5 % from 1,142.0 to 1,205.7 billion passenger kilometres (Pkm) between 2003 and 2012.

Motorised individual transport is unquestionably the dominant mode of transport. While cars and motorcycles performed 875.6 billion Pkm in 2003, the figure was 914.6 billion Pkm in 2012. The proportion of individual motorised transport in total passenger transport rose from 74.0 to 75.9 %.

Air transport is the most dynamically growing mode of passenger transport: while it provided a passenger transport performance of 43.7 billion Pkm in 2003, this increased to 56.3 billion Pkm by 2012, which corresponds to a 4.7 % share in passenger transport performance.

Ecomobility (pedestrian, bicycle, rail and

Supporting ecomobility in passenger transport

While passenger transport performance has increased, the share of ecomobility (pedestrian, bicycle, rail and public transport) has remained constant at a value of 19 % since 2003. The share of transport performance provided by rail has increased significantly, the share of bicycle traffic slightly, but the transport performance of public transport and the overall pedestrian distance has shrunk.

The German Government has established the National Cycling Plan 2020 to strengthen cycling as an environmentally friendly alternative of mobility.

public transport) was 234.9 billion Pkm in 2012 or 19.5 % of passenger transport performance compared to 222.7 billion Pkm, or 19.4 %, in 2003.

Rail transport is the fastest growing segment within ecomobility. Trains provided 71.3 billion Pkm in 2003, but this grew to 89 billion Pkm in 2012, a 20.0 % growth. Bicycle traffic showed a 13.9 % increase (2003: 30.4 billion Pkm, 2012: 35.3 billion Pkm).

By contrast, 34.6 billion Pkm were covered by foot in 2012 which was 10.9 % less than 38.8 billion pkm in 2003. Public transport also shrank: transport performance was 82.2 billion Pkm in 2003 and it decreased to 76 billion Pkm by 2012, which was 7.5 % lower.

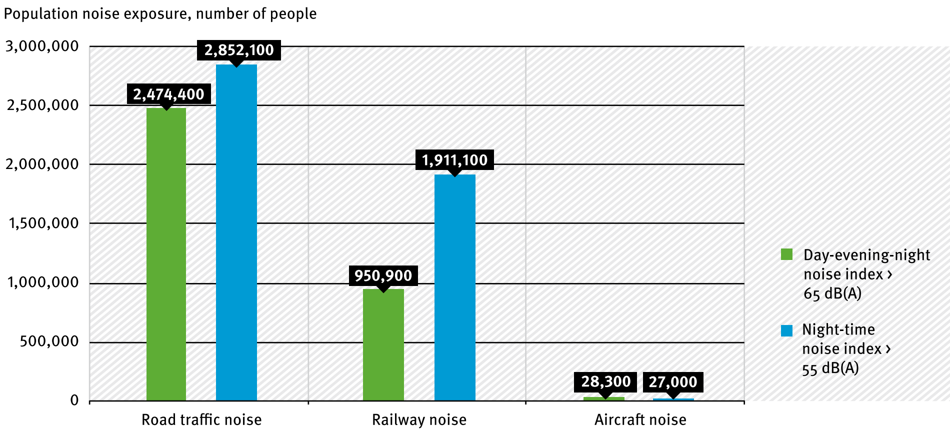
Non-motorised traffic is quiet and does not afflict the environment with pollutants and greenhouse gases due to its “zero emissions”. Pedestrians and cyclists are most definitely environmentally and urban friendly forms of transport that are also supportive to health. A shift in motorised individual transport to this environmentally friendly transport mode is therefore most apt. In particular, promotion of cycling is a key part of an integrated settlement and transport policy.

07

ENVIRONMENT, HEALTH, LIFE QUALITY

Noise pollution

Population exposure to traffic noise according to Environmental Noise Directive
around major roads, major railways, major airports and in agglomerations



As of 30.06.2015

Source: Federal Environment Agency 2015, Compilation of the information from the states (Länder) and the Federal Railway Authority in accordance with § 47c BImSchG

High noise pollution in Germany

Large parts of the population in densely populated and congested Germany are affected by noise. Recent noise mapping results show that more than 4.7 million people were exposed to night-time noise levels above 55 decibels dB(A) in agglomerations, along main roads and around major airports at the middle of 2015. In addition, more than 3.4 million people were also affected by noise levels above 65 dB(A) in these areas throughout the day.

These noise levels pose a greatly increased health risk for the affected population. A short-term environmental quality objective is therefore to avoid high noise levels. For this, the existing tools for noise protection must be used more efficiently and in a more targeted way.

Traffic noise affects the lives of many people in Germany. The problems caused by road, rail or air traffic noise can negatively affect the health and well-being in many ways. Noise affects the quality of life, and also a person's sleep. This manifests itself in an altered sleep pattern, increased awakenings and greater production of stress hormones and increased risk factors for cardiovascular disease. The World Health Organization (WHO) recommends that the night-time noise exposure should not exceed an average noise level of 40 dB(A) for health reasons. If the noise at night exceeds 55 dB(A) or the average sound level during the day is higher than 65 dB(A), the risk of cardiovascular disease increases significantly.

Therefore, the Federal Government is committed to reducing noise pollution and improving noise protection. Basically, noise abatement should primarily focus on the source. Noise limits have been established and stipulated for road, rail and aircraft. Of great importance is also the low-noise flow of traffic. Where emission limits are not sufficient to tackle the noise problem, other measures for the prevention or reduction of noise levels should be taken [BMUB 2014d].

Noise mapping and noise action planning are important tools for noise protection in Germany. Noise mapping has been established in the Federal Pollution Control Act since June 2005 and is the basis of informing the population and developing action plans. In the EU this is done in accordance with uniform standards based on the Environmental Noise Directive. The aim is to reduce ambient noise and prevent an increase in noise in previously quiet areas. For this, noise pollution must be determined on noise maps and then reduced by specific measures. Noise maps had to be drawn up by 30 June 2012, and noise action plans established by 18 July 2013 for:

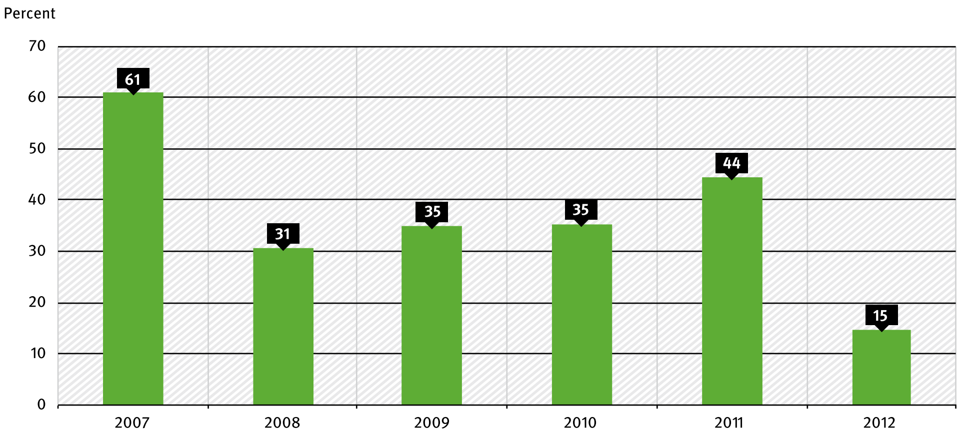
- agglomerations with more than 100,000 inhabitants,
- major roads with more than 3 million vehicle passages per year,
- major railway lines with over 30,000 trains per year,
- large airports with more than 50,000 movements per year.

Noise mapping has been carried out for 71 agglomerations totalling approximately 24.5 million inhabitants, for 44,000 kilometres of major roads, 13,700 kilometres of major railway lines and eleven major airports in Germany. Noise pollution was determined over the entire day and separately for the night in each case. EU-wide indicators, i.e. the day-evening-night noise indicator (LDEN) and the night-time noise indicator (LNight) have been used to compare the results.

Based on noise mapping and noise action planning, many cities and municipalities have taken measures to reduce noise pollution. These include, for example, noise-reducing road surfaces or speed reductions on frequently used roads.

Health risks due to particulate matter

Share of the German population affected by particulate matter concentrations exceeding the WHO guideline value *



* WHO guideline value: 20 µg/m³ PM10 (annual average).
The EU annual average limit of 40 µg/m³ PM10 has not been reached.

Source: Federal Environment Agency, 2014

Particulate matter denotes a complex mixture of solid and liquid particles with an aerodynamic diameter of less than 10 µm (PM10). Particulate matter is primarily generated by anthropogenic activities: for example by emissions from motor vehicles, in power plants and district heating plants, from heating buildings, in metal and steel production, agriculture and handling of bulk materials. In Germany, road transport in metropolitan areas is the dominant source of pollution.

Size, shape, surface structure and number of dust particles and their chemical composition largely determine the properties of particulate matter. Size, shape and pollutants adhering to the particle surface are likely to be responsible for the adverse health effects of dust particles. Penetration depth of the particles in the respiratory tract varies depending on their size, so particulate matter can cause a range of adverse health effects [WHO 2013; Henschel, Chan 2013]. These range from irritation of the mucous membranes, respiratory infections, narrowing of blood vessels and increased thrombotic tendency up to changes in the regulatory function of the autonomic nervous system (heart rate variability). Very fine particles with a diameter of less than 2.5 µm poses a particular health risk because they can penetrate deep into the bronchi where they can exert harmful effects on health. Ultra-fine dust particles can even penetrate

unfiltered into the bloodstream and affect vital organ systems.

In order to protect the public from air pollutants such as particulate matter, a uniform approach to improving air quality and providing public information on air quality and reducing air pollution has been agreed in the EU. The foundation is the European Parliament Council's Air Quality Directive 2008/50/EC of 21 May 2008 on ambient air quality and cleaner air for Europe. In Germany, the Directive was implemented by the 39th Ordinance of the Federal Pollution Control Act [BMUB 2014d]. The objective is to protect the public from harmful environmental effects. For PM10 these regulations stipulate a daily average limit of 50 µg/m³ PM10, not to be exceeded more than 35 times a year, and an annual average limit of 40 µg/m³ PM10. Regardless of that, WHO have also recommended maximum particulate matter concentrations in their air quality guidelines. A daily average of 50 µg/m³ PM10 without any allowable exceedance days and an annual average of 20 µg/m³ PM10 as guideline values have been recommended for safeguarding health [WHO 2006]. This indicates that the WHO guideline values are more stringent than the EU limits.

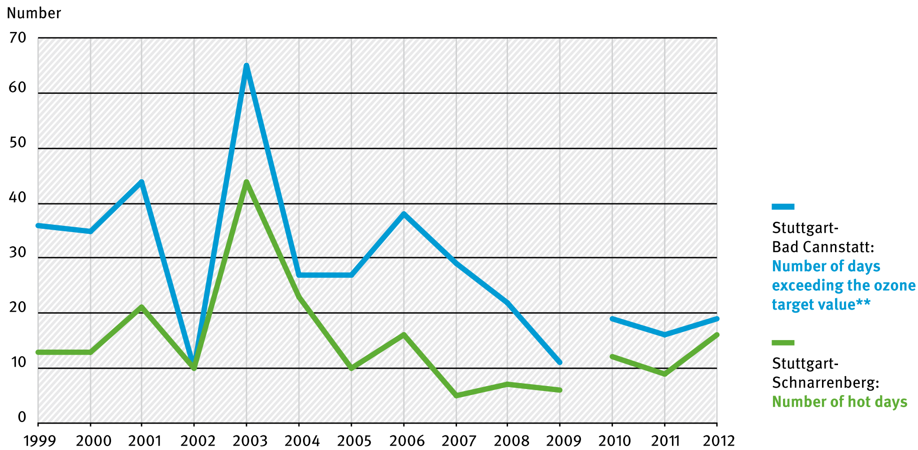
If the EU air quality limits are exceeded, the EU Member States are obliged to draw up air quality plans. In Germany, the state (Land) and local authorities cooperate with each other preparing these plans. The air quality plan measures, usually developed across large areas, are aimed at a comprehensive solution to the particulate matter problem and a lasting and comprehensive compliance with the particulate matter limits. In order to reduce air pollution by particulate matter at small scales, low emission zones with restrictions for road traffic have been set up in many cities. In Germany, urban agglomerations and agriculture need further measures in the future to permanently and comprehensively comply with the WHO guideline values for health protection. This must be the common goal of all environmental measures at the various levels involved (EU, federal, state (Land) and local).

Smaller shares of the population affected by high particulate matter concentrations in recent years

The proportion of Germany's population exposed to an annual average particulate matter pollution (PM10) above the 20 µg/m³ WHO Air Quality Guideline value for safeguarding health significantly decreased in the period from 2007 to 2012. In 2012, the proportion of the population exposed to the same particulate matter pollution level was around 15 %, i.e. far below the 2007 level of 61 %. However, no clear trend can be inferred for the period under review since the average particulate matter pollution depends strongly on the annual weather conditions, and the available time series is still too short to establish trends. The proportion of the population exposed to particulate matter pollution above the WHO guideline value also changes depending on the annual variation of weather conditions.

Health impacts of climate change

Amount of hot days (T_{max} >30°C) and exceedings of the target value for ozone* in Stuttgart



* 1999-2009: 120 µg/m³ (8-h average) on max. 25 days in the year; from 2010: 3 year average (calculated for 2010 from 2008-2010)
** Number of days exceeding the ozone target value (120 µg/m³) established for the protection of human health

Source: Deutscher Wetterdienst; Landesanstalt für Umwelt, Messungen und Naturschutz Baden-Württemberg

Climate change affects the environmental conditions in Germany in many ways. According to the German Weather Service hot days will continue to increase in the future. This also increases health risks associated with heat waves.

High temperatures during heat waves can pose risks to health. In extreme heat, the body tries to keep its temperature constant through sweating. At very high temperatures, however, the body's cooling system can become overburdened. Dehydration, inadequate clothing and heat build-up can also enhance the heat impact. Thermoregulation disorders and circulatory problems may occur as a result of heat-induced stress. Typical symptoms include headache, fatigue and dizziness. The elderly and people with cardiovascular diseases are particularly affected by these symptoms.

A further health hazard originates from ground-level ozone. Hot weather and intense sunlight favours the formation

of ground-level ozone which is formed by complex photochemical processes from different precursor pollutants such as nitrogen oxides and volatile organic compounds. High ozone concentrations may constitute a burden for health and cause various unpleasant symptoms. Ozone irritates the mucous membranes of the eyes and respiratory tract, restricts lung function and impairs the physical performance of the body. These effects may increase in the case of physical exertion and increased respiratory volume.

The sensitivity of the population to ozone varies a lot. Therefore, a risk group cannot be accurately narrowed down. It is estimated that about 10 to 15 % of the population are particularly sensitive to ozone.

High ozone concentrations should be avoided near the ground in order to protect public health. Target values and long-term objectives for ozone must be achieved and complied with as established by Directive of 2002 relating to ozone in ambient air which set an ozone target value for the protection of human health. This was reinforced in 2008 by the Directive on ambient air quality and cleaner air for Europe. Since January 2010, a cubic meter of air must not contain more than 120 micrograms ozone within eight hours. This value may only be exceeded 25 times in a year.

In order to further reduce the negative health impacts of ozone, emissions of pollutants that facilitate the formation of ozone must drop. These primarily include nitrogen oxides and volatile hydrocarbons. A reduction in emissions of these air pollutants must be targeted by the transport sector, through the use of biomass for energy, energy saving systems and reducing the use of solvents in industry, commerce and households.

Health risks from hot days and ozone

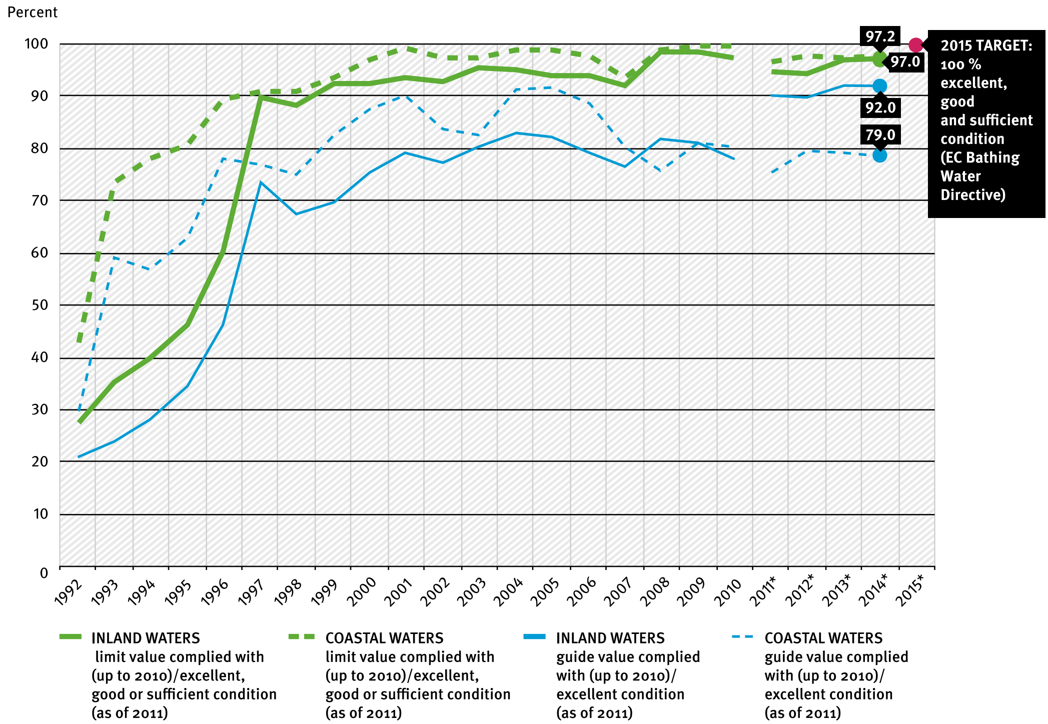
Many climate models suggest that in the next few decades, climate change may lead to more hot days during the summer months.

High temperatures stress the cardiovascular system and may adversely affect health. Each day on which the daily maximum temperature exceeds 30° C is classified as a "hot day" ("Hitzetag"), as determined by the German Weather Service. For example, the monitoring station in Stuttgart-Schnarrenberg recorded 16 hot days in 2012.

High air temperature and intense solar radiation also favour the formation of ozone close to the ground. During prolonged summer weather this leads to increased health risks due to high ozone concentrations. Ozone measurements from all over Germany show that the ozone target value of 120 µg/m³ established for the protection of human health is exceeded regularly on hot summer days. For example, in 2012 at a station in Stuttgart-Bad-Cannstatt, the ozone target value was exceeded 19 times.

Bathing waters

Share of German bathing waters, which comply with the requirements of the Bathing Water Directive or achieve "excellent" bathing water quality



* Change in the assessment: as of 2011 when new quality classifications of bathing waters came into effect, in accordance with the new EC Bathing Water Directive (2006/7EC)

Source: European Commission, Quality of Bathing Waters. Bathing season 2014, Brussels 2015

Bathing can be associated with health risks. Bathing waters on the coast or in lakes and rivers are there not only for swimming, like all waters, they are exposed to many different influences and uses and therefore to pollution risks as well. Due to the presence of certain pathogens, bathing in open waters may lead to disorders that are accompanied with fever, diarrhoea and vomiting. Such risks mainly arise after heavy rainfall washes out combined sewer overflows from sewage treatment plants or from runoff from agricultural land. Another

health risk is posed by cyanobacteria (blue-green algae) in the aquatic environment. These bacteria produce toxins that cause nausea, conjunctivitis and rashes and can damage the liver.

The EU has established the EC Directive on the quality of bathing water (2006/7/EC) which establishes values for excellent, good and sufficient hygienic quality of natural bathing waters. Thus, the old EU Bathing Water Directive (76/160 / EEC) of 1975 has been replaced by a new regulation, adapted to the latest scientific findings. In the meantime, states (Länder) implemented the new EC Bathing Water Directive into national law and adopted appropriate regulations.

In 2014, 2,290 bathing waters were monitored in Germany according to the new regulation. 367 of which were on the North and Baltic Sea coasts, 31 at rivers and 1,896 at lakes. The hygienic data of these bathing waters were reported to the EU, which appointed each bathing water a quality grading according to the data from the previous three years.

State (Land) authorities are responsible for the designation and monitoring of bathing water and to regularly create a water condition profile for any bathing water. The profile shows all sources of pollution that might affect the quality of the water and exposes problems with cyanobacteria as well. In addition, the state's (Land) authorities must provide public information on the website of each state (Land) regarding bathing water quality.

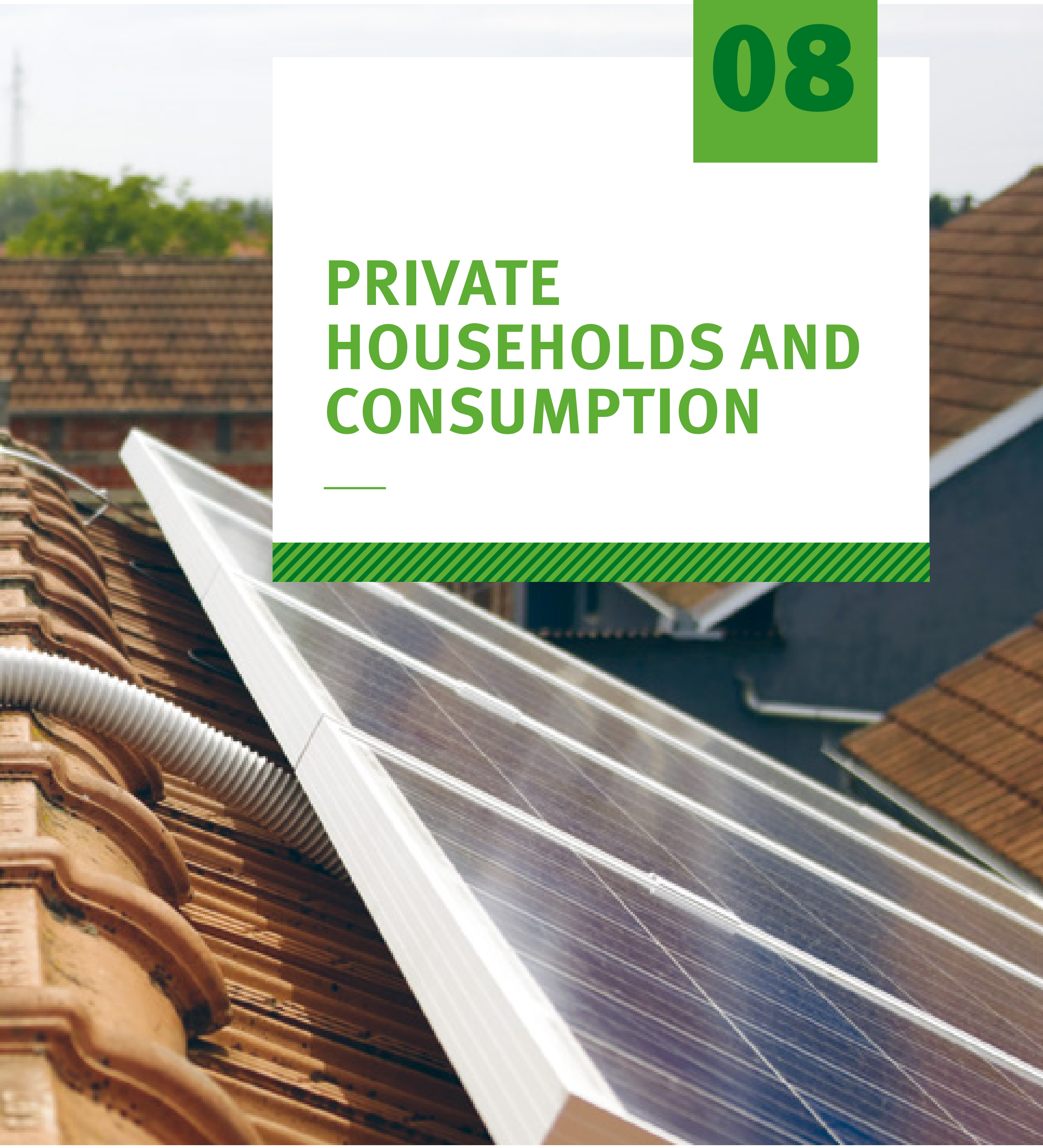
In recent years, the quality of bathing water in Germany has been steadily improving through better sewage treatment plants and reduced material emissions from agriculture and industry. In the future, additional improvements in bathing water quality should be achieved, particularly through the implementation of measures envisaged by the Water Framework Directive.

Good condition of bathing waters

The results of the latest water quality assessment show that the bathing waters in Germany are in a good condition. In 2014 nearly 98 % of all bathing waters met the EU quality requirements. 92.2 % of inland waters and 78.8 % coastal waters even reached an excellent bathing water quality.

The hygienic quality of bathing water was poor in only 14 bathing waters in the 2014 season (0.6 % of all bathing waters). During that time, 55 bathing waters were also partly or completely closed. Temporary closures occurred principally because of problems with flooding and cyanobacteria (blue-green algae). Long-term closures were due to renovation work or changes in use, but rarely because of bad water quality.

In retrospect, the number of target and limiting value exceedances declined steadily between 1992 and 2001 in relation to the then valid EC Bathing Water Directive 1975. Since then, the quality of bathing waters constantly remained on a high level. In the last 4 years 96 % of the inland bathing waters' microbiological parameters adhered to the values of the directive, 91 % to the more stringent requirements for a high water quality. Similar proportions of coastal bathing waters were 97 % and 78 %.



08

PRIVATE HOUSEHOLDS AND CONSUMPTION

Environmental awareness

Trends in the assessment of environmental quality

PROPORTION OF PARTICIPANTS IN %, WHO GAVE A "VERY GOOD" OR "RATHER GOOD" ASSESSMENT	2000	2002	2004	2006	2008	2010	2012	2014*
Environmental qality in own community	79	82	86	84	85	87	84	86
Environmental quality in Germany	75	82	82	66	64	66	69	73
Global environmental quality	16	20	16	9	18	18	21	7

* Online survey, sample from 14 year olds onwards

Source: Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety / Federal Environment Agency (ed.): Environmental Awareness in Germany 2014, results of a representative population survey. Environmental Research Plan FKZ 3711 17 11, Berlin/Dessau-Roßlau 2015

Since 1996, the Federal Ministry for the Environment and the Federal Environment Agency carry out a representative survey every two years by asking citizens about environmental quality as well as current topics of environmental policy. These studies on the “Environmental awareness in Germany” show that the population’s assessment of the quality of the environment is very varied, depending on whether the question asks about the global, national or local environment.

Most citizens are satisfied with the quality of the environment in their own community. In a longer-term comparison, since 2000, satisfaction with the quality of the environment in their own city has increased by 7 %, while questions on global environmental quality receive significantly more pessimistic responses. Although the share of respondents who evaluated the global environmental quality as “rather good” or “very good” increased between 2006 and 2012, in 2014, only 7 % of the respondents considered the global environmental quality to be satisfactory.

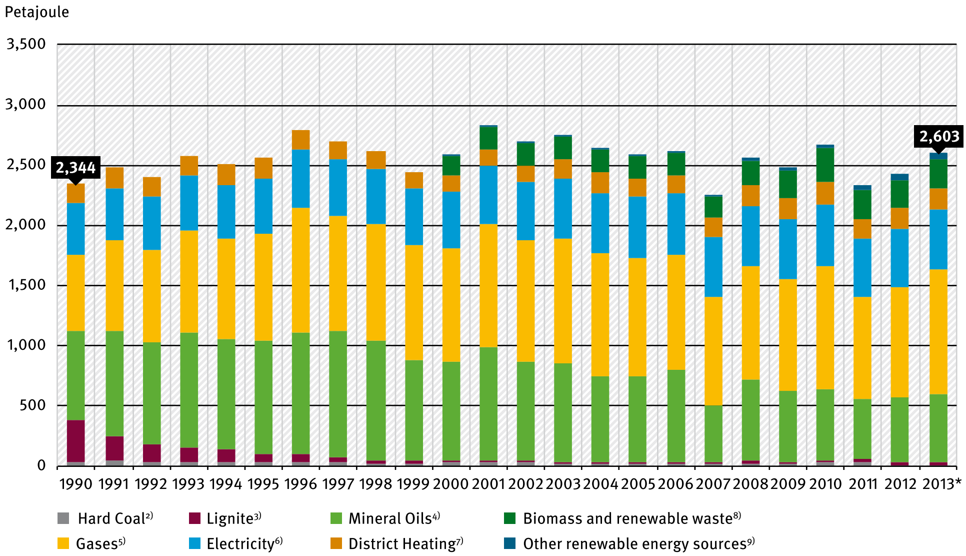
When asked about the most important problems in Germany out of two registered responses in 2014, almost 19 % of the respondents spontaneously named one aspect of environmental and climate protection. In 2012 – one year after the nuclear reactor accident in Fukushima, and at the time of the Rio+20 summit – 35 % of the respondents addressed environmental and climate protection. However, the proportion declined in 2014 to a level comparable to 2000-2010. A significant increase was found in the importance of environmental and climate protection for addressing other political tasks: In 2014, almost two thirds of respondents (63 %) believed that environmental and climate protection is an essential prerequisite for ensuring that future challenges such as globalisation can be tackled. In 2012 it already became clear that increasing importance was attributed to environmental protection in terms of meeting the task of globalisation, and improving the competitive capability of the German economy. This trend has continued and intensified in 2014.

Satisfaction with the quality of the environment is locally high, but from a global perspective, low

According to the latest survey carried out in 2014, the vast majority of the population is satisfied with the quality of the environment in their own community and in Germany. With regard to the global environmental quality, just about every fifteenth respondent evaluated it as “very good” or “fairly good”. Compared to previous years, the assessment of the local environmental quality is quite steady, while on the other hand, that of the global environmental quality is significantly worse.

Energy consumption by private households

Total final energy consumption of private households [1)]



1) 1990 to 1994: Households included in "households and small consumers". Since 1995, household consumption is accounted for separately.

2) Coal, hard coal briquettes, coal coke.

3) Brown coal briquettes, lignites (‹ 0,2 %).

4) Fuel oil (light), petrol (‹ 1 %).

5) Natural gas, liquid petroleum gas (approx. 5 %).

6) Including electricity created from renewable energies.

7) Including district heat created from renewable energies.

8) Primarily firewood.

9) Geothermics, solar thermics, heat pumps.

* Preliminary figures

Source: AGEB, Evaluation tables of the energy balance of the Federal Republic of Germany 1990 to 2013, as of September 2014

Between 1990 and 2013, energy consumption increased in households by 9.2 % – without the use of fuel, since this is assigned to the transport sector. However, due to weather fluctuations, increase in energy consumption was not steady. 1996, 2001 and 2010 had very cold winters, which led to increased fuel consumption for space heating. As such, the energy consumption in 2010 was about 13 % higher compared to the rather warm year of 1990.

The trend of having more households, larger living space and fewer members per household favours higher energy consumption. This trend was temporarily offset by the ever improving energy standards for new buildings and the renovation of old buildings. Although

Total final energy consumption of households increases once again

In 2013 German households spent around 2,603 PJ of energy (heat and electricity). That is 723 billion kWh. Energy consumption for transport is not included. Households have therefore a share of 28.1 % in the total final energy consumption. The share for transport is 28.2 %, industry 28.5 % and the services sector 15.2 %.

The mix of energy sources shifted between 1990 and 2013 in favour of fuels with lower carbon dioxide emissions. For example, the consumption of hard coal, lignite and mineral oil decreased while the proportion of renewable energies increased. This also reduced the greenhouse gas emissions directly caused by private households.

Compared to 1990, the total final energy consumption of households increased overall by around 9 %. Between 1990 and 2013, electricity consumption increased by roughly 18 %. Temperature - for example, cold winters - has a high impact on the total final energy consumption for space heating, which accounts for over two-thirds of the energy consumed by private households.

energy in households is needed mainly for space heating, the demand also depends not only on the size of the apartment, but on the energy-saving condition of the house and whether it is a single or a multi-family home.

From 1990 to 2013, electricity consumption increased by 18.1 %. The power consumption for information and communication, for example, has risen sharply and is now about twice as high as the consumption for lighting.

This trend must reverse. The power saving initiative of the Federal Ministry for the Environment offers possibilities for action. In addition, electricity must be used more efficiently. The EU Ecodesign Directive aims to reverse the trend of growing power consumption and to increase the energy efficiency of energy-using and energy-related products such as televisions, computers or refrigerators and freezers. Moreover, the share of renewable energies in the electricity supply must be increased.

Energy consumption in private households for space heating

Final energy consumption in private households by energy source and application in 2012*

	SPACE HEATING		HOT WATER		PROCESS HEAT		AIR CONDITIONING		PROCESS COOLING	
	PJ	TWh	PJ	TWh	PJ	TWh	PJ	TWh	PJ	TWh
Oil	422.0	117.2	80.4	22.3	0	0	0	0	0	0
Gas	726.6	201.8	176.9	49.1	3.6	1	0	0	0	0
Electricity	31.6	8.8	68.6	19.1	141.1	39.2	0	0	105.1	29.2
District heating	154.3	42.9	18.5	5.1	0	0	0	0	0	0
Coal	51.0	14.2	1	0	0	0	0	0	0	0
Renewables	279.0	77.5	24.7	6.9	0	0	0	0	0	0
Total	**1,664.5**	**462.4**	**370.4**	**102.9**	**144.7**	**40.2**	**0**	**0**	**105.1**	**29.2**

	MECHANICAL ENERGY		INFORMATION/ COMMUNICATION		LIGHTING		TOTAL	
	PJ	TWh	PJ	TWh	PJ	TWh	**PJ**	**TWh**
Oil	0	0	0	0	0	0	**502.4**	**139.6**
Gas	0	0	0	0	0	0	**907.1**	**252.0**
Electricity	12.3	3.4	88.8	24.7	45.9	12.8	**493.4**	**137.1**
District heating	0	0	0	0	0	0	**172.8**	**48.0**
Coal	0	0	0	0	0	0	**52.3**	**14.5**
Renewables	0	0	0	0	0	0	**303.7**	**84.4**
Total	**12.3**	**3.4**	**88.8**	**24.7**	**45.9**	**12.8**	**2,431.7**	**675.5**

*Preliminary figures

Note: The conversion factor from watt-hour (Wh) to joule (J) is 3,600, i.e. 1 TWh = 3.6 PJ or 1 PJ = 1/3.6 TWh

Source: AGEB, Application balances for Germany's final energy sectors in 2011 and 2012, with 2008-2012 time series, as of 11/2013

Private households use more than two thirds of their energy consumption for heating

Private households needed more than two thirds of their final energy consumption to heat rooms in 2012, for which they mainly used natural gas and oil. The third group was renewable energy, the fourth district heating, coal took fifth place and electricity was last. The use of fossil fuels to generate electricity, which is then used for heating is ecologically and economically questionable. In the transition of the energy system, with an increasing proportion of electricity coming from renewable sources, electricity and heat must be more strongly linked with other sources such as using heat pumps for space heating. With regenerative energy generation plants being currently curtailed due to bottle-necks in the electricity grids, the use of regenerative surpluses for heating is reasonable. The energy efficiency renovation of buildings in order to permanently reduce energy consumption for heating is especially important.

Private households needed about 69 % of their energy for heating in 2012. 15 % was used for hot water, 6 % for cooking, 4 % for cooling and refrigeration applications, 4 % for information and communication technology, 2 % for lighting and less than 1 % for other electric appliances.

Energy efficiency renovation in all residential buildings could reduce space-heating demands by nearly 60 % (technical potential). The German Government supports this, among others, with the following programmes:

- The "Energy Efficiency Renovation" programme of the Reconstruction Loan Corporation (KfW) provides grants and low-interest loans as part of the Federal Government's CO_2 Building Renovation Programme for this purpose.
- The Federal Ministry of Economics (BMWi) promotes the conversion of heating systems to renewable energies such as solar thermal, biomass boilers and/or heat pumps with its Market Incentive Programme (MAP). The Federal Office of Economics and Export Control (BAFA) is the competent application and approval authority.
- The BMWi also grants subsidies for energy-saving advice to homeowners.

There are other ways to reduce energy demand for heating. When a landlord has implemented energy-saving measures, tenancy law allows him to be exempt from rent reduction claims by tenants to a limited extent. He also may distribute the costs of efficiency-increasing measures onto the rent. It is reasonable that "municipal heating mirrors" and an energy performance certificate for existing buildings be distributed within the shortest possible period.

Annex | Reference list

BfN 2014: Federal Agency for Nature Conservation, Grünland-Report. Alles im grünen Bereich? – Positionspapier. Bonn-Bad Godesberg; 34 S. http://www.bfn.de/ (in German only)

BMEL 2015: Federal Ministry of Food and Agriculture (Ed.), Statistisches Jahrbuch über Ernährung, Landwirtschaft und Forsten, Münster-Hiltrup, verschiedene Jahrgänge, http://www.bmel-statistik.de/ (in German only) and communication as of July 2015

BMU 2007: Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, Nationale Strategie zur biologischen Vielfalt, Berlin 2007, http://www.biologischevielfalt.de/ (in German only)

BMU 2012: Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, German Resource Efficiency Programme (ProgRess). Programme for the sustainable use and conservation of natural resources, Cabinet Decision of 29.02.2012, Berlin 2012, http://www.bmub.bund.de/en/service/publications/downloads/details/artikel/german-resource-efficiency-programme-progress/?tx_ttnews[backPid]=1742

BMUB 2014a: Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety, Rivers and Lakes. http://www.bmub.bund.de/en/topics/water-waste-soil/water-management/rivers-and-lakes/ (Status: 01.03.2013)

BMUB 2014b: Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety, Groundwater. http://www.bmub.bund.de/en/topics/water-waste-soil/water-management/groundwater/ (Status: 01.03.2013)

BMUB 2014c, Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety, GreenTech made in Germany 4.0. Environmental Technology Atlas for Germany, Berlin 2014, http://www.greentech-made-in-germany.de/fileadmin/user_upload/greentech_atlas_4_0_en_bf.pdf

BMUB 2014d: Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety, Noise Protection, http://www.bmub.bund.de/en/topics/air-mobility-noise/protection-against-noise/general-information/?cHash=708635c8a9f766bc5d0c165b53867c44

BMUB 2014e: Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety, Particulate Matter. http://www.bmub.bund.de/en/topics/air-mobility-noise/air-pollution-control/general-information/?cHash=708635c8a9f766bc5d0c165b53867c44 (Status: 30.09.2013)

BMUB/UBA 2015: Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety / Federal Environment Agency, Umweltbewusstsein in Deutschland 2014. Ergebnisse einer repräsentativen Bevölkerungsumfrage, Berlin, http://www.umweltbundesamt.de/publikationen/umweltbewusstsein-in-deutschland-2014 (in German only)

BMWi 2015: Federal Ministry of Economic Affairs and Energy, Development of renewable energy sources in Germany 2014. Berlin 2015, http://www.bmwi.de/EN/Topics/Energy/Renewable-Energy/renewable-energy-at-a-glance.html

BÖLW 2015: Zahlen, Daten, Fakten. Die Bio-Branche 2015. http://www.boelw.de/uploads/media/BOELW_ZDF_2015_web.pdf (in German only)

Coalition agreement 2013: Deutschlands Zukunft gestalten. Koalitionsvertrag zwischen CDU, CSU und SPD. 18. Legislaturperiode, Berlin 2013, http://www.bundesregierung.de/Content/DE/StatischeSeiten/Breg/koalitionsvertrag-inhaltsverzeichnis.html (in German only)

Edler, D., J. Blazejczak 2014: Beschäftigungswirkungen des Umweltschutzes in Deutschland im Jahr 2010. In: UBA, BMUB (Hrsg.): Reihe Umwelt, Innovation, Beschäftigung, 02/2014. Dessau-Roßlau, Berlin, http://www.umweltbundesamt.de/publikationen/beschaeftigungswirkungen-des-umweltschutzes-in-1 (in German only)

Eurostat 2014: Environmental tax statistics, Main tables, database, http://ec.europa.eu/eurostat/statistics-explained/index.php/Environmental_tax_statistics (Status: 01.03.2015)

Federal Government 2002: The Federal Government, Perspectives for Germany. Our Strategy for Sustainable Development. Berlin, 2002, http://www.bundesregierung.de/Content/EN/StatischeSeiten/Schwerpunkte/Nachhaltigkeit/nachhaltigkeit-2006-07-27-die-nationale-nachhaltigkeitsstrategie.html

Federal Government 2010: Federal Ministry of Economics and Technology / Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, Energy Concept for an Environmentally Sound, Reliable and Affordable Energy Supply. 28 September 2010. http://www.bmwi.de/EN/Topics/Energy/Energy-Transition/monitoring,did=646088.html

FSC 2014: Forest Stewardship Council Deutschland. http://www.fsc-deutschland.de/ (Status: November 2014) (in German only)

Gehrke, B., U. Schasse, K. Ostertag 2014: Wirtschaftsfaktor Umweltschutz. Produktion-Außenhandel-Forschung-Patente: Die Leistungen der Umweltschutzwirtschaft in Deutschland. In: UBA, BMUB (Hrsg.): Reihe Umwelt, Innovation, Beschäftigung, 01/2014. Dessau-Roßlau, Berlin http://www.umweltbundesamt.de/publikationen/wirtschaftsfaktor-umweltschutz-0 (in German only)

GWS 2014: Gesellschaft für Wirtschaftliche Strukturforschung (GWS) mbH, Erneuerbar beschäftigt in den Bundesländern: Bericht zur aktualisierten Abschätzung der Bruttobeschäftigung 2013 in den Bundesländern, Osnabrück 2014, http://www.gws-os.com/de/content/blogcategory/111/366/ (in German only)

Henschel, Chan 2013: Susann Henschel, Gabrielle Chan, Health risks of air pollution in Europe - HRAPIE project: New emerging risks to health from air pollution - results from the survey of experts. WHO Regional Office for Europe, Copenhagen: 65 p., https://extranet.who.int/iris/restricted/handle/10665/108632

IPCC 2014: Intergovernmental Panel on Climate Change, Fifth Assessment Report (AR5) "Climate Change 2014. Synthesis Report", November 2014, http://www.ipcc.ch/report/ar5/syr/

KOM 2011: Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. A resource-efficient Europe – Flagship initiative under the Europe 2020 Strategy, KOM (2011)571 fin., Brussels 2011, http://ec.europa.eu/resource-efficient-europe/

Naturland 2014: Naturland - Verband für ökologischen Landbau e. V. http://www.naturland.de/de/

PEFC 2014: https://pefc.de (Status: November 2014)

SRU 2015: German Advisory Council on the Environment, NITROGEN: Strategies for resolving an urgent environmental problem. Summary. January 2015, http://www.umweltrat.de/SharedDocs/Downloads/EN/02_Special_Reports/2012_2016/2015_01_Nitrogen_Strategies_summary.pdf;jsessionid=3114C9E384DCB5B565F8BD8D65B8D440.1_cid325?__blob=publicationFile

StBA o. J.: Federal Statistical Office, Waste Balances, various years, https://www.destatis.de/EN/FactsFigures/NationalEconomyEnvironment/Environment/EnvironmentalSurveys/WasteManagement/Tables/Tables.html

StBA 2014: Federal Statistical Office, Nachhaltige Entwicklung in Deutschland. Indikatorenbericht 2014, Wiesbaden 2014

Stern, N., 2006: Review on the Economics of Climate Change, http://www.cambridge.org/us/academic/subjects/earth-and-environmental-science/climatology-and-climate-change/economics-climate-change-stern-review?format=PB

O'Sullivan, M., Edler, D., Bickel, P., Lehr, U., Peter, F. & Sakowski, F. (2014): Bruttobeschäftigung durch erneuerbare Energien in Deutschland im Jahr 2013 - eine erste Abschätzung. Studie im Auftrag des Bundesministeriums für Wirtschaft und Energie, Berlin (in German only)

UBA 2010: Federal Environment Agency, Water Framework Directive - The way towards healthy waters. Short version, Dessau-Roßlau 2010, http://www.umweltbundesamt.de/en/publikationen/water-framework-directive-way-towards-healthy-0

UBA 2011: Federal Environment Agency, Stickstoff – Zuviel des guten? Überlastung des Stickstoffkreislaufs zum Nutzen von Umwelt und Mensch wirksam reduzieren. http://www.umweltbundesamt.de/publikationen/stickstoff-zuviel-des-guten (in German only)

UBA 2013a: Federal Environment Agency, Germany in 2050 – a greenhouse gas-neutral country. Climate Change 07/2014, Dessau-Roßlau, January 2015, http://www.umweltbundesamt.de/publikationen/germany-in-2050-a-greenhouse-gas-neutral-country

UBA 2013b: Federal Environment Agency, Politikszenarien für den Klimaschutz VI. Treibhausgas-Emissionsszenarien bis zum Jahr 2030, Reihe Climate Change 04/2013, Dessau Roßlau 2013, http://www.umweltbundesamt.de/publikationen/politikszenarien-fuer-den-klimaschutz-vi (in German only)

UBA 2013c: Federal Environment Agency, Economic Valuation of Environmental Damage – Methodolocical Convention 2.0 for estimates of environmental costs, Dessau-Roßlau 2013, http://www.umweltbundesamt.de/publikationen/economic-valuation-of-environmental-damage-0

UBA 2014a: Federal Environment Agency, Emissionsbilanz erneuerbarer Energieträger 2013. Bestimmung der vermiedenen Emissionen im Jahr 2013, Reihe Climate Change 29/2014, Dessau-Roßlau 2014, http://www.umweltbundesamt.de/publikationen/emissionsbilanz-erneuerbarer-energietraeger-2013 (in German only)

UBA 2014b: Federal Environment Agency, Reactive nitrogen in Germany. Causes and effects - measures and recommendations. Dessau-Roßlau 2015, http://www.umweltbundesamt.de/en/publikationen/reactive-nitrogen-in-germany

Voß, J.; Knaack, J.; von Weber, M., 2010: Ökologische Zustandsbewertung der deutschen Übergangs- und Küstengewässer 2009. In: Meeresumwelt aktuell Nord-und Ostsee. Bund-Länder Messprogramm, http://www.blmp-online.de/PDF/Indikatorberichte/2010_02_s.pdf (in German, summary in English)

WHO 2006: World Health Organization, WHO Air quality guidelines for particulate matter, ozone, nitrogen dioxide and sulfur dioxide: global update 2005. Summary of risk assessment. World Health Organization, Occupational and Environmental Health Team, Geneva: 20 pp., http://apps.who.int/iris/handle/10665/69477

WHO 2013: World Health Organization, Review of evidence on health aspects of air pollution - REVIHAAP Project- First results. WHO Regional Office for Europe, Copenhagen: 33 p., http://www.euro.who.int/en/health-topics/environment-and-health/air-quality/publications/2013/review-of-evidence-on-health-aspects-of-air-pollution-revihaap-project-final-technical-report

Abbreviations

%	percent
°C	degree Celsius
CHP	combined heat and power
ct	cent
db(A)	decibel
EC	European Community
EEG	Renewable Energy Act
EQS	Environmental Quality Standard
EU	European Union
FSC	Forest Stewardship Council
GDP	gross domestic product
GHG	greenhouse gas
ha	hectare
HELCOM	Baltic Marine Environment Protection Commission (a.k.a. Helsinki Commission)
kg	kilogram
kg/ha*a	kilogram per hectare and year
km²	square kilometre
kt	kilotonne (metric)
kWh	kilowatt-hour
m³	cubic metre
mg/l	milligram per litre
µg	microgram
µm	micrometre
NEC Directive	EU Directive on National Emission Ceilings
NMVOC	non methane volatile organic compounds
OSPAR	Oslo Paris Commission for the Protection of the Marine Environment of the North-East Atlantic
p. a.	per annum
PEFC	Programme for the Endorsement of Forest Certification Schemes
PHEV	plug-in-hybrid electric vehicle
PJ	petajoule
pkm	passenger-kilometre

ppm	parts per million
RMC	Raw Material Consumption
RMI	Raw Material Input
t	tonne (metric)
t/a	tonne per year
tkm	tonne-kilometre
TWh	terawatt-hour
WFD	EU Water Framework Directive

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