# Energy for Germany

## Facts, Perspectives and Positions in a Global Context | 2018

MAIN TOPIC:

**CLIMATE PROTECTION IN ROAD TRAFFIC – GLOBAL CHALLENGES AND INSTRUMENTS**

# Foreword

Dear Readers,

It all starts with politics. This applies in particular to the energy sector and climate protection. The most pressing issues of energy policy today include further coal-fired power generation, the use of fossil fuels in combustion engines versus synthetic fuels and e-mobility, the reform of the Renewable Energy Sources Act, the implementation of sector coupling, increasing energy efficiency in the building sector, the replacement of oil and gas heating systems, but also, in particular, the competitiveness of the energy-intensive industry.

It is now up to the new German government to find and implement solutions to further advance the transformation of the energy systems and to meet the objectives of the Paris climate agreement. Even if transportation contributes only about 20 percent of the $CO_2$ emissions in Germany, measures for more climate protection in road traffic are undoubtedly needed, the main topic of this year's "Energy for Germany" issue. Approximately 95 percent of the emissions of the EU-28 transport sector result from road traffic and its emissions are currently rising again. The automotive industry is increasingly becoming the focus of attention in climate protection, as the current discussion about possible diesel driving bans shows.

After the energy sector, the transport sector is now also called upon to make a significant contribution. The German government has set a corresponding reduction target for the first time in its 2050 climate protection plan: By 2030, traffic-related greenhouse gas emissions are to be reduced by at least 40 percent compared to 1990. In view of the constantly increasing traffic volume, this is a massive challenge.

The World Energy Council repeatedly emphasizes the international dimension and the need for cooperation at European and global level. The reduction of greenhouse gases is such a global challenge that national targets and strategies alone are not enough to solve it. The spectrum of instruments currently used ranges from emission limits for new cars, mineral oil and vehicle taxes to the promotion of electric vehicles and synthetic fuels – albeit in very different forms globally. The internal combustion engine may still exist for a long time – but consumption and emissions must be reduced if climate protection is taken seriously.

Whatever the political compromise will be: It is important to set the course for the future now. Another of these future topics is sector coupling. In order to include the international component in the discussion, the World Energy Council Germany commissioned its own study in 2018 entitled "International Aspects of a Power-to-X Roadmap". The starting point is the expectation that Germany will not be able to achieve its decarbonization targets without the import of green fuels, as the generation of electricity from renewable energies in Germany is limited in terms of area.

Together with our supporting members and partners, including for example the gas and petroleum industries, chemicals, aviation and the automotive industry, we start our project exactly where most of the existing studies come to an end – namely on the international feasibility of Power-to-X projects, a specific criteria and country analysis as well as conclusions regarding cooperation and technical and political framework conditions.

I would like to invite you to our Energy Day on October 18, 2018 in Berlin to discuss mobility, sector coupling and other global issues of the future with representatives from politics, business and science from all over the world. Until then, we have compiled some interesting topics for you to read – with a neutral eye, fact-based, technology-open and future-oriented.

U. Franke

Dr. Uwe Franke
President, World Energy Council – Germany

# Main Topic:

## Climate Protection in Road Traffic – Global Challenges and Instruments

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# Executive Summary

The transport sector is responsible for about a quarter of global $CO_2$ emissions. The economic and social agenda after 1990 led to an increase in traffic, leading to a global increase in $CO_2$ emissions from road transport of around 75% between 1990 and 2015.

In the EU, the implementation of the internal market was the main driver of mobility and the main cause of the increase in emissions. In addition, after the fall of the Berlin Wall in 1990, there was a significant catching-up of participation in transport services in Eastern Europe. In 2015, passenger cars in the EU-28 accounted for a good 61% of road transport emissions.

## Challenge for the future: Sector coupling

The Paris climate agreement aims to limit the increase in the global average temperature to well below 2 °C. This can only be achieved through a global reduction in greenhouse gas emissions, to which all countries and all sectors contribute. A decarbonization target of 80% or even 95% by 2050 would mean that virtually all sectors other than agriculture would have to become 100% free of $CO_2$ emissions.

Against this background, the transport sector is facing a paradigm shift to replace the combustion of fossil fuels in the long term with a largely $CO_2$ -free energy supply. This can only be achieved through the interaction of the various sectors, the so-called sector coupling.

The prerequisites for a successful sector coupling and the conversion to the primary energy carrier electricity are:

- The early development of the necessary supply infrastructure for transport and the interface infrastructure to the electricity sector,
- A technology-neutral regulatory framework with overarching instruments,
- An overarching coordination mechanism to limit $CO_2$ emissions – consistent $CO_2$ price signals in all sectors should be sought.

According to all forecasts, the demand for renewable electricity will rise sharply as a result of the sector coupling. The greater the proportion of electricity-based fuels, the greater the electricity demand will be, as their production is less energy-efficient due to the numerous conversion processes. Nevertheless, they represent an indispensable component of the future energy supply of transport, especially as the existing supply infrastructure can continue to be used.

So far, the regulation for the use of electricity in the transport sector is very simple: all $CO_2$ emissions are added to the electricity sector. For transport, an electric vehicle is considered a zero-emission vehicle. However, the use of $CO_2$ -free e-fuels is not rewarded by the regulatory system of transport as a contribution to climate protection.

## Regulation has so far ignored important factors

The main regulatory instrument is based on emissions from new cars in a standardized test environment, i.e. with a theoretically measured emission potential of a small part of the vehicle fleet. Factors such as existing infrastructure, traffic jams or travelled distances have been largely ignored so far. The sector coupling is also currently missing. In order to achieve better regulation in road traffic, it is necessary to broaden the focus and pursue an integrated approach that tries to embed as many emission-relevant factors as possible into a coherent overall concept.

The aspect of predictability should be at the forefront of all measures in order to control long-term investment decisions. Mobility is essential for citizens to network the different aspects of their lives. Traffic is therefore always a variable derived from various individual decisions. Changes in behavior can therefore often only be brought about in the medium to long term.

## High fuel taxes in the EU have so far failed to have a steering effect

A globally accepted climate policy instrument is the levying of taxes on fuels, so-called “mineral oil taxes”. Combustion of one liter of diesel causes 2.64 kg $CO_2$, petrol produces 2.33 kg $CO_2$ per liter. If the weighted European taxation of fuels, which according to the EU Commission amounted to 71.8 cents per liter of diesel and 85.6 cents per liter of petrol in March 2018, is applied, an implicit $CO_2$ tax of around 368 euros per ton for petrol and 272 euros for diesel is calculated in the EU-28.

The EU-28 puts much more pressure on road transport than China, the US or the rest of the world in terms of limits and tax rates. In China, for example, oil taxes have been around 19 cents per liter since January 2015. This puts them at the US level, which has remained unchanged since 1993. The implicit $CO_2$ price of mineral oil taxation in the US and China is just over 80 euros per ton of $CO_2$.

## Manufacturer limit values as a key instrument of the EU

The EU's key climate protection instrument for road transport envisages limiting the average $CO_2$ emissions of all newly registered passenger cars in the EU to 95 g $CO_2$/km from 2021. For the year 2015 a value of 130 g $CO_2$/km was specified and with an average value of 119.5 g $CO_2$/km this was clearly undershot. For the period after 2021, it is currently planned to reduce the emissions of newly registered passenger cars by a further 15% by 2025 and by 30% by 2030. The limit values of the EU-28 for the next decade are thus significantly below the comparative values from the US, China or Japan.

Manufacturers are slowly reaching physical limits in increasing the efficiency of combustion engines and are therefore already being forced to develop alternative drive concepts and make them marketable. In addition to the various forms of powertrain electrification, such as plug-in hybrids or fully battery-powered vehicles, natural gas-powered drives and the fuel cell should be mentioned here. Suppliers expect electrification to contribute about 70% of savings by 2030.

## Further increases in efficiency are imperative

In recent years, road transport emissions in China in particular have risen sharply, whereas in the EU and the US they have tended to stagnate. There are still two opposing trends to be observed. On the one hand, technical progress is increasing the efficiency of vehicles, and on the other hand, the trend towards higher demand for transport services continues unabated. In the passenger car sector, car buyers are canceling out efficiency gains with the trend towards large vehicles such as SUVs. For this reason, technical progress is only slowly being transferred to global emissions development.

Remarkably, although online trading has increased sharply in recent years, emissions from light commercial vehicles have continued to fall after 2013. The fact that the increasing small-scale delivery traffic coincides with falling emissions suggests that efficiency increases in the area of light commercial vehicles are compensating for the effects of the increase in traffic.

The regulatory focus today is predominantly on further efficiency improvements. Although the actual greenhouse gas emissions of a vehicle are related to the emission potential considered in the regulation, they are also determined by the driving performance and the behavior of the driver.

## The future of mobility is electric: China is leading thanks to high subsidies

In the future, electricity will play an increasing role in the energy supply of road traffic and will at least partially replace petrol and diesel. Many governments are trying to accelerate this transformation process through support measures, with subsidies in Norway and China proving to be particularly high on a global scale.

Overall, China has become the largest market for electric vehicles thanks to strong industrial policy promotion, followed by the EU-28 and, by far, the US. It is to be expected that electric cars will become marketable in the next decade even without subsidies. Measured against the total vehicle population, however, they will only gradually increase their share due to the long service life of passenger cars.

## E-Fuels as alternative storage technology

An alternative storage technology to batteries are so-called e-fuels, i.e. gaseous or liquid fuels produced using electricity. However, any material transformation requires the use of energy and is accompanied by conversion losses.

The use of synthetic fuels significantly increases the electricity demand of the transport sector. Nevertheless, they will play an important role for the energy supply of transport, since the current state of the art does not allow us to predict whether batteries will reach the volume- and weight-specific energy densities that are necessary in the transport of goods or in air traffic.

## Declining sales of diesel vehicles leads to higher emissions

In Germany, the debate on the climate balance of road traffic is currently determined by the question of nitrogen dioxide pollution. The background is both the scandal about manipulated exhaust emission measurements during the registration of diesel vehicles and possible driving bans for diesel vehicles in German cities. The debate about nitrogen oxides is having a massive impact on diesel vehicle sales figures. In Germany, diesel accounted for 47% of new registrations in December 2014 and fell to 33% in December 2017.

Thanks to more efficient combustion technology, diesel vehicles emit around 15% less $CO_2$ per kilometer than petrol vehicles with comparable engines. In addition, diesel cars are typically used by road users with a high annual mileage. The declining market share of diesel vehicles means that the energy efficiency of new vehicles tends to deteriorate.

The discussion on nitrogen oxide thus has a direct influence on the climate balance of road traffic in Europe and has a long-lasting effect. The higher-emission new cars that are now being registered have a life expectancy of around 17 years in the EU-28 and will therefore influence the climate balance over a long period of time.

## 1.1 Global Emission Situation

***Developments in road transport pose challenges to global and European climate policy. Compared with the base year 1990, vehicle emissions have increased, and both traffic forecasts and current emission trends suggest that emissions will continue to rise for the time being. This applies in particular to China. In the EU-28, road transport emissions will fall in the medium term, but from today's perspective it still seems hardly possible to achieve the climate targets set for 2030. The challenge and opportunity for future climate policy lies in the consistent integration of road transport into an overall strategy.***

Global emissions from the combustion of non-renewable primary energy sources have grown strongly since the base year 1990. The emission statistics of the International Energy Agency (IEA, 2018) show an increase in emissions of 20.5 gigatons $CO_2$-equivalent to 32.3 gigatons for the 1990 to 2015 period. This corresponds to an increase of about 58%.

Emissions are unevenly distributed globally between countries. Only ten countries account for a good two thirds of emissions. By far the largest emitter is China with more than nine gigatons or 28.1%, followed by the US with almost five gigatons (15.5%). India has the third highest emissions with just over two gigatons (6.4%). These three countries already account for half of the emissions covered by the IEA. The EU-28, which pursues a common climate policy, has a share of 9.9%. Together, these four heavyweights already account for 60% of the emissions covered. Germany ranks 6th in these statistics with 730 megatons.

An efficient climate policy is only possible if the EU, China and the US work together.

From a climatological point of view, the location of $CO_2$ emissions is irrelevant. Only total global emissions count. From a climate policy perspective, however, the high regional concentration of emissions leads to the conclusion that a sensible climate policy should be designed to encourage the few emission heavyweights to take coordinated action.

If global emissions are broken down by sector rather than by emission location (Figure 1.1), particular attention must be paid to certain sectors. Both the absolute emission quantities and emission trends must be taken into account. Some sectors have grown strongly over the entire period under review. They are to be regarded as the main starting points for climate policy.

According to current IEA figures, global $CO_2$ emissions from electricity and heat generation amounted to a good twelve gigatons in 2015 and were thus around 80% higher than in the base year. The increase in emissions in this sector has accelerated since 2002. This global trend is mainly supported by economic catch-up processes in the Asian region. Growing prosperity goes hand in hand with increased demand for energy and has in the past been satisfied mainly with the help of coal-fired power plants in China and India. The comparatively high $CO_2$ emissions per kilowatt hour of electricity generated reflect this.

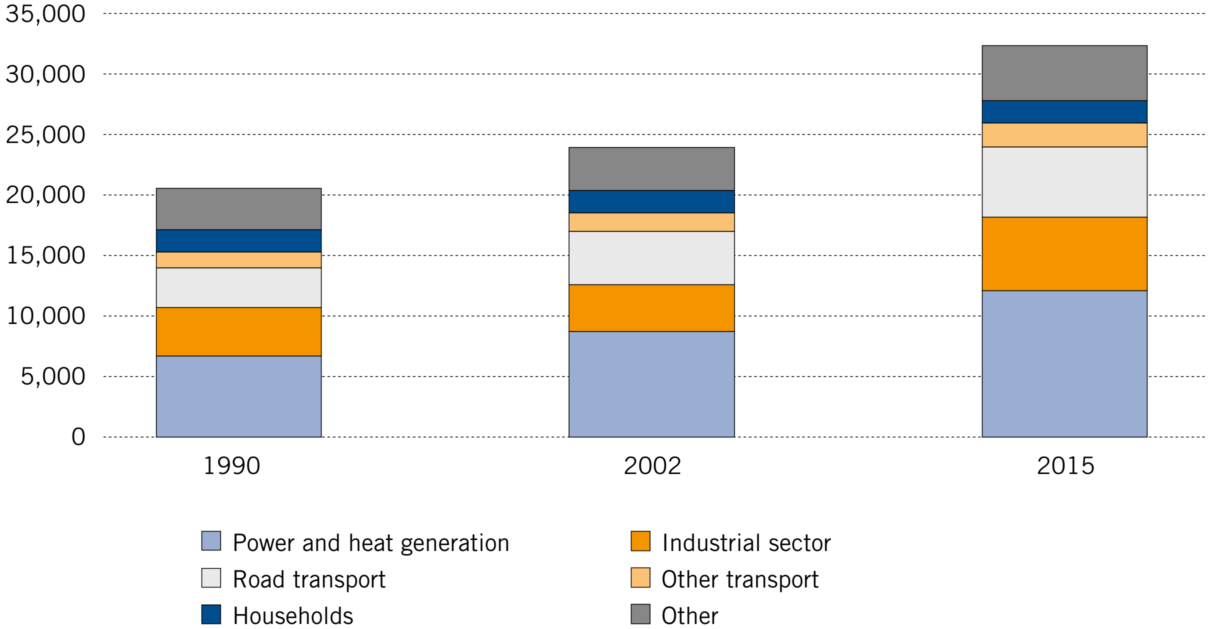
In terms of emissions, the industrial sector is also a heavyweight with just over six gigatons. Looking at this sector, global emissions according to IEA statistics actually fell slightly in the first half of the period under review and then increased faster than any other category. This observation is mainly explained by the industrial collapse of the former central government economies in the early 1990s and the rapid increase in industrial production in Asia after the turn of the millennium.

The third relevant sector is road transport, which will be the focus of the forthcoming report. Road transport is responsible for the mass of emissions from the transport sector, which is estimated at 7.7 gigatons in total. The rapidly growing emissions of international aviation and shipping are not included in this figure, only mentioned for information purposes. The reason for their exclusion is that, in accordance with the conventions in force since the conclusion of the Kyoto Protocol, these emissions cannot be allocated to any country and are therefore also ignored by the Paris climate agreement. Together, international aviation and shipping emitted just under 1.2 gigatons in 2015. Compared to 1990, they show the highest growth rates of all sectors, which is due to increasing global networking.

Without significant changes in China, global emissions from road transport cannot be reduced.

Road transport is the backbone of mobility and is therefore important for the climate debate. The IEA adds 5.8 gigatons of emissions to road traffic worldwide. This means that by 2015 about 18% of emissions from the combustion of fossil fuels are allocated to road traffic.

**Figure 1.1: Global emission trends by sector, figures in million tons**




Source: IEA, 2017, $CO_2$-Emissions from Fuel Combustion

Over the period 1990 to 2015, road transport emissions increased by around 75%, which represents a continuous increase from a global perspective.

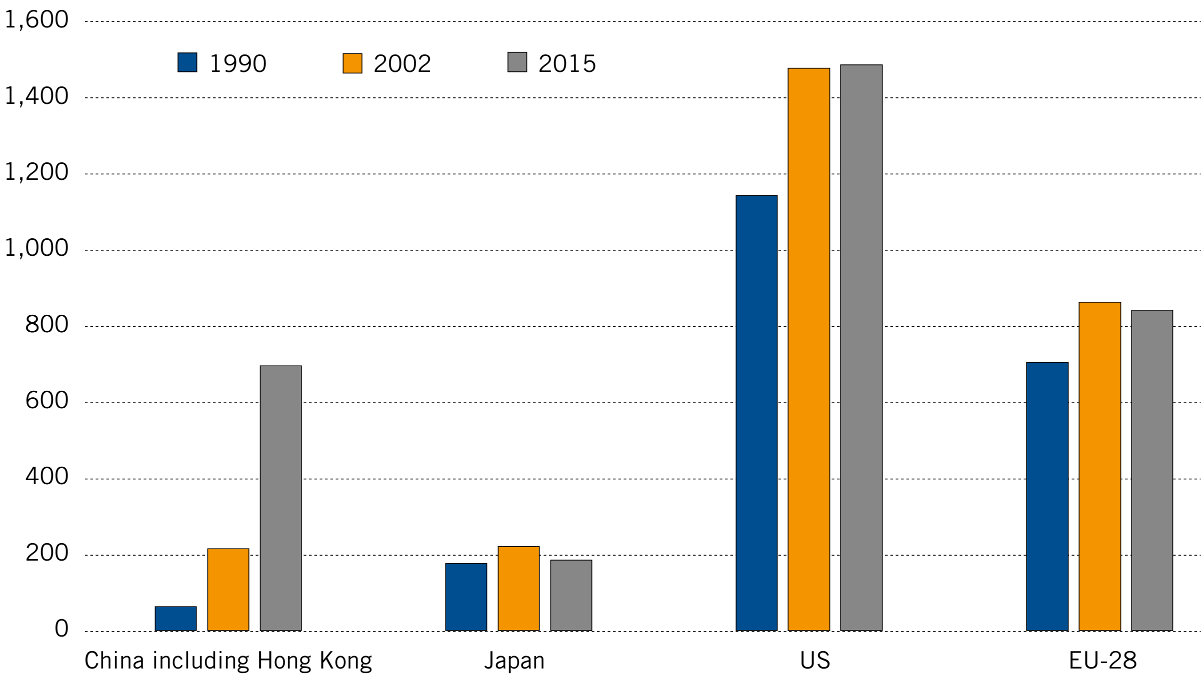
A regionally differentiated analysis shows that the emission trends in the regions with the highest emissions are very different (Figure 1.2). The US has by far the largest emissions in road traffic. They are estimated at around 1.5 gigatons of $CO_2$ per year. While the US recently recorded stagnating road traffic emissions, the EU-28 and Japan even recorded declines compared to 2002, and the growth in emissions in the 1990s was weaker than in the US. However, it should be noted for the EU that the decline in emissions is linked to the beginning of the economic crisis in 2008 and that emissions have recently risen again.

**Traffic flows are the result of private and business location decisions.**

While the countries of the classic triad – consisting of the economic areas of NAFTA, the EU-28 and Japan – have predominantly recorded emission reductions since 2002, there has been a rapid increase in China or the ASEAN region. In 2015, Chinese cars emitted a good 700 million tons of $CO_2$ and the emission growth continues unabated. Emissions increased by 9.3% in 2015. This corresponds to an absolute increase of almost 60 million tons or about 40% of the total emissions of German road traffic.

The demand for road transport mobility services is always a function of economic development. Transport is not the real purpose, but the result of individual, business and political decisions. This applies in particular to the settlement and economic structure, economic growth and other factors. These decisions determine mobility needs in the long term and it is generally difficult for individuals to adjust these decisions in the short term. The willingness to change places of residence or work due to changes in general conditions, such as higher mineral oil taxes, is extremely low. Other factors, such as the social anchorage at the place of residence or also the place of work of the partner are more decisive for the way of life. For people, mobility is above all an opportunity to network the various aspects of their lives. It is important for people, but it is not a goal in itself and a dependent factor. Consequently, mobility is highly valued by the population as an enabling factor for their own way of life, which is why political intervention to restrict traffic is difficult for the majority of the population to accept.

**Figure 1.2: $CO_2$ emissions from road transport in important countries, figures in million tons**




Source: IEA, 2018

The same applies to freight transport – transport services are to be understood as advance performance. There are industries that select their locations on the basis of transport links, such as steelworks. For most companies, however, transport issues are one of many location factors. They too will not change their location or their complete logistics system in the short term due to changes in mobility offers.

With the implementation of the EU internal market, European policy has been a driver for greater mobility over the last 25 years. The EU has been enlarged several times, the internal market created and transnational production networks promoted. These decisions were not justified by transport policy, but they did create a framework within which transport volumes increased. In addition, after the fall of the Berlin Wall in 1990, there was a significant catching-up of participation in mobility in Eastern Europe. Large population groups now had the opportunity to purchase a car for the first time.

Against this background, the separate and isolated discussion of transport policy issues is not useful. Influences outside the transport sector have a decisive influence on where and how much traffic is generated, and thus also on its emissions.

## 1.2 The emission situation in the EU-28

***Emission trends in Europe differ from the world situation at various points, including emissions from road transport. For European consideration, a more detailed data set can be used, which is transmitted by the EU to the UNFCCC (EEA, 2017). This data set makes it possible to further differentiate the emissions of European road traffic and, for example, to make separate considerations about the emission development of freight and passenger traffic.***

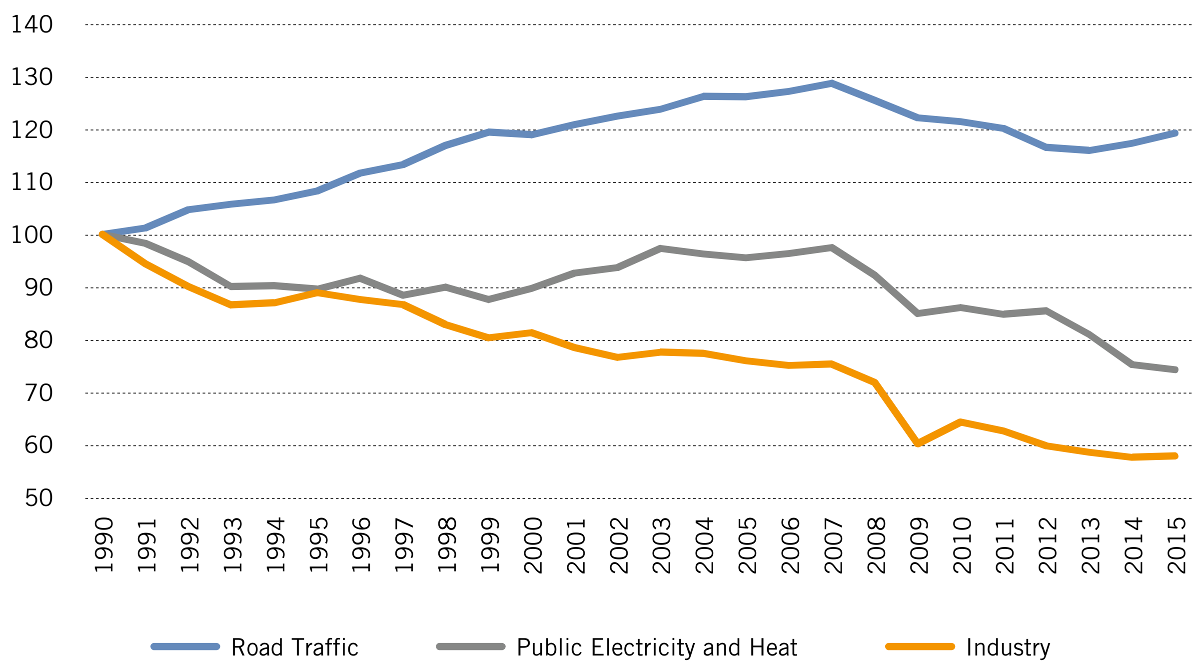
In the EU-28, absolute $CO_2$ emissions have fallen by about 1.4 gigatons since 1990. The largest reductions in emissions were achieved in the industrial sector and in public power generation, largely due to the disappearance of corresponding plants in Eastern Europe. Similarly, households and agriculture reduced their emissions between 1990 and 2015.

In the EU-28, absolute $CO_2$ emissions have fallen by about 1.4 gigatons since 1990.

If one compares the development of emissions over time in road traffic with that in the areas of public electricity and heat production and industry (Figure 1.3), then clear differences become apparent, which provide indications as to why the development of emissions in road traffic has been comparatively unfavorable.

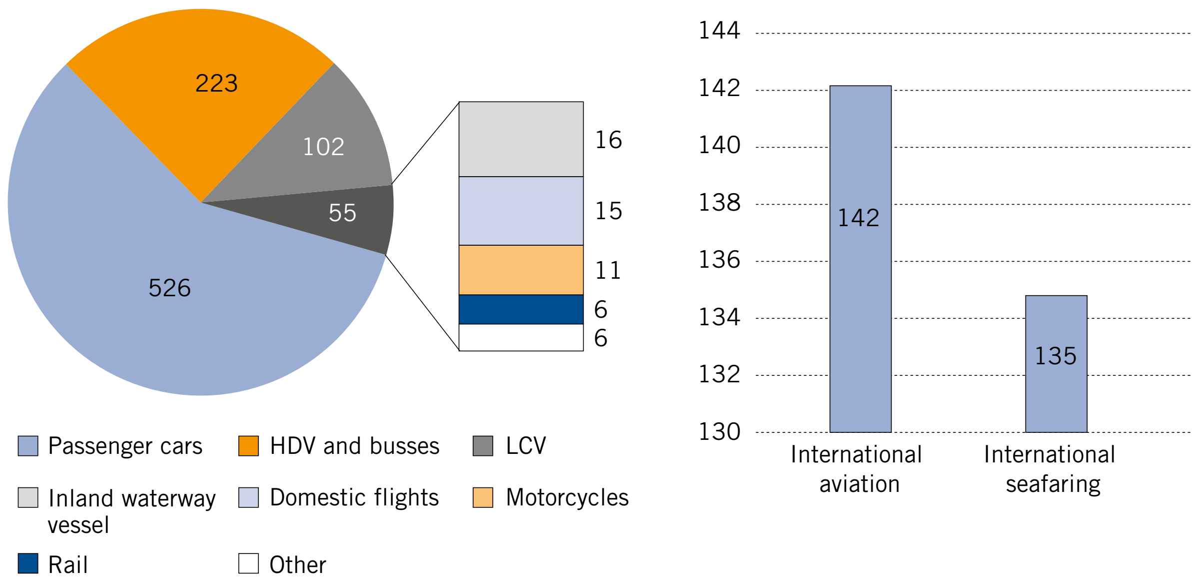
Emissions from other sectors benefited from the collapse of central government economies in the early 1990s, but road transport did not. In Eastern Europe, large sections of the population began to participate in private mobility and to adapt to the transport structures established in the West. This meant a visible shift in traffic from rail to road and a significant increase in privately owned cars. In addition, the interdependence of the European economy was promoted. The internal market was established in 1993 and the first EU enlargement to the east took place in 2004. The increasing networking of the European economy has been accompanied by an increase in freight traffic. Rising incomes in large parts of the EU-28 also increased the degree of motorization. The economic and social agenda after 1990 caused an increase in transport. Demand for transport services increased significantly, and this volume effect more than compensated for the technological advances in efficiency in road transport.

**Figure 1.3: Sectoral emission trends in the EU-28; 1990 = 100**




Source: EEA, 2017

**Figure 1.4: Transport emissions in the EU-28, figures in million tons**




Source: EEA, 2017

The transport sector – excluding international aviation and shipping – has therefore significantly increased its emissions. This is mainly due to road transport emissions, which account for more than 95% of transport emissions in the EU-28. Rail transport more than halved its emissions in the same period. The increasing electrification of rail traffic played an important role here, as electric railways are treated as zero-emission vehicles and the actual emissions are allocated to the electricity sector. As a result, intra-European aviation is now the second largest emitter in the transport sector – with around 14 million tons of $CO_2$ equivalent in 2015, but due to the dominant position of road transport in terms of emissions from the transport sector in the EU-28 shown in Figure 1.4, the following comments refer exclusively to this.

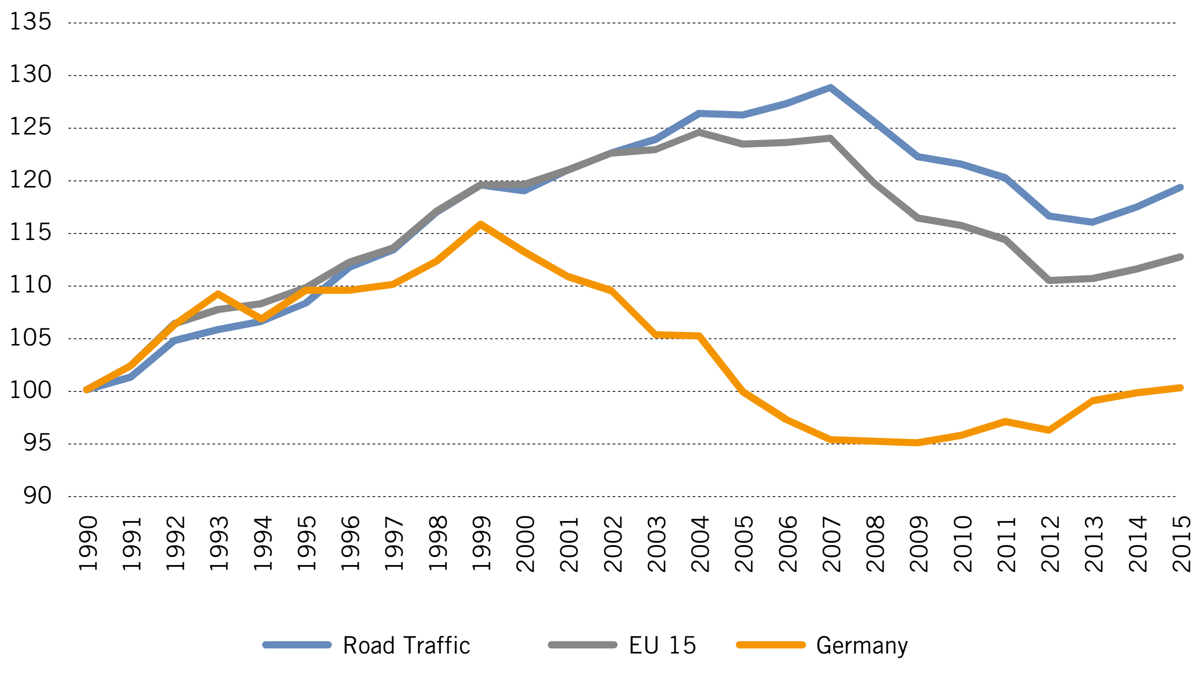
In 1990, 723 million tons of $CO_2$ emissions were attributed to it. The EU-28 recorded the previous emission peak in 2007 at 931 million tons. In the wake of the global economic crisis, economic output fell noticeably in large parts of Europe, resulting in lower emissions. In 2013,

**Table 1.1: Actual values for 1990 and 2014, minimum targets for 2030 according to the federal climate protection plan**

| Field of activity | Emissions (in million t $CO_2$ equivalent) | | | Reduction per year on average | | Required hastening by factor |
|---|---|---|---|---|---|---|
| | 1990 | 2014 | Target 2030 | So far (1990–2014) | Future (2014–2030) | |
| Energy | 466 | 358 | 175 | –1.1% | –4.1% | 3 |
| Buildings | 209 | 119 | 70 | –2.3% | –3.1% | 1 |
| Transport | 163 | 160 | 95 | –0.1% | –3.0% | 39 |
| Industry | 283 | 181 | 140 | –1.8% | –1.5% | 0 |
| Agriculture | 88 | 72 | 58 | –0.8% | –1.0% | 1 |
| Other | 39 | 12 | 5 | –4.8% | –4.1% | 1 |
| **Total** | **1,248** | **902** | **543** | **–1.3%** | **–2.9%** | **2** |

Source: Federal Government, own calculations

**Figure 1.5: Emission trends in the EU-28, 1990 = 100**




Source: EEA, 2017

road traffic emissions had fallen to 838 million tons of $CO_2$. The renewed turnaround in 2015 brought annual emissions to 862 million tons of $CO_2$, which have continued to rise in 2016.

**Road transport accounts for 95% of emissions from the EU-28 transport sector and its emissions are currently rising again.**

Particularly worth mentioning is the emission value for 2005, which amounted to 912 million tons. In its climate policy objective for road transport, the EU-28 refers to this year as a basis. By 2030, emissions from road traffic in the EU-28 are to be reduced by 30% compared with 2005, according to the Burden Sharing Regulation. In 2015, the decline was just under 5.5% and is currently falling. The original interim target of minus 10% by 2020 is unattainable and the figures suggest a clear failure to meet the climate policy target for road transport. Germany has set itself an even more ambitious goal in its climate protection plan for 2050. The German government even wants to reduce emissions in the transport sector by more than 40% between 2005 and 2030, as shown in Table 1.

In this context, the other non-ETS sectors have also been assigned climate targets that go beyond EU requirements. But the reduction commitment of transport stands out, as no other sector would have to accelerate its pace of reduction so much in order to achieve the national targets. In the case of transport, an annual reduction rate of just over 3% would be necessary, which would require an acceleration of the pace of reduction by a factor of 39.

Transport also faces major challenges at EU-28 level. The current regulatory framework based on the sector goals set by the company itself does not produce the desired results. If a target of minus 95% emissions for the economy as a whole were to be achieved by 2050, the emissions of the entire transport sector would have to be reduced to zero.

A regionally differentiated view of emission trends in the EU-28 reveals significant differences. Looking at the development of road transport as a time series (Figure 1.5), it can be seen that although there was a continuous increase between 1990 and 2007 in the EU-28, there were regional differences. Emissions from road transport in the

EU-15 countries (excluding Germany) entered a phase of stagnation as early as around 2004, only to decline sharply after 2007. After 2004, emission growth only took place in the Eastern European accession countries.

The development of emissions in Germany is an exception. In this country, emissions already peaked in 1999 and then fell significantly by 2007. This special development is strongly attributable to changes in road freight transport. In the 1990s, freight traffic emissions in Germany rose by 55% for heavy duty vehicles (HDV) and 92% for light commercial vehicles (LCV), while passenger car traffic only increased its emissions by 2%. After the turn of the millennium, emissions of the HDV fell sharply, while the LCV continued to increase slowly. In 2005, HDV's emissions were only 15% higher than in 1990, but passenger car traffic also began to show emission reductions from 1999 and reached 90% of 1990 emissions in 2005 (EEA, 2017).

There are various possible reasons for the drastic decline in freight traffic. One possible explanation is a relative change in fuel prices abroad, as the trend reversal coincides with the introduction of the eco-tax in Germany. It is possible that trucks in seaport hinterland traffic filled up in Germany until the turn of the millennium and then only behind the border in Belgium or the Netherlands. It is also conceivable that the declining consumption of trucks could result in higher ranges, which could also lead to a shift of refueled volumes abroad. Not to be forgotten is the marked slump in construction activity in Germany at the turn of the millennium. Since the construction industry is the largest customer of road freight transport in terms of tonnage transported, this too will have left its mark. All these aspects may have played a role in the fact that German road traffic was able to report a reduction in emissions at the time of an economic recovery process, which then visibly increased again from 2009.

**At 61%, passenger car traffic is now responsible for the majority of $CO_2$ emissions from road traffic.**

The mass of emissions in the EU-28 is still attributable to passenger car transport (Figure 1.6). In 2015, passenger car traffic accounted for a good 61% of road traffic emissions. This is a decrease of about 2.5 percentage points compared to 1990, meaning that emissions from freight transport increased more than those from passenger cars.

The growth in emissions was particularly strong for light commercial vehicles (LCV) with a gross vehicle weight of less than 3.5 tons. This vehicle category increased its emissions by almost 66% between 1990 and 2007. With the beginning of the economic problems in the EU-28 in 2008, there was a reduction in emissions. It is worth noting that LCV emissions have continued to fall after 2013, in view of the increase in online trading and the associated small-scale delivery traffic. Here, an increase in emissions could have been assumed. Increasing traffic is coinciding with falling emissions, which suggests that LCVs are becoming more efficient.

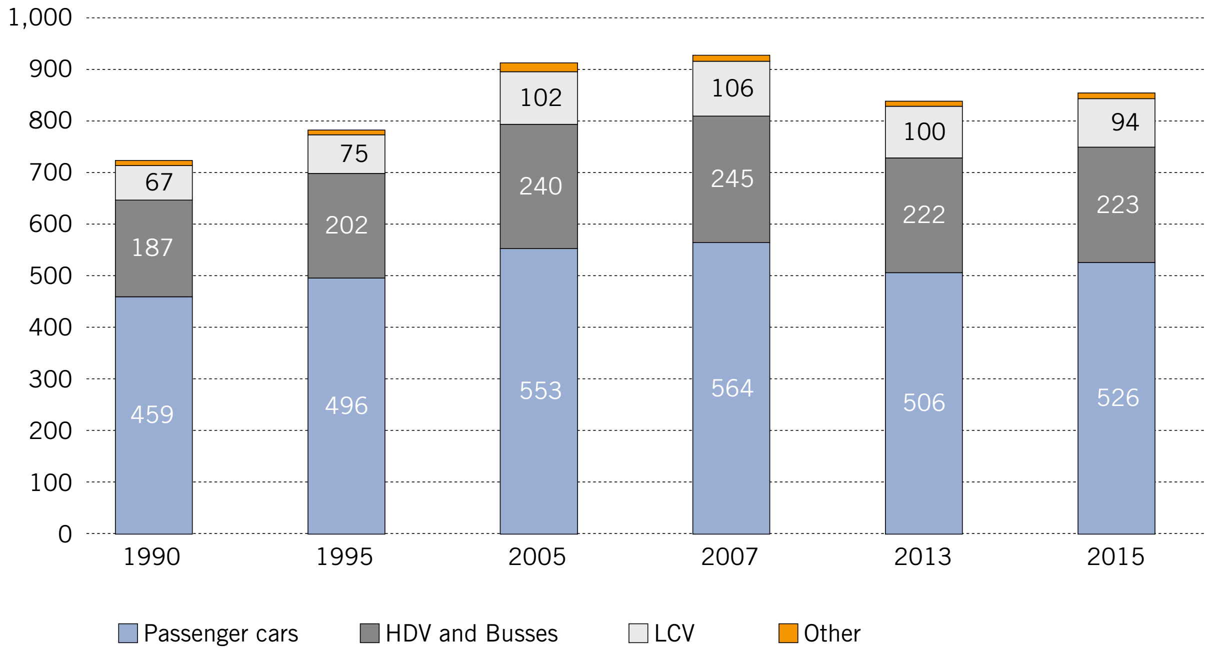
In the group of heavy duty vehicles and busses (HDV), there has been a comparatively high growth in emissions in the EU-28. Between 1990 and 2007, emissions increased by more than 30%. Subsequently, the deteriorating economic situation in many EU countries led to a significant reduction in emissions and a sideways movement in this area has been observed since 2013. Here, too, improvements in the efficiency of HDV's can be assumed.

**From 2007 onwards, the efficiency of passenger car traffic improved – emissions fell by 7% with an increase of 2.7% in passenger-kilometers.**

Emissions from passenger car transport increased by almost 23% between 1990 and 2007, i.e. significantly less than in freight transport for commercial vehicles (66%) and HDV (30%). Passenger car emissions collapsed with the start of the economic turbulence and fell by more than 10% by 2013; it is worth noting that the increase in emissions in European road traffic after 2013 is exclusively attributable to passenger car traffic.

A comparison with the development of transport performance in European road transport can provide some information on how transport efficiency has developed in the past. Transport performance is expressed in passenger-kilometers or ton-kilometers. It is therefore the product of the transport volume in persons or tons and the distance covered. It takes into account an increase in distance travelled and is typically used to study the development of traffic volumes. An analysis over the period

**Figure 1.6: Emission trends in the EU-28 by vehicle class – in million tons of $CO_2$**




Source: EEA, 2017

1990 to 2015 is not possible, as traffic performance data for all EU-28 countries are not available until 1995. Nor is it possible to differentiate between LCV and HDV (Odyssee Database, 2018).

Car traffic increased by about 17.7% between 1995 and 2007. During the same period, $CO_2$ emissions from passenger car traffic rose by just under 14%, indicating a slight improvement in transport efficiency in private motorized transport during this period. This changed significantly in subsequent years, as passenger transport services increased again by 2.7% between 2007 and 2015, but emissions fell by almost 7%.

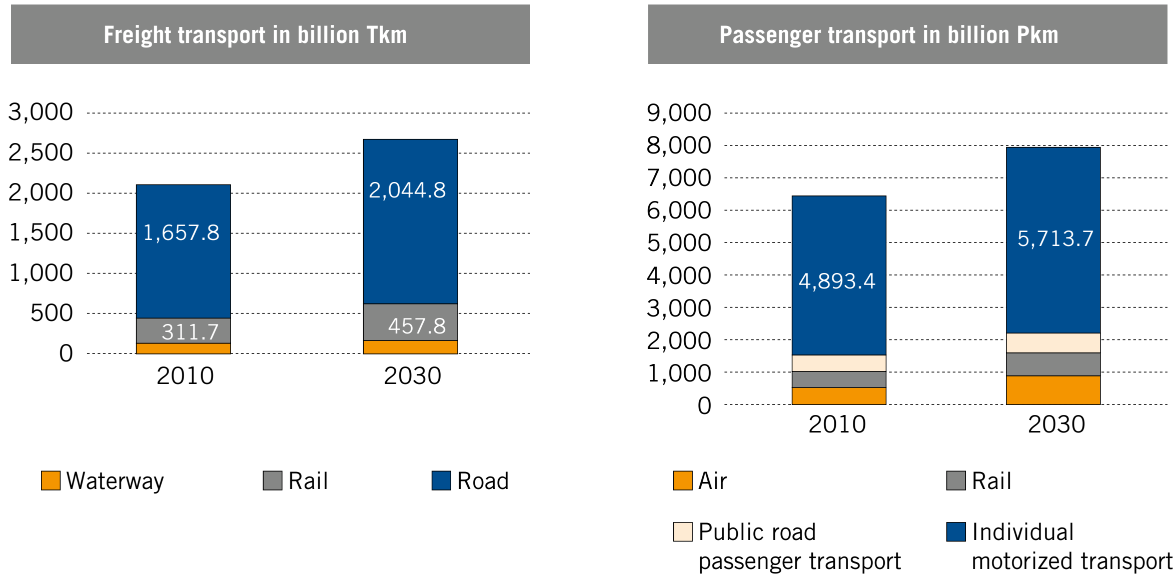
A different picture is emerging for road freight transport. Between 1995 and 2007, transport performance in ton-kilometers increased by almost 50%, while combined emissions from LCV and HDV increased by 34.5%. A significant increase in efficiency was therefore achieved in road freight transport. With the beginning of the crisis years from 2007, transport performance began to decline. Between 2007 and 2015, it fell by just over 8%, in line with the general reduction in emissions. Road freight transport was no longer able to achieve any further increases in efficiency. The reason for this is that in road freight transport, in addition to the technical development of the vehicles used, another factor has an influence on emissions efficiency: vehicle utilization. Emission efficiency decreases when vehicles are driven at low load or empty.

In view of the economic development in Europe after 2007, it can be assumed that there were two conflicting influences on road transport emissions. The efficiency of new vehicles improved, while capacity utilization in operation fell due to lower freight rates. There is much to suggest that, if the economy recovers, capacity utilization will rise again and that the expected increase in freight traffic will not fully impact on emissions statistics.

**Road freight transport will grow by 24% across Europe between 2010 and 2030.**

Although growth expectations for road freight transport have been reduced in recent years, current forecasts nevertheless assume a significant increase in traffic volumes. A current forecast for 2017 (freight transport) and 2014 (passenger transport) is shown in Figure 1.7. It assumes a significant increase in demand for freight trans-

**Figure 1.7: Traffic forecasts for the EU-28 for the period 2010 to 2030**




Source: Prognos 2017; EU Commission 2014

port by 2030. Overall, transport performance is expected to increase in future roughly in line with gross domestic product. For the period between 2010 and 2030, a total increase of almost 24% is expected for road freight transport (Prognos, 2017). It is assumed that road freight transport will increase its transport performance by more ton-kilometers than rail transported overall in 2010. This clearly shows that possible shifts in traffic can only represent a small building block in climate policy.

Significant growth is also expected for motorized private transport, with growth expected primarily in Eastern Europe, where driving habits are steadily converging with those in Western Europe. In addition, public road passenger transport is forecast to grow by around 16%. Growth expectations are exacerbating the challenge for climate policy in road transport even more drastically.

## 1.3 Excursus: Nitric oxide pollution in Europe

***In Germany, the debate on the climate balance of road traffic is currently being overshadowed by the question of nitrogen dioxide pollution. The background to the debate is both the scandal about manipulated exhaust emission measurements during the type approval of diesel vehicles and possible driving bans for diesel vehicles in German cities, which the Federal Administrative Court declared possible in principle in February 2018. The debate about nitrogen oxides is currently having a massive impact on the sales figures for diesel vehicles. Their market share is falling dramatically across Europe. In Germany, diesel accounted for 47% of new registrations in December 2014 and fell to 33% in December 2017, but diesel vehicles emit around 15% less $CO_2$ per kilometer than petrol engines with comparable engines. This is due to their more efficient combustion technology. Another complicating factor is that diesel cars are typically used by people with a high annual mileage.***

The discussion on nitrogen oxide thus has a direct influence on the climate balance of road traffic in Europe and has a quite long-lasting effect. The higher-emission new cars that are now being registered have a life expectancy of around 17 years in the EU-28 and will therefore influence the climate balance over a long period. It is therefore appropriate at this point to also address the issue of nitrogen oxide pollution.

→ The declining market share of diesel vehicles means that the energy efficiency of new vehicles tends to deteriorate, resulting in 15% more $CO_2$ per km being emitted.

As with all traditional pollutants, the emission situation in the EU-28 has improved in relation to nitrogen oxides (NOx) since 1990 (Figure 1.8). Approximately 17.5 megatons of $NO_2$-equivalent were emitted in the EU-28 in the base year. Of this, about 7.4 megatons were attributable to road transport, which accounted for a good 42% of total emissions. Since then, emissions have fallen drastically in all sectors of the economy. The EU-28 will see a 56% reduction in emissions by 2015. At 7.75 megatons, total emissions in 2015 were only slightly higher than road transport emissions in 1990; road transport was able to reduce its emissions by just over 60% and caused emissions of just over 2.9 megatons in 2015.

In the case of road transport, this is primarily due to the introduction of Euro 1-6 emission standards. These registration standards limited the emissions of new vehicles in the European standard test (NEDC). Since the introduction of the euro standards, permissible emissions have fallen by around 97%. Diesel vehicles registered in accordance with Euro 6 should only emit 80 micrograms of $NO_2$ per kilometer in the standard test. Vehicles meeting the Euro 6d standard must meet this value after a new test cycle (WLTP) and in a road test (RDE). The VW scandal in 2015 ignited on the violation of euro standards or their American equivalent. To be blunt: It was proven that the emission measurement had been deceived. The retrofitting of vehicles that were registered under false pretenses is the focus of the debate about possible compensation.

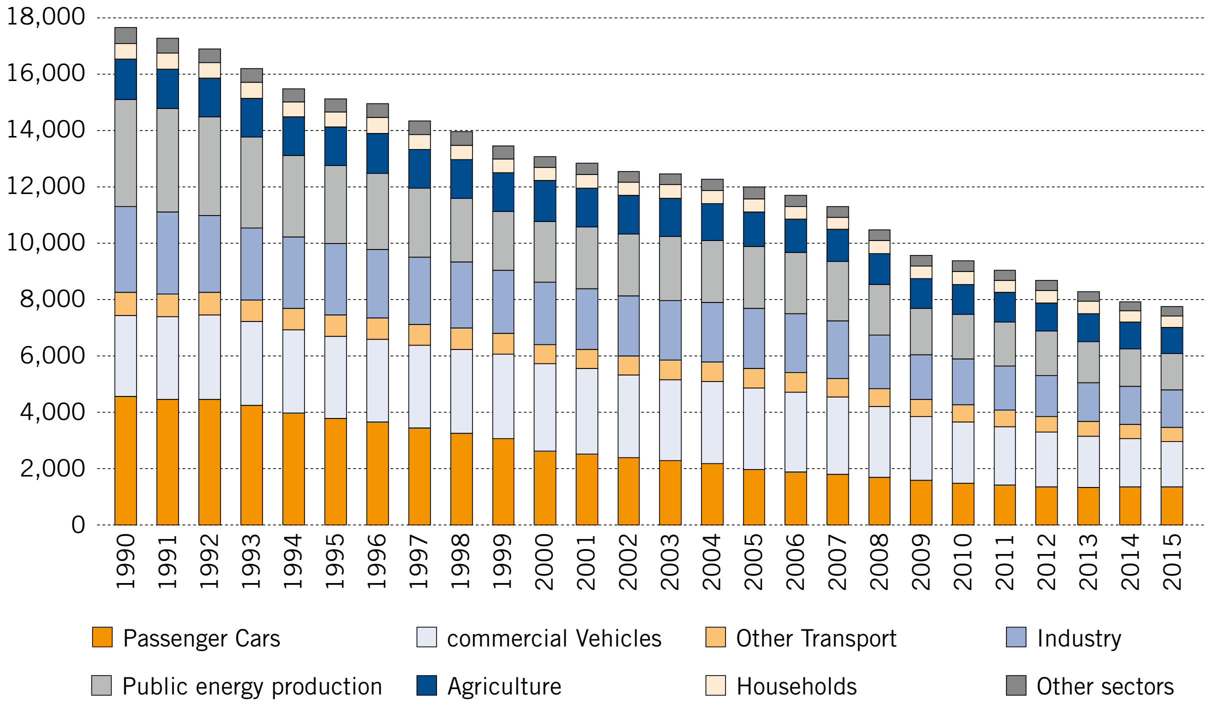
In addition to the emission legislation in the form of the Euro standards, the EU-28 also has immission legislations that were issued within the framework of the EU Ambient Air Directive. In this guideline, various immission limit values were specified for pollutants, including nitrogen dioxide ($NO_2$). The Directive set two limit values for this pollutant, which would have had to be met from 2014, taking into account all transitional periods.

The first limit value limits the load in the hourly average. An hourly average value of 200 micrograms in the ambient air may be exceeded for a maximum of 18 hours per year. This limit was met for the first time at all measuring points in Germany in 2017. In 2006, there was a station with more than 850 hours of overrun. In 2016, 39 stations across Europe reported a violation of this limit value, 24 of which are in Turkey, which has joined the EU air monitoring network. The highest load was reported from Izmir with 2,150 exceedances.

→ Nitrogen dioxide pollution in Europe's cities has fallen sharply – hotspots remain.

The second limit value refers to the annual average burden. This stipulates that the annual average may not exceed 40 micrograms per cubic meter of ambient air. This value was exceeded at 49 measuring points in Germany in 2017, at 15 even by more than ten micrograms (UBA, 2018). In the European measuring network, 309 limit values were exceeded for 2016, 110 stations of which exceeded the value of 50 micrograms. In terms of the annual average, too, the points with the highest load were in Turkey, with the station in Izmir with 122 micrograms the highest burden.

**Figure 1.8: Nitric oxide emissions in the EU-28, figures in kilotons**




Source: Federal Environment Agency Austria, 2017

The measuring points that exceed a limit value are all hotspot measurements. They take place in places where a particularly high concentration is expected due to structural and traffic conditions. Due to the chemical properties of $NO_2$, however, these values do not mean that the limit value is exceeded across the board in the cities concerned. Based on measurements, it can be assumed that even in the most heavily polluted areas the limit values in the buildings and side streets there are largely complied with. In addition, it is expected that the $NO_2$ problem will be solved in the foreseeable future at many exceedance points by the gradual renewal of the vehicle population, as the difference between the measured value for 2017 and the limit value is small. However, this will not apply to the most highly loaded measuring points. Here, additional measures, adapted to local conditions, will be necessary to achieve a reduction of the measured values.

The overpasses mainly take place on closely built-up main roads, which lack effective ventilation. Local location factors such as a traffic light system with hill approaches, tunnel exits, road constrictions or the presence of a large car park also have an effect on the measurement results. These factors may favor an emission level which exceeds the limit values. Therefore, the actual load at a hotspot is always the result of a combination of local factors, which is why the problems must be approached with tailor-made solutions.

## 1.4 Instruments of climate change policy in road transport in the EU

***Numerous instruments are used in the effort to reduce greenhouse gas emissions from road transport. The spectrum ranges from emission limits for new cars, mineral oil and vehicle taxes to the promotion of electric vehicles. In addition, there are also approaches in the EU-28 to shift road traffic to rail.***

The governments in the US and China, as well as the EU Commission, use the instruments in various forms. The EU-28 puts much more pressure on road transport in terms of limits and tax rates than China, the US or the rest of the world. China, on the other hand, has the highest commitment to promoting e-mobility among the heavyweights of emissions. In some small countries such as Norway, the subsidies are significantly higher. The instruments are outlined below using the example of European regulation. In many ways, $CO_2$ regulation in road transport differs fundamentally from that in other sectors, particularly with regard to the approach and scope of the instruments used.

The main instrument of the manufacturer-specific $CO_2$ target values for new cars only specifies maximum emission potentials.

In November 2017, the EU Commission reaffirmed once again in presenting the Clean Mobility Package that it intends to continue to set limits for new cars in its climate protection policy in road traffic. This instrument deserves a closer look, not only because of its prominent position in the EU and worldwide, but also because of its design, which is rather unusual in climate policy.

In contrast to the ETS sectors, where the EU uses emission volume regulation, road transport is primarily based on a system that is to determine the emission potential of new vehicles in a rolling stand test. These limit values are not based on the actual target figure – real $CO_2$ emissions – but try to have an indirect influence on the actual target figure by reducing the emission potential. They relate exclusively to the new vehicle fleet – so they have no effect over the existing fleet. Corresponding limit values currently exist for passenger cars and commercial vehicles. There are currently no specifications of this kind for HDV, but efforts are being made to create comparable standards for these as well.

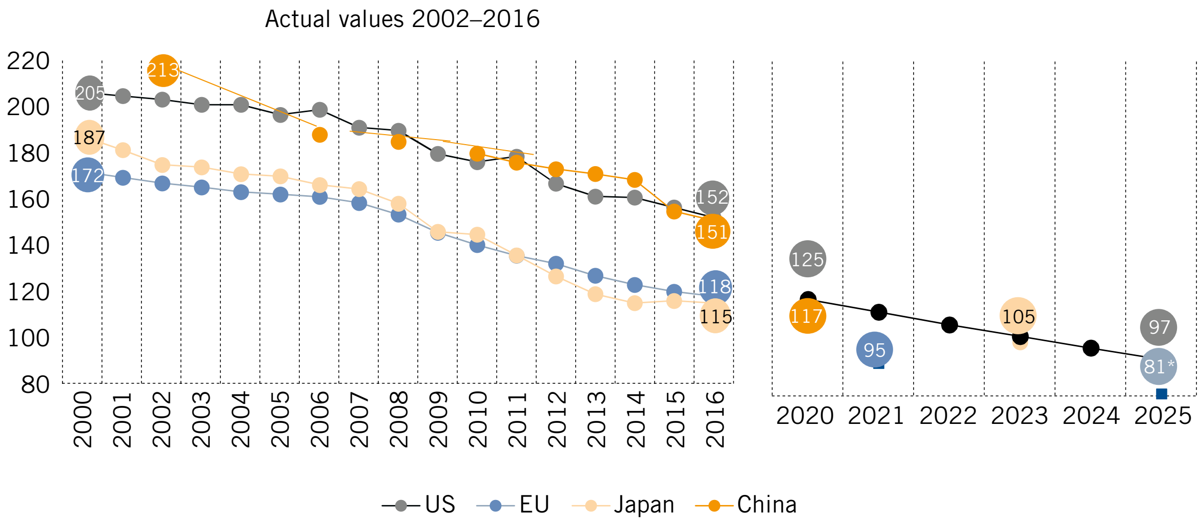
The EU's central climate protection instrument for road transport envisages limiting the average $CO_2$ emissions of all newly registered passenger cars in the EU to 95 g $CO_2$/km from 2021. For the year 2015 a value of 130 g $CO_2$/km was specified and with an average value of 119.5 g $CO_2$/km this was clearly undershot. For 2016, the average emissions of new passenger cars registered in the EU-28 were 118.1 g $CO_2$/km (EEA, 2018). Current forecasts (PA Consulting, 2018) assume that the limit values for 2021 cannot be reached by all manufacturers. A major reason for this prediction is the customers' abandonment of diesel.

The regulatory target for passenger cars and commercial vehicles for 2015 has been exceeded – accessibility for 2021 is questionable.

For commercial vehicles, different limit values and a different timetable apply than for passenger cars: the newly registered commercial vehicles should not exceed an average emission of 175 g $CO_2$/km in 2017. In 2016 they achieved an average emission of 163.7 g $CO_w$/km (EEA, 2018). The next limit for commercial vehicles is 147 g $CO_2$/km in 2020.

For the period after 2021, it is currently planned to reduce the emissions of newly registered passenger cars by a further 15% by 2025 and by 30% by 2030. The latter two values cannot currently be expressed in grams, as the measurement method is being changed. If the change of test procedure is ignored, the new requirements would mean a limit value of 81 g $CO_2$/km in 2025 and 66 g $CO_2$/km in 2030. The change of the test procedure should not change the sharpness of the value, but it will lead to a change in the relative usefulness of technologies with regard to the test results. An example is the cubic capacity of the engines used as an influenced component. The old test promoted the development of small but highly supercharged engines. The new test takes longer, which is why engines with larger displacement tend to perform better in this test than they did in the NEDC. Another example is the automatic start-stop system, which was very efficient in the NEDC with its long stoppage periods life but achieves much less effect in the new test. All in all, the entire powertrain development has to be redirected to the new cycle, which requires considerable development work and thus causes high costs.

**Figure 1.9: $CO_2$ actual and limit values for new cars in g $CO_2$/km according to NEDC**




* Calculated according to NEDC, which will no longer apply in 2025

Source: ICCT, 2017

However, the average values discussed so far are only one part of a far more complex regulation system that deals with the distribution of the reduction loads among the individual vehicle manufacturers, as outlined in the following using the example of passenger car regulation.

In order to achieve burden sharing between the individual manufacturers, the EU has decided not to introduce a uniform limit value. Instead, it sets specific target values for each manufacturer, which add up to an average of 95 g $CO_2$/km over the entire new car fleet in 2021. The weight of new cars sold by a manufacturer is used as a differentiating factor, which is determined by the level of manufacturer-specific limit values. The inclusion of vehicle weight when setting limits is one way of taking into account the different possible uses of a vehicle. A family van is heavier than a small car, but also offers other benefits. The weight also has a considerable influence on fuel consumption and $CO_2$-emissions. As a result of the weight differentiation, manufacturers of larger cars will be able to report higher new car fleet emissions in 2021 than manufacturers of small cars. However, the target value does not increase in line with the additional energy consumption caused by a higher weight. Despite this adjustment, the manufacturers of large vehicles have to make greater progress in efficiency than pure small car manufacturers.

Consumption and emissions of every new car are currently determined in the NEDC. In future, the measurement will take place in the new WLTP cycle, which is expected to produce more realistic results. The NEDC shows real journeys at best approximately. The changed test cycle will generally result in higher emissions and consumption than is the case with NEDC measurements. Nevertheless, there will be vehicles that tend to perform better under the new conditions.

Regardless of the change in the measurement procedure, if the average emissions of a manufacturer's new cars are above the target value determined by the average weight of the new cars, the manufacturer must pay substantial fines. The amount of the fine depends on the excess amount and the number of new cars sold and is 95 euros per gram or part thereof above the target value and the number of new cars sold. This value can be converted into a price per ton of $CO_2$ assuming a normal lifetime mileage of a vehicle. A value of 200,000 km is typically used here. On this basis, the manufacturer's fine of 475 euros per ton of $CO_2$ is calculated, which is far above the current prices for $CO_2$ emissions or the usual damage cost estimates.

Although the instrument of manufacturer limits has various weaknesses, it is used in all relevant regions of the world. The EU-28 sets itself the most restrictive targets, as shown in Figure 1.9 for passenger car limit values.

Here, the limit values based on different driving cycles were converted into values on the basis of the NEDC in order to achieve comparability. The Chinese limit applies to vehicles with petrol engines, but applies to all newly registered vehicles with internal combustion engines due to the composition of the Chinese new car fleet.

## If the target value is not reached, car manufacturers must pay fines, corresponding to 475 euros per ton of $CO_2$.

The EU-28 limits for the next decade are significantly lower than those of the US, China or Japan, with the current US government announcing in April 2018 its intention to soften them. It is therefore foreseeable that the difference in the limit values will continue to increase in the future. It is also considered certain that the EU limits will only be achievable if electric vehicles are taken up by the market on a larger scale.

Manufacturers are slowly reaching physical limits in increasing the efficiency of internal combustion engines, which is why the contribution of more efficient combustion engines is still required, but in the long term will not be enough to meet the targets. For the manufacturers of premium vehicles, conventional improvements will no longer be sufficient to achieve their target values by 2021. This is particularly true following the slump in the market for diesel passenger cars. Premium manufacturers are therefore already being forced to develop alternative drive concepts and make them marketable. In addition to the various forms of powertrain electrification, such as plug-in hybrids or fully battery-powered vehicles, natural gas-powered drives and the fuel cell should be mentioned here. Volume manufacturers are also affected by this with a delay. Large suppliers expect that the electrification of the drive train will have to deliver about 70% of the savings by 2030.

## Petroleum taxes are an implicit $CO_2$ price.

A worldwide common instrument is the levying of taxes on fuels. The levying of such taxes, hereinafter simply called fuel tax, implies a pricing of $CO_2$ emissions from road traffic, because there is a fixed relationship between fuel consumption and $CO_2$ emissions, which is calculated from the carbon content of the fuel. Combustion of one liter of diesel causes 2.64 kg $CO_2$. 2.33 kg $CO_2$ per liter is produced by petrol. Regardless of whether mineral oil taxes are levied for climate policy reasons – which is typically not the case – they do ensure that $CO_2$ receives a price. Thus, the fuel tax is undoubtedly a climate policy instrument that is applied globally, although it generally serves other purposes at the same time.

The level of taxation varies greatly. Europe has comparatively high tax rates on diesel and petrol. However, the EU sets only a minimum level, while the structure of the tax rates is within the sovereignty of the member states. In addition to the mineral oil tax, some Member States levy other taxes on fuel. The total tax rate per liter for diesel ranges from around 48 cents in Luxembourg to 86 cents in Sweden. For petrol, between 52 cents in Romania and 104 cents in the Netherlands are charged. If the weighted European average tax rate, which according to the EU Commission amounted to 71.8 cents for diesel and 85.6 cents for petrol in March 2018 (Weekly Oil Bulletin, 2018), an implicit $CO_2$ tax of around 368 euros per ton for petrol and 272 euros for diesel is calculated.

This means that fuel taxes in Europe are many times higher than in the other important regions. In China, for example, oil taxes have been around 19 cents per liter since January 2015. This puts them at the US level, which has remained unchanged since 1993. The implicit $CO_2$ price of mineral oil taxation in the US and China is just over 80 euros per ton of $CO_2$.

## 1.5 The global funding policy for e-mobility

***Global road traffic is facing a paradigm shift. This essentially consists of the increasing electrification of the drive train. As a result, the primary energy supply of road traffic is changing for the first time in over 100 years. In the future, electricity will play an increasing role in the energy supply of road traffic and will at least partially replace petrol and diesel. Many governments are trying to accelerate this transformation process through support measures, with subsidies in Norway and China proving to be particularly high on a global scale. The reasons for support measures vary greatly.***

In the EU-28, environmental considerations play the main role. Electrically powered vehicles are free of local pollutants and can be decarbonized analogously with the electricity grid. Another argument in favor of the funding of electrified vehicles from a European perspective is the finite nature of fossil fuels. In the US, too, these were the main reasons for promoting electric cars in the past.

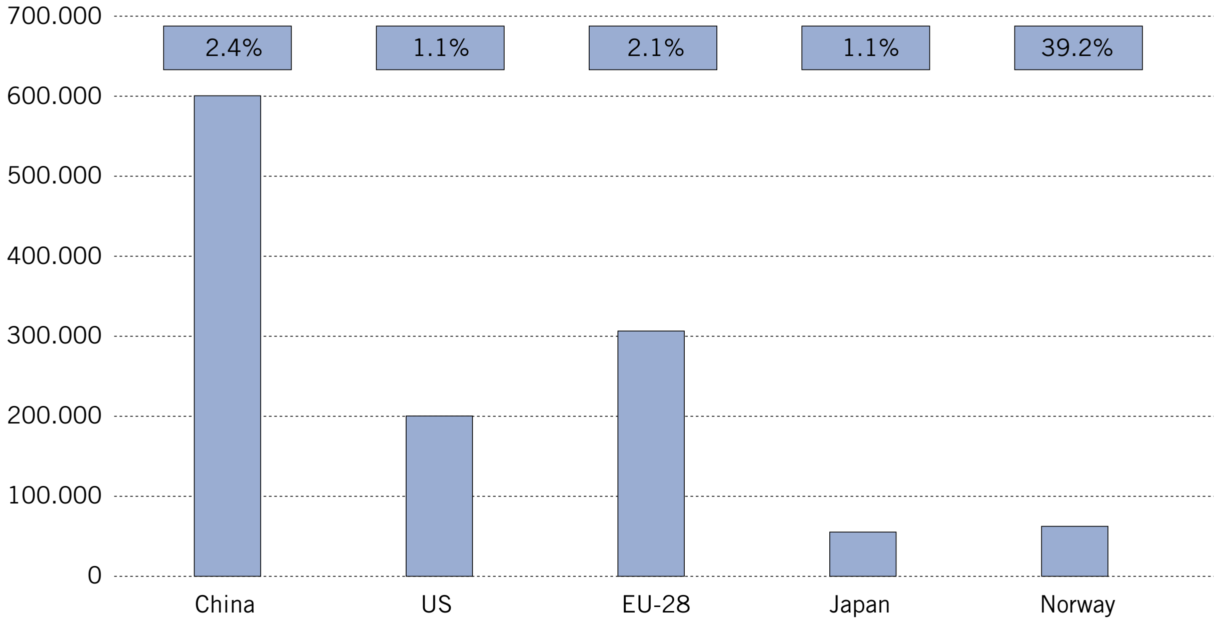
In China, on the other hand, electric cars are promoted primarily for reasons of industrial policy. The Chinese government sees the opportunity here to overcome the technological leadership of foreign manufacturers in combustion technology and to bring its own manufacturers into leading market positions. Fewer pollutants in large cities and a reduction in oil imports will also be seen as positive side-effects.

Electric mobility is promoted at all levels of government. The EU and China are pursuing policies that are strongly aimed at motivating manufacturers to bring electric vehicles onto the market. These include purchase premiums, tax rebates and transport privileges, which are often granted by member states or regional governments.

→ Norway has a high proportion of electric vehicles – thanks to strong subsidy models.

To promote electric vehicles, the EU uses their inclusion in the system of manufacturer-specific target values. A pure electric car is credited to the manufacturer as a zero-emission vehicle, a plug-in hybrid is recorded with very low emission values for the manufacturer. For the period between 2020 and 2023, vehicles sold that are certified with an emission value of less than 50 g $CO_2$/km are counted several times towards the total value of the manufacturer. Failure to meet the target values would result in substantial fines and a loss of image, so this regulation represents a significant incentive for manufacturers to bring electrified vehicles onto the market.

**Figure 1.10: Electric car sales in the 5 largest markets in 2017**




Source: EV Volumes, 2018; OICA, 2018

Norway occupies a special position in the funding of electric cars. The small country now has a market share of around 40% for new registrations of electric vehicles. This was made possible by massive state support. Since electric cars – battery electric vehicles (BEV) and plug-in hybrids (PHEV) – are exempt from the extremely high registration tax and VAT when purchased, they cost no more than conventional vehicles and are cheaper to operate. But this Iis an expensive approach to the treasury. The amount of the tax reduction depends on the value of the vehicle and can amount to 20,000 euros per vehicle. In addition, Norway has always had a comparatively inexpensive infrastructure for electric cars. On the one hand, Norwegian electricity is almost $CO_2$-free thanks to hydropower and on the other hand, electric parking heaters are very common in this cold country. Therefore there are many freely accessible sockets. The Norwegian government also prescribes the expansion of public loading facilities, for example for car park operators. The Norwegian funding model is successful, but extremely expensive and hardly transferable to other countries. Moreover, Norway is too small a vehicle market to have a greater influence on global technological developments.

The situation is different in China. The country produces electric vehicles in several ways. The central government is supporting the purchase with about 6,000 dollars. This amount will be increased by up to 50% by some regional governments. In addition, the regional governments buy electric vehicles from local manufacturers, for example for the taxi fleets. Last year, a quota system was adopted to encourage manufacturers to sell more vehicles. This quota rule is based on a complex points system, which assigns each model a certain value of "ecopoints". A pure electric car earns four to five points, a plug-in hybrid two points. The quota requires manufacturers to produce a quantity of ecopoints in 2019 equivalent to 10% of the number of new cars sold by the manufacturer. This is not to be confused with a quota of 10% of new cars, but rather 2 to 5%. However, this is a tough target, as the failure to meet the target can be accompanied by massive penalties up to and including a ban on sales.

Overall, China has developed into the largest sales market for electric vehicles thanks to strong promotion, as Figure 1.10 shows. However, China is also by far the largest market for new cars overall. In 2017, 24.2 million cars were sold in China, of which 600,000 were electric vehicles with a market share of approx. 2.5%. With the introduction of the quota system, the Chinese government has left no doubt that it intends to increase this proportion rapidly. The second largest market is now the EU-28, which has lagged far behind the US. All in all, the subsidy will ensure that the market for electric cars worldwide develops faster than previously expected, and it is foreseeable that electric cars will become marketable in the next decade even without subsidies.

Measured against the total vehicle population, however, electric cars will only gradually increase their share due to the long service life of passenger cars.

### Instruments check EU-28:

**$CO_2$ limit value for the new car fleet:** 95 g $CO_2$/km in 2021, to be reduced by a further 15% by 2025 and 30% by 2030. Manufacturers receive individual target values based on the average weight of their new car fleet.

**Fuel taxes:** Minimum rates set by the EU, tax rates are the responsibility of the member states, which leads to considerable margins. The average tax rate on petrol corresponds to an implicit $CO_2$ price of just over 200 euros per ton.

**Funding of e-mobility:** Pure electric cars are considered zero-emission vehicles when determining the manufacturer's target value. Plug-in hybrids receive significant discounts. From 2021 to 2023, vehicles with standard emissions of less than 50 g $CO_2$/km are counted several times. Many member states grant further subsidies such as purchase premiums, tax rebates or transport privileges.

### Instruments check China:

**$CO_2$ limit value for the new car fleet:** Oriented towards the – European system. In 2021, gasoline engines are expected to emit a maximum of 117 g $CO_2$/km on average in the new car fleet.

**Fuel taxes:** The mineral oil tax was increased to around 18 cents per liter in 2015. The tax rate on petrol corresponds to an implicit $CO_2$ price of just over 80 euros per ton.

**Funding of e-mobility:** The central government will pay a premium of about 6,000 dollars, which will be increased by up to 50% by the regional governments. From 2019, a quota system based on ecopoints will apply for vehicle manufacturers. The most important cities grant privileges for registration. Regional governments buy vehicles of local production for the municipal fleets.

### Instruments check US:

**Consumption limits for the new car fleet:** the system has existed since the oil crises, but the penalties for exceeding them are minimal. In 2020, the consumption of the new car fleet is to fall to a level that would correspond to 125 g $CO_2$/km in the NEDC. The target for 2025 is 97 g $CO_2$/km. In April 2018, the US government announced its intention to soften these limits.

**Fuel taxes:** The mineral oil tax was last increased in 1993 and amounts to about 18 cents per liter. The tax rate on petrol corresponds to an implicit $CO_2$ price of just over 80 euros per ton.

**Funding of e-mobility:** So far, the Federal Government has granted a tax reduction depending on the size of the battery when purchasing electric vehicles. The tax reform presented in November 2017 provides for the abolition of subsidies. The states have their own programs and grant additional subsidies.

## 1.6 Weaknesses of the regulatory system in the EU-28

***The current regulatory framework in the EU-28 has proved inadequate with regard to the goal of reducing greenhouse gas emissions. This applies in particular to the main regulatory instrument, i.e. the manufacturer-specific emission target values for new car fleets. Although the requirements have so far been exceeded, road traffic is far from the climate protection requirements.***

Emissions should fall by 30% between 2005 and 2030. By 2015, emissions have fallen below 6% and are currently rising again. In addition, transport services in the EU-28 are expected to increase further. The difference between climate protection targets and the results achieved comes as no surprise, as the limit value system has systematic weaknesses that prevent efficient reduction.

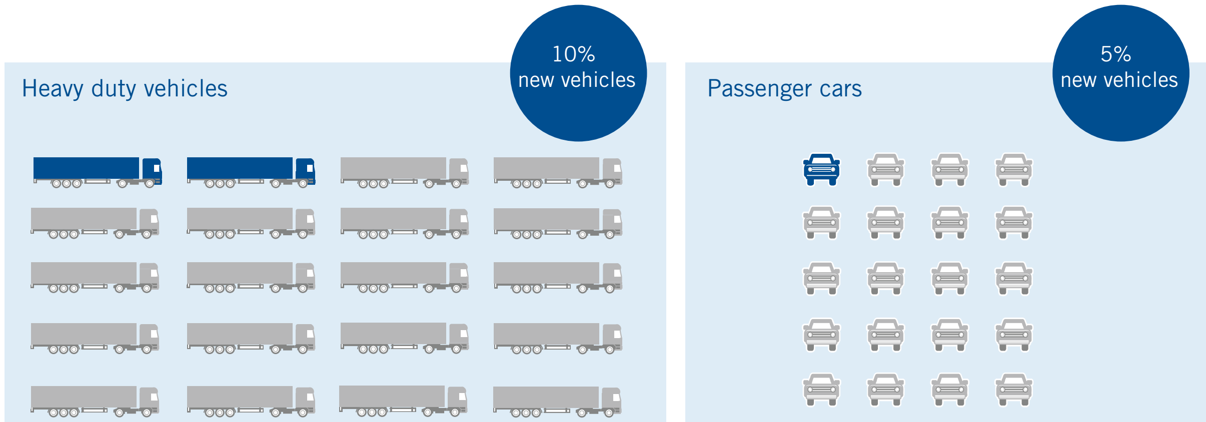
Only new cars are regulated, existing vehicles are not affected.

A central problem of the limit value approach is that it only covers a very manageable part of the vehicle population. Approximately 253 million cars are currently registered in the EU-28. In 2017 there were 15.1 million new registrations, significantly more than in previous years. In a normal year, just over 5% of vehicles are subject to regulation. This is no problem if the stock is renewed quickly. The average age of the passenger car fleet in the EU-28 is currently eleven years; in Germany, the average age is now nine years. As a result, almost half of today's passenger car fleet was already built before the introduction of the limit value system.

On average in the EU-28, a vehicle is scrapped after 17 years of service and the fleet thus represents on average the technical status of 2007. The average vehicle in 2030, by which the climate policy target of minus 30% in road traffic is to be achieved, will roll off the assembly line in 2018. If one compares the emissions of passenger cars in 2007 determined in the standard test with the current data (2016), a reduction of 25% was achieved at the rolling stand. An extended mileage and a further increase in vehicle age are not taken into account. Overall, the technical progress achieved over the last ten years is likely to lead to a visible reduction in emissions from passenger car traffic after 2020. However, it seems unlikely that this will be sufficient to achieve the EU-28 target.

This becomes even more questionable considering that commercial vehicles have also only been regulated for a few years and are on average considerably older than the passenger car fleet, so that the effect of regulation will begin later. In addition, the growth expectations for LCV traffic are high due to the increasingly small-scale delivery traffic resulting from online trading. However, the fact that the HDV have not yet been regulated is less problematic. Due to their high driving performance, HDV have a twice as high annual replacement rate as passenger cars. This applies above all to semitrailer tractors in long-haul transport. The buyers of HDV regard these as operating resources and have always paid much more attention to

**Figure 1.11: Annual fleet renewal rates in the EU-28**




Source: Own presentation

**Figure 1.12: Overview of the integrated approach**

**Integrated approach: Including all areas in regulation**

**Total emissions in tons =**
Consumption in liters * Emission factor in kg $CO_2$/liter * Mileage

**Car industry**

- Optimization of combustion engine
- Alternative fuels
- Lightweight construction
- Electrification of the powertrain
- Use of digitization (Avoidance of parking search traffic)

**State**

- Infrastructure status
- Construction site management
- Promotion of low-emission drives and fuels
- Stock renewal

**Drivers**

- Driving distance (how much?)
- Driving (how?)
- Vehicle selection (with what?)

Source: Own presentation

consumption than the buyers of passenger cars. As a result, the emissions of new trucks have fallen continuously, by around 1 to 1.5% per year over the last 20 years. If this trend continues, this will be sufficient to offset the expected increase in transport performance, but not to achieve the reduction target of 30% between 2005 and 2030.

## Emission potential is regulated at the test stand – driving style and distance are not taken into account!

Another weakness of the regulation system is that only one emission potential is considered in a standardized test environment. Such a rolling resistance test cannot fully reflect the reality on the roads; the NEDC was originally not designed for a realistic consumption measurement. How high the vehicle's emissions actually are is influenced by countless other factors. The user's driving style alone can cause up to 30% more emissions compared to the test. The driving environment also plays a role. Are there many gradients? Does the outdoor temperature require air-conditioning? These factors have a major impact on emission performance. Manufacturers optimize their vehicles with regard to the rolling resistance test, as this decides how manufacturers are evaluated in the regulatory system.

The biggest structural shortcoming probably lies in the actual driving performance of the vehicle which is not considered in the current regulation. A super sports car that only drives 500 kilometers a year is a problem in the current system because of its high emission potential, while a small car that drives 20,000 kilometers a year is rated positively. On the road, the small car causes many times more emissions than a sports car that hardly leaves the garage.

This gap could theoretically be closed by fuel taxes, since these can be converted precisely into $CO_2$ pricing. However, Europe's fuel taxes, which are high by international standards, have little steering effect, at least in the short term. In fact, demand elasticities, i.e. users' reaction to price changes, are very low when fuel prices rise all over the world. The fewest people are able to react quickly to price changes and adapt their mobility strategy, as binding restrictions, such as the choice of their place of residence and work, are much more difficult to change. This is also true for companies. In the medium term, a lower-consumption vehicle can be purchased or the place of residence or location can be changed, which increases the elasticity. However, these adjustments can hardly be brought about by one-off price increases, as there are effects of habituation. Overall, the reduction effect of fuel consumption is always disproportionately low. For this reason, states like to resort to the mineral oil tax as a stable source of income. Pricing measures achieve greater effects above all if they are designed for the long term and can be planned for people. The Swedish example of an announced gradual increase shows how long-term $CO_2$

### Fuel taxation in Sweden

In Sweden, the pricing of emissions is based on taxation. Fuels for road transport are subject to both energy and $CO_2$ taxation. Energy tax rates are differentiated between sectors. Due to its low price elasticity and the fact that it is not in international competition, transport has comparatively high tax rates. Between 2000 and 2017, the tax burden on petrol increased by 42% and on diesel by as much as 91%. Sweden has now reached a very high level of taxation; for diesel it has the highest tax rates in the EU-28.

In 2009, a gradual tax increase was decided with the aim of reducing emissions. In 2011 and 2013, fuel taxes were increased by about 4 cents per liter, followed by a further tax increase of about 5 cents in 2016. From 2017, an automatic tax increase on fuels took effect. Both the energy and $CO_2$ taxes on fuels will increase by 2% each year and are also subject to an automatic adjustment via the Swedish consumer price index (Naturverket, 2017, 10f.). In this way, a predictability of taxation is created, which should have an impact on the medium-term decisions of motorists such as vehicle procurement and choice of place of residence. This pricing strategy is accompanied by a $CO_2$-based vehicle tax, congestion tax concessions in Stockholm and Gothenburg and other subsidies for low-emission and zero-emission vehicles. All in all, Sweden is sending out clear price signals, but is also placing a greater burden on its citizens than most other countries.

pricing can work if the state is prepared to impose significant additional burdens on its own citizens (see box).

The current regulation only applies to a comparatively small proportion of the factors that determine the emissions from road traffic. The regulatory focus is on new car emissions in a standardized test environment. Factors such as infrastructure stock, traffic jams or the travelled routes have been largely ignored so far. Regulation is therefore neither well targeted nor effective. Another complicating factor is that $CO_2$ avoidance costs in transport are very high. There is no uniform information on this, but various studies usually show several hundred euros per ton.

Moreover, the regulatory approach to road transport has so far completely ignored the issue of sectoral coupling, although this will be a key element of the future. In order to achieve better regulation in road traffic, it is necessary to broaden the focus and follow an integrated approach that tries to embed as many emission-relevant factors as possible into a coherent overall concept, which is outlined in Figure 1.12.

An integrated approach will only produce the desired results if it is linked to the other sectors and their regulation.

## 1.7 Challenge for the future: Sector coupling

***So far, the transport and building sectors in particular have shown that sector-specific targets are only partially suitable for reducing greenhouse gas emissions at low cost. In these sectors, the reduction of emissions must accelerate visibly if the EU's climate targets are to be met. Market-based instruments that are more strongly based on $CO_2$ emissions than hitherto appear desirable, but at the same time might lead to a migration of industry and affected companies and thus also of the corresponding emissions – known as carbon leakage.***

Sector coupling is an important topic of the future in road transport, since in addition to the promise of a more efficient overall climate policy, the impending paradigm shift towards alternative fuels will automatically lead to sector coupling. There is broad agreement that decarbonization of the traffic sector can only be achieved by switching to electricity as a primary energy source.

→ Electricity is the fuel of the future – whether as e-fuel or directly from batteries.

The switch to electricity as a primary energy source in road traffic has begun and will gain momentum in the coming years. This is not the same as the use of battery electric vehicles (BEV), which today's foreseeable battery technology only offers sufficient volume- and weight-specific energy densities for part of the traffic. Important parts of transport, such as air and sea transport, but also supra-regional road freight transport, require quantities of energy that can hardly be provided by batteries in the vehicle. For passenger cars and commercial vehicles, on the other hand, it can be assumed that electricity storage in batteries in vehicles will become the dominant technology in the long term, which does not necessarily mean that they will have the same dominant position as today's internal combustion engines. On the way there, various hybrid variants will create an evolutionary transition. Technologies such as the plug-in hybrid (PHEV) will ensure that long-distance vehicles remain on the market.

An alternative storage technology are the so-called e-fuels, i.e. gaseous or liquid fuels that can be produced using electricity. Here, electricity is de facto used to synthetically reproduce the fuels used today from water and air. The end product of this process can be molecular hydrogen ($H_2$), pure methane ($CH_4$) or a pure hydrocarbon that is already found in diesel or gasoline. Only (renewable) electricity, water and $CO_2$ are required as raw materials for production. These are therefore climate-neutral fuels if the electricity comes from renewable sources and the $CO_2$ from the ambient air.

### Chemical background knowledge

The production process of synthetic fuels can be outlined as follows. In the first step, the electrolysis process splits water ($H_2O$) into pure hydrogen ($H_2$) and pure oxygen ($O_2$). The $H_2$ is suitable for energetic use and contains almost three times as much energy per ton as petrol, for example. Hydrogen can either be burned in a vehicle in an internal combustion engine or converted back into electricity in a fuel cell. However, the distribution and storage of hydrogen in a vehicle is comparatively difficult. This is mainly due to the low volume-specific energy content of the $H_2$, which must be extremely compressed (~700 bar) in order to store sufficient energy in a vehicle. Among other things, this requires a specialized and cost-intensive supply infrastructure (Puls, 2006, 70f.). For this reason, there is a lot to be said for further processing of the $H_2$ in order to be able to integrate the energy carrier better into existing supply systems.

The next conversion step is methanization. The hydrogen is converted into methane ($CH_4$) via the addition of carbon dioxide ($CO_2$). This process requires the use of larger amounts of energy, especially in the form of heat. The energy requirement of methanization increases when the concentration of $CO_2$ drops. When ambient air is used, the energy requirement is therefore much higher than when a $CO_2$ source such as a power plant is available. The gas produced in this way – also known as power-to-gas or PtG – can be distributed over the natural gas network and used in any natural gas car already available today. Natural gas filling stations already exist in large numbers and due to the higher volume-specific energy content of methane, it does not have to be compressed so much when stored in the vehicle (~200 bar). A further conversion step can be carried out with the addition of additional energy. By using Fischer-Tropsch synthesis (Puls, 2006, 39f.) a long-chain hydrocarbon can be produced from the $CH_4$ molecules, as it is found in today's gasoline or diesel. This power-to-liquids (PtL) substance is chemically comparable to an extremely pure gasoline and could be distributed over the existing supply network and used in any modern vehicle.

The chemical digression refers to the chemical-physical framework conditions of e-fuels: The more chemical conversions are carried out, the better the synthetic fuel fits the existing system. PtL is currently the only method of using renewable electricity in today's vehicle fleet and thereby reducing emissions from the fleet.

## Batteries are efficient – but currently not suitable for heavy trucks or air and sea travel.

Every transformation requires the use of energy, which goes hand in hand with conversion losses. The more often the energy source is converted, the less of the originally used electricity arrives in the vehicle as usable energy. Looking at the PtG process, a process efficiency of 56% currently seems conceivable. About 44% of the energy used is therefore lost on the way from the electricity supply to the filling station (well-to-tank). If the PtG is then burned in an engine, two thirds of the energy used is lost and only the rest is converted into kinetic energy. The energy efficiency of the entire process (well-to-wheel) will therefore in all probability be below 20%.

In battery systems, on the other hand, more than two thirds of the current energy fed into the grid can be converted into motion. As a result, the use of synthetic fuels significantly increases the electricity requirements of the transport sector. The current state of the art does not allow us to predict whether batteries will achieve the volume- and weight-specific energy densities that are particularly necessary in the transport of goods. Synthetic fuels will therefore play an important role in the energy supply of transport, despite their rather poor energy efficiency.

Various studies (dena, 2017; BDI, 2018) have shown that e-fuels will be indispensable in the long term to achieve the ambitious climate targets for transport. The dena study found that in 2050 at least 70% of the energy requirements of EU-28 transport – by air and sea – must be covered by e-fuels (Siegemund, 2018, 197). The majority would be used in aircraft and ships. The demand for road transport, on the other hand, depends on the reduction targets to be implemented in 2050. The possible range is between 80% and 95%. The 95% target means complete decarbonization of transport, which in this case means that the need for e-fuels is significantly higher than the lower target. Due to the described energy losses in the production of e-fuel, this has a correspondingly drastic effect on the demand for renewable electricity.

According to dena, decarbonization in the transport sector – including international sea and air transport – would create electricity demand equivalent to 1.7 to 3 times current electricity production in the EU-28, depending on the scenario. dena states the electricity requirements of the transport sector – including international sea and air transport – in 2050 at a minimum of 4,700 TWh and a maximum of 8,450 TWh. The amount of electricity required depends on the decarbonization target pursued. According to the study, this high electricity demand can be covered most cost-effectively by imports of synthetic fuels. For imports from North Africa, production costs of one euro per liter of diesel equivalent are considered possible in 2050. The current cost is 4.5 euros per liter. It therefore seems possible to produce synfuels at reasonable costs in the future. Synfuels are currently the only option for decarbonizing today's vehicle fleet. In view of the targets for 2030, it is advisable to tackle the topic early, even if the costs for a market launch are too high up to now.

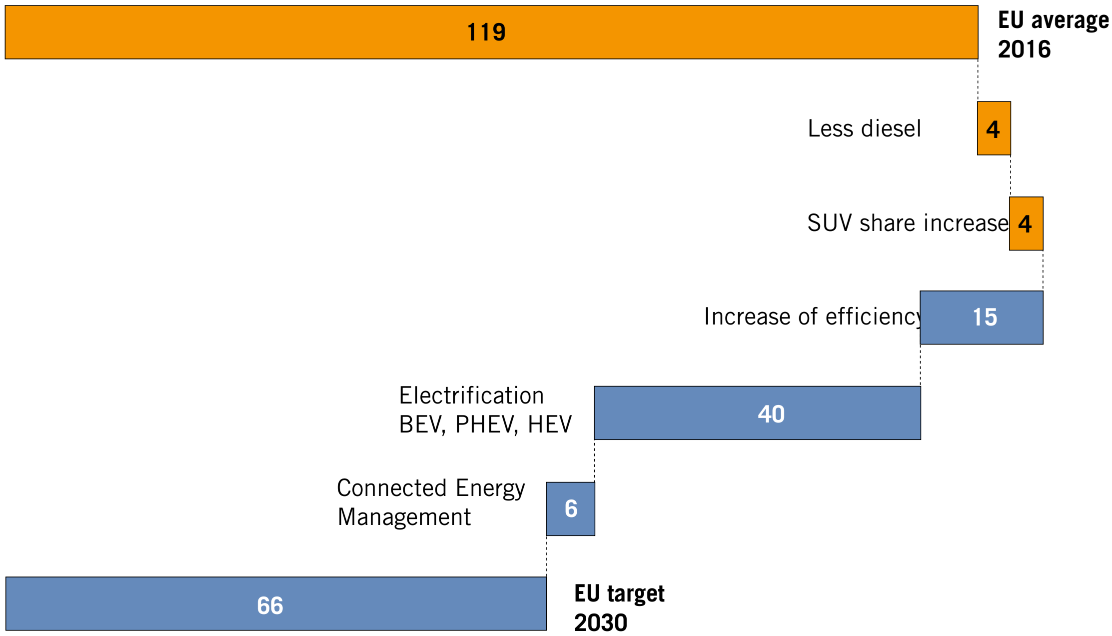
## The transport sector has an enormous energy demand – the electricity sector is the natural partner.

Regardless of whether batteries, synfuels or even catenary vehicles will be used on our roads in the future – the electrification of the transport sector will have to follow in the coming years and decades. The climate policy guidelines leave no room for another approach. The question today is no longer whether the transport sector will switch to electricity as a primary energy source, but how. This process will not take place abruptly, but evolutionarily. This allows for the possibility of preparing the conversion of the energy supply for road traffic to electricity as the primary energy source. Above all, the supply structure must be adapted, because without sufficient interfaces between the transport and electricity sectors, a change is not possible.

The same applies to regulation. So far the regulation is comparatively simple and unproblematic for traffic. When electricity is used in the vehicle, all emissions are generated in the electricity sector. The same applies to railroad electricity. Due to the low number of electric vehicles, this is no serious distortion yet. However, the long-term growth of an electrified transport sector will have a drastic impact on overall electricity demand.

The demand for electricity in road transport could rise quite rapidly in the coming decade. Various major vehicle manufacturers are now setting targets for the share of

**Figure 1.13: $CO_2$ reduction path in passenger cars by 2030 – electrification must address it**
Figures in grams per kilometer




Source: Continental, 2018

electric vehicles (battery electric vehicles (BEV) and plug-in hybrids (PHEV) in global sales of 20% to 25% by 2025. The supplier industry also expects a massive wave of electrification in the passenger car sector, as without this step the future $CO_2$ targets for new cars can no longer be met. In order to meet the EU-28 target values for 2030, the electrification of the drive train must already generate the lion's share of the savings. This means, on the one hand, the widespread use of full hybrids, but also the widespread use of BEV and PHEV, which will at least partially shift their emissions to the electricity sector. An expected distribution of future reduction benefits in the existing limit value system is shown in Figure 1.13.

In the limit value system, the current shift away from diesel and the trend towards more and more SUVs will lead to higher emissions from the new vehicle fleet by 2030. If emissions targets are to be reached, this must be more than compensated for, above all, by ever more extensive electrification of the drive train, because the classic methods of increasing efficiency no longer have the potential to achieve the future target values. The additional demand for electricity cannot be quantified, but by 2030 at the latest the trend towards electricity-based mobility will have to accelerate enormously.

## 1.8 Quo vadis transport sector?

***The transport sector is at a critical point in its development. Decarbonizing road transport can only succeed as part of an overall strategy. The gradual electrification of the transport sector is on the horizon for the future. This can only be achieved by sector coupling.***

Increasing electrification strengthens the coupling of the electricity and transport sectors. The electricity sector is increasingly supplying the necessary transport energy. Thus, sector coupling between the transport sector and the electricity sector is the prerequisite and integral component for the sustainable development of climate policy. The various drive and storage technologies must therefore be further developed and become market-ready. A technology-open promotion and support of research is a fundamental prerequisite for this.

The development of the necessary supply infrastructure, from the expansion of the distribution networks to the production of synfuels, is a long-term project for which the right course must now be set. Without a sufficient number of public interfaces between the transport and electricity sectors, the comprehensive coupling of the two sectors cannot be achieved, and the switch to electricity as the primary energy source could only be made by a comparatively small user group with its own supply points. The development of the supply infrastructure is a considerable economic challenge, as the operation of the required interfaces has not yet been a business model. Today, the operation of public charging stations is a subsidy business. The production of e-fuels today is also prohibitively expensive.

→ A prerequisite for successful sector coupling is the provision of the corresponding interface infrastructure.

In addition, regulatory challenges have to be met. Sector-specific instruments can play an important role as an accompanying and transitional solution. One example of this is the measurement of energy and fuel taxes according to their $CO_2$ content. This would create a uniform tax base which would facilitate further coupling. The existing energy tax on fuels would be rebased in such a way that diesel and petrol vehicles would be taxed on the basis of their emissions. At the same time, the motor vehicle tax would have to be adjusted, which up to now has been a counter-entry to the lower taxation of diesel.

The instrument of the $CO_2$-based energy tax could be an approach to standardizing the assessment bases if the further framework conditions are set accordingly. The existing limit value regulation for new vehicles only addresses manufacturers and the emission potential of newly registered vehicles. Direct taxation based on real emissions includes the vehicle condition and thus also those who decide on the actual emissions of a vehicle on the basis of its mileage and driver's behavior.

→ The transport sector will continue to rely on conventional fuels such as petrol, diesel and natural gas until they are fully electrified.

In summary, the transport sector is already undergoing a major transformation process towards the electrification of the drive system. Various technologies, such as the fuel cell or battery-powered vehicles, are available. Until it is fully electrified, the sector will continue to rely on conventional fuels such as gasoline, diesel or natural gas. Against the background of the necessary reduction of greenhouse gas emissions, both electric and conventional drives must make their contribution. Electric drives must prove their marketability in terms of economy and meeting customer requirements; conventional drives must continue to achieve efficiency improvements and thus reduce their emissions.

The concrete transformation process will vary greatly depending on the sub-segment of the transport sector. The energy storage requirements of cars, trucks, ships and airplanes are too different to be based on a uniform solution such as the internal combustion engine. There is currently much to suggest in the passenger car sector that the battery-electric vehicle will establish itself in large market segments in the long term. For the long-distance transport of goods by land and sea, but also for air transport, the signs are different. There is much to be said for the use of e-fuels, which will also play an important role in the debate on the future energy supply of the transport sector.

**Binding, long-term reduction targets combined with targeted pricing of emissions allows for planning security and facilitate investment decisions.**

The steadily increasing electrification in the transport sector links it closely to the electricity sector and brings with it additional requirements. The generation of transport energy in the electricity sector increases demand for electricity and shifts emissions to the electricity sector. So far there has been no integrated consideration of cross-sectoral emissions and thus no effective cross-sectoral measures to reduce them. Instruments such as fuel taxes have little effect on mobility strategies in the short term. This applies to both private consumers and companies. The ability to plan mobility decisions is therefore crucial – binding, long-term reduction targets combined with targeted pricing of emissions allows for planning reliability and facilitate investment decisions.

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# Energy in Germany

4.1 Facts & Figures

2

# 4.1 Facts & Figures

***In 2017, 462.3 million tons of coal equivalent (tce) of energy were consumed in Germany. Germany ranks seventh in the ranking of the world's largest energy markets. However, after the USA, China and Japan, Germany achieved the world's fourth highest economic performance. Per unit of gross domestic product, energy consumption in Germany is half the global average. 70% of energy consumption in Germany was covered by imports in 2017. Russia is the most important supplier of energy raw materials. Renewable energies and lignite are the only domestic energy sources. Renewable energies contributed 36% to Germany's electricity supply in 2017. Measured in terms of gross electricity consumption, their share has thus increased more than fivefold since 2000.***

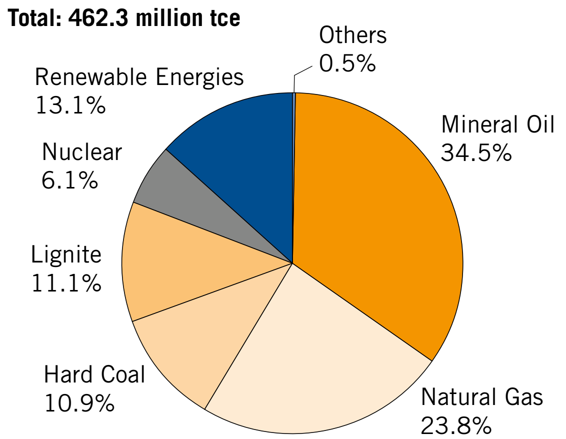
## Key data of the German energy market

In 2017, 462.3 million tce energy were consumed in Germany, corresponding to 319 million tons of oil units (2016: 458.1 million tce). This puts Germany in seventh place in the ranking of the world's largest energy markets after China, the USA, Russia, India, Japan and Canada. Per capita energy consumption in Germany amounts to 5.6 tce per year. This is twice the global average and half the comparable figure for the USA.

Taken the goods and services generated as a benchmark, energy is used very efficiently in Germany: Energy consumption in 2017, for example, reached around 142 kg ce per €1,000 gross domestic product. On a global average, this specific energy consumption is twice as high.

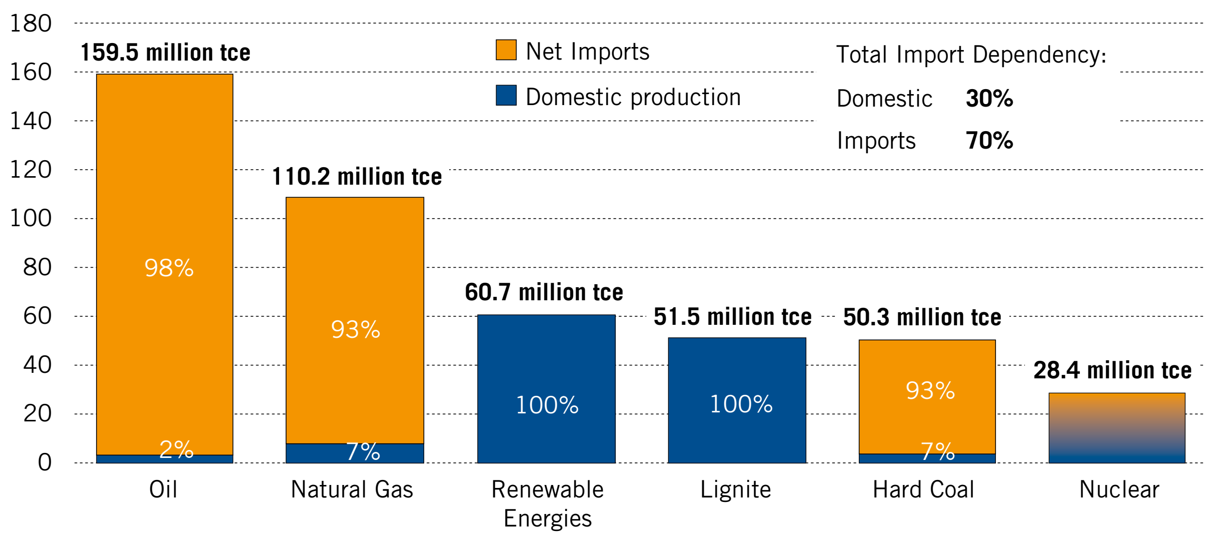
Between 1990 and 2017, overall economic energy efficiency – measured as primary energy consumption per

**Figure 4.1: Primary energy consumption in Germany by energy source 2017**



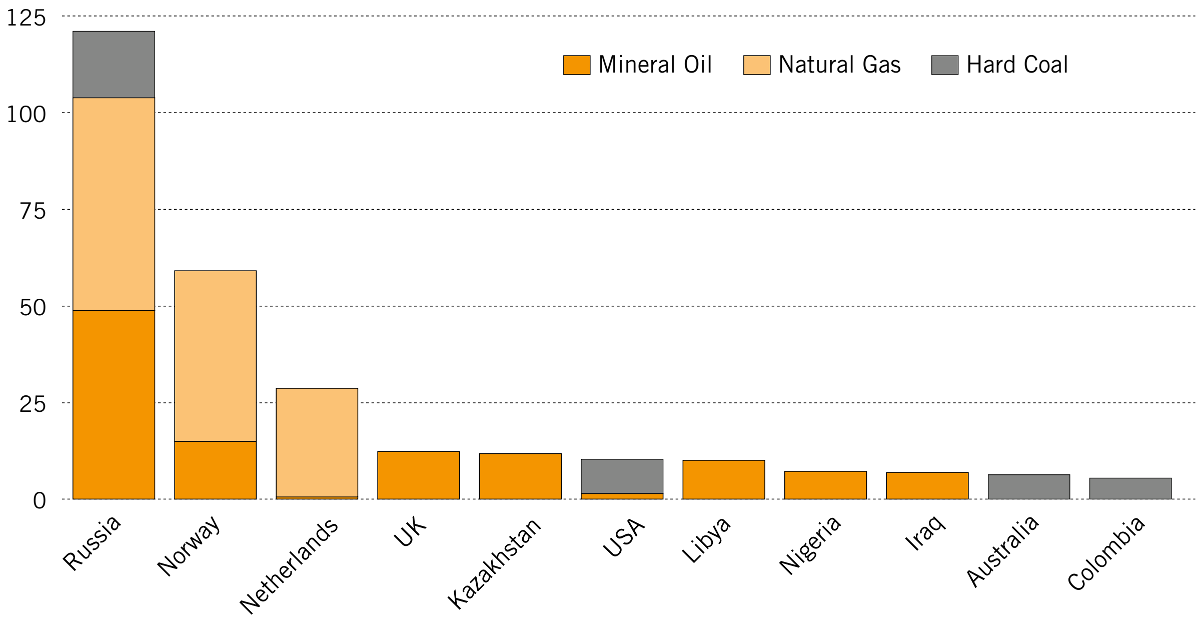

Source: Arbeitsgemeinschaft Energiebilanzen, March 2018

**Figure 4.2: Germany's dependence on energy imports in 2017**




Source: Arbeitsgemeinschaft Energiebilanzen, March 2018 (Percentages calculated as shares of domestic subsidies in the respective primary energy consumption); including other energies, such as the above-mentioned foreign trade balance for electricity, of 1.7 million tce, the total primary energy consumption amounts to 462.3 million tce.

**Figure 4.3: Energy raw material suppliers 2017**
Figures for Germany in million tce




Source: H.-W. Schiffer (ermittelt auf Basis BAFA)

unit of real gross domestic product – improved by around 38%.

**Taken the goods and services generated as a benchmark, energy is used very efficiently in Germany.**

Germany's own energy reserves are low. The country is therefore particularly dependent on imports. Imports account for more than 90% of primary energy requirements for mineral oil, natural gas and hard coal. Renewable energies and lignite are the only domestic energy sources that Germany has on a larger scale.

In 2017, 30% of the energy consumption was covered by domestic energies. In 2017 (2016), renewable energies contributed 61.6 (58.1) million tce to domestic energy production, followed by lignite with 52.6 (52.7) million tce. Domestic production of natural gas amounted to 7.9 million tce (8.6) in 2017, of hard coal to 3.7 (3.9) million tce, of mineral oil to 3.8 (4.0) million tce and of other energies, such as the non-biogenic proportion in household waste to 8.2 (8.4) million tce.

Import energies cover 70% of energy consumption. Energy imports are diversified according to energy sources and countries of origin. Germany's most important suppliers of energy raw materials in 2017 were Russia, Norway, the Netherlands, Great Britain, Kazakhstan, Libya, the USA, Nigeria, Iraq, Australia and Colombia.

Russia ranks first among Germany's most important suppliers of energy raw materials for crude oil, natural gas and hard coal. Germany obtains crude oil and natural gas from Norway. The focus of deliveries from the Netherlands is natural gas. Crude oil in particular is imported from Great Britain. Germany imports crude oil from Kazakhstan, Libya, Nigeria and Iraq. The USA, Australia and Colombia were the most important suppliers of hard coal after Russia in 2017.

**Russia ranks first among Germany's most important suppliers of energy raw materials for crude oil, natural gas and hard coal.**

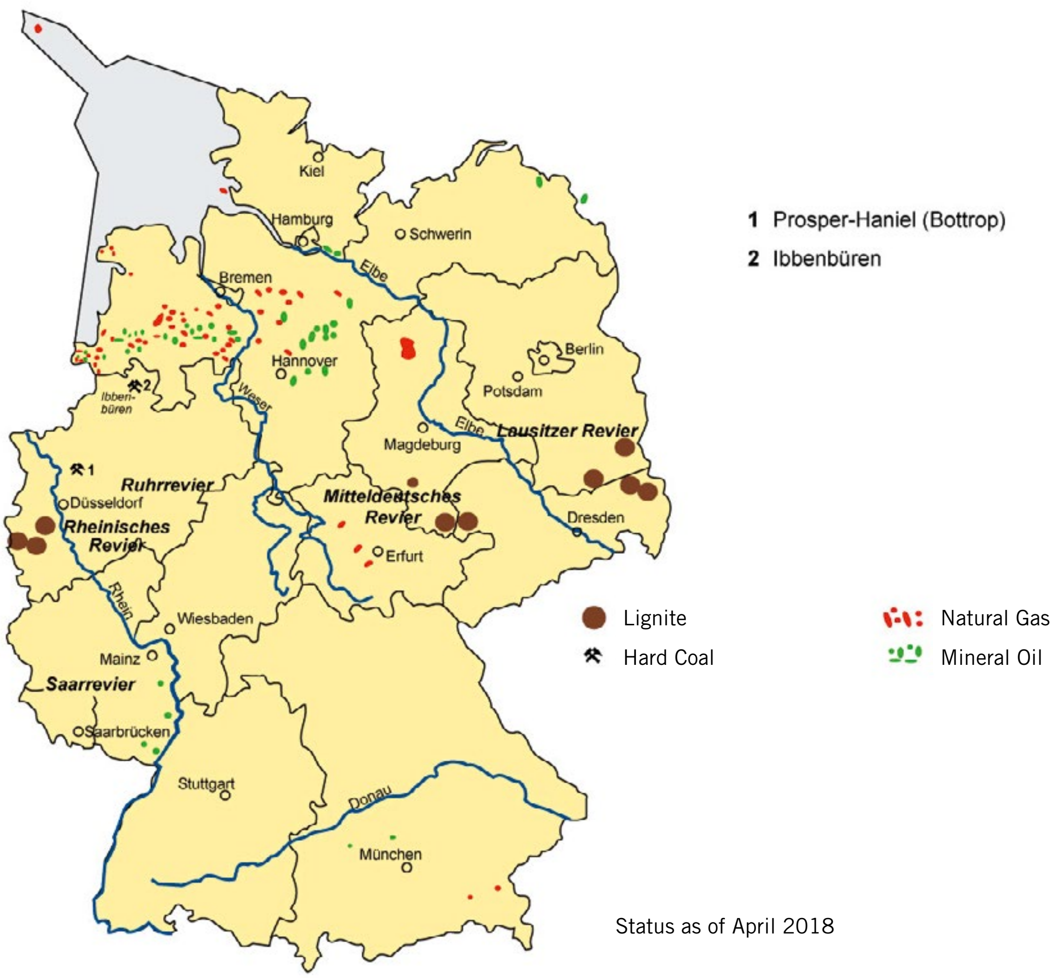
On the basis of data from the Federal Statistical Office, the balance of foreign trade in energy sources increased by 24% from €49.1 billion in 2016 to €60.8 billion in 2017, an increase of €11.7 billion. This increase is mainly due to price developments on the international oil markets. Net oil imports accounted for the largest part of Germany's net import invoice at €38.6 billion (2016: €31.3 billion). Imports of natural gas held the second most important position at €18.6 billion (2016: €16.0 billion). Coal accounted for €5.2 billion (2016: €3.5 billion) and uranium for €0.2 billion (2016: €0.1 billion). The export balance for electricity is €1.8 billion (2016: €1.8 billion).

## Electricity

In 2017, total gross electricity generation amounted to 654.7 TWh. Of this figure, 91.5% was attributable to power plants operated by the energy utilities (including plants operated by third parties) and 8.5% to industrial power plants.

Deducting the power plants' own consumption of 34.2 TWh, net electricity generation for 2017 is 620.5 TWh. The structure of net electricity generation by input energy showed the following picture in 2017: renewable energies 34.4%, lignite 22.0%, hard coal 13.6%, natural gas 13.5%, nuclear energy 11.6%, and heating oil and other energies 4.9%.

**Figure 4.4: Focuses of energy production**




Source: H.-W. Schiffer, Energiemarkt Deutschland

| Table 4.1: Installed capacity of power generation plants in Germany | | |
|---|---|---|
| **Source of Energy** | **Net capacity at the end of 2016 MW** | **Net capacity at the end of 2017 MW** |
| Lignite | 21.033 | 21.033 |
| Nuclear | 10.799 | 10.799 |
| Hard coal | 27.711 | 25.341 |
| Natural gas | 29.606 | 29.645 |
| Mineral oil products | 4.728 | 4.474 |
| Renewable energies, of which: | 104.024 | 112.404 |
| Wind power onshore | 45.384 | 50.251 |
| Wind power offshore | 4.150 | 5.429 |
| Hydropower | 5.598 | 5.605 |
| Photovoltaics | 41.275 | 43.300 |
| Biomass | 7.578 | 7.780 |
| Geothermal | 39 | 39 |
| Pumped storage | 5.710 | 5.710 |
| Other energies | 6.421 | 6.440 |
| **Total** | **210.032** | **215.846** |

As of February 2018 Source: BDEW, VGB, Federal Network Agency, AGEE Stat

The installed capacity of the power generation plants amounted to 215,846 MW (net) towards the end of 2017. A good half of this was accounted for by renewable energies. The power plant capacity based on conventional energies was distributed as follows: 29,645 MW for natural gas, 25,341 MW for hard coal, 21,033 MW for lignite, 10,799 MW for nuclear energy and 4,474 MW for oil. In addition, pumped-storage power plants with 5,710 MW also contributed to securing electricity supplies in Germany. In view of the strong expansion of plants based on renewable energies, installed capacity in the area of general supply is now two and a half times as high as the annual peak load.

The average utilization of power generation plants varies considerably – depending on technical availability, natural conditions (water, wind and sun) and the economic efficiency of the various plants, among other factors. The German Association of Energy and Water Industries (BDEW) has determined the following annual full load hours for 2017:

- Nuclear energy: 6,880
- Lignite: 6,490
- Biomass: 5,720
- Running and storage water: 3,570
- Hard coal: 3,570
- Wind offshore: 3,690
- Natural gas: 2,820
- Wind onshore: 1,820
- Oil: 1,130
- Pumped storage: 1,020
- Photovoltaics: 940

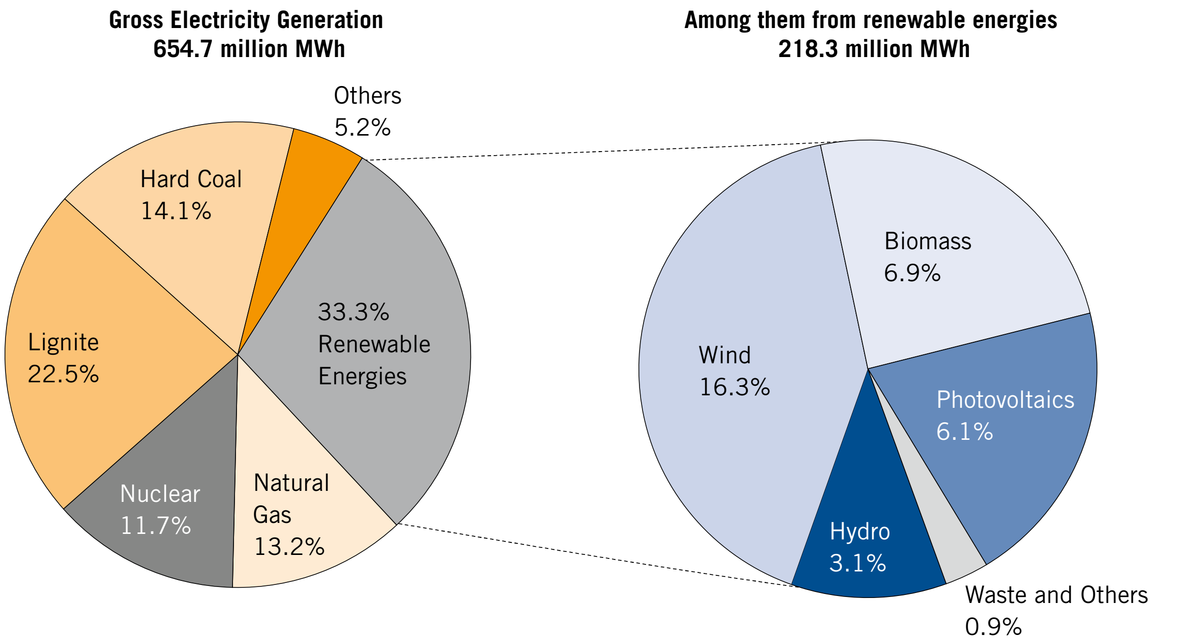
The full load hours characterize the plant utilization. This indicator is based on net output and the 8,760 hours of the year. Significant changes in performance during the year are taken into account accordingly.

**In view of the strong expansion of renewable energies, installed capacity in the area of general supply is now two and a half times as high as the annual peak load.**

Production at German sites was supplemented by imports of electricity, which amounted to around 28.4 TWh in 2017. Electricity exports amounted to 83.3 TWh in 2017. Electricity imports increased by 5.2% compared to the previous year. Electricity exports increased by 3.2%. The balance of exports and imports amounted to 54.9 TWh in 2017, compared with 53.7 TWh in 2016.

Gross electricity consumption reached 599.8 TWh after 596.9 TWh in 2016. 2017 net electricity consumption of 530 TWh (excluding grid losses and power plant own consumption) was distributed among industry (46.9%),

**Figure 4.5: Energy mix in power generation 2017**




Source: BDEW, February 2018

with 24.3% among private households (26.6%) among trade and commerce, public institutions and agriculture and 2.2% among transport.

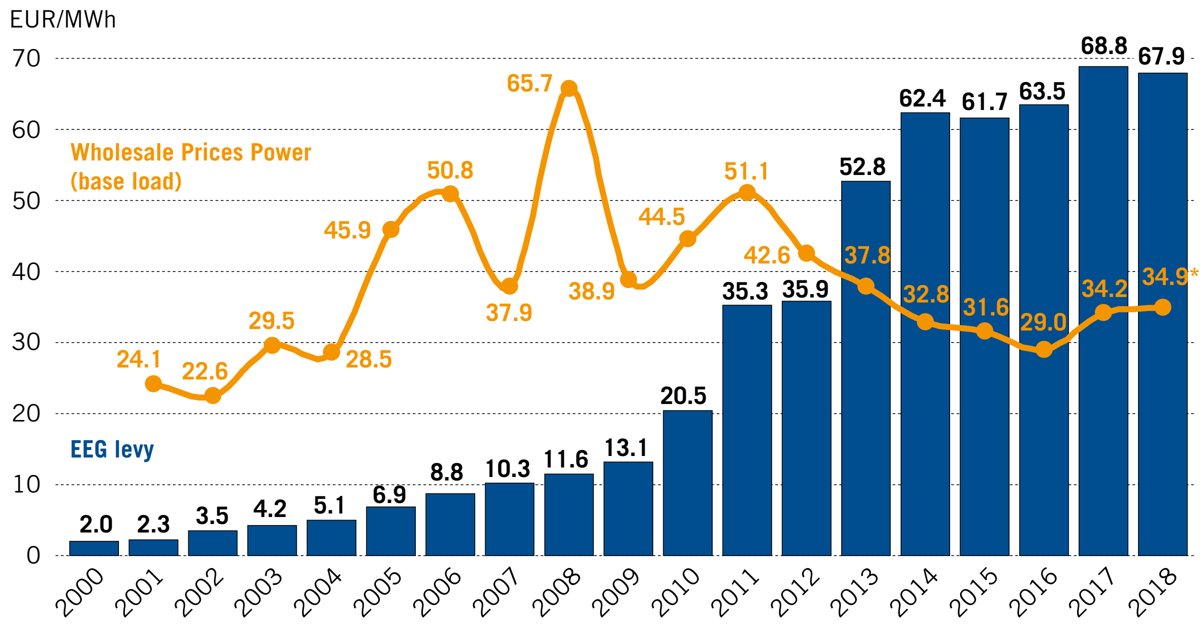
## Renewable Energies

Renewable energies accounted for 13.1% of primary energy consumption in 2017. Energy is provided by renewable energies to generate electricity and to cover heat and fuel consumption. With a share of 57.1% – measured in terms of primary energy consumption from renewable energies – the use for electricity generation was the most important in 2017. 5.5% of the primary energy consumption of renewable energies was used in power plants to generate heat (district heating). Consumption at conversion (including losses) amounted to 1.4%. The final energy consumption of renewable energies accounted for 36%.

According to BDEW, renewable energies accounted for 218.3 TWh (2016: 189.4 TWh) or 36.4% of Germany's electricity supply (gross generation as measured by gross domestic consumption) in 2017 (2016: 31.8%). Net electricity generation from renewable energies amounted to 213.3 TWh in 2017. Wind energy accounted for 104.6 TWh, photovoltaics for 39.9 TWh, hydropower for 20.0 TWh and other renewable energies (in particular biomass) for 48.7 TWh. In the case of water, pumped storage power plants without natural inflow are not classified as renewable energies. Overall, electricity generation from renewable energies increased by 15.6% in 2017 compared with 2016. The strong increase in electricity generation from renewable energies was due to more favorable wind conditions than in 2016 and the construction of additional plants.

Wind power recorded the strongest capacity growth in 2017. Net additions to onshore wind turbines (WEA) amounted to 4,867 MW. In addition, 222 offshore wind turbines (OWEA) with an output of 1,250 MW fed into the grid for the first time in 2017. According to Deutsche WindGuard GmbH, 1,792 onshore wind turbines with a capacity of 5,334 MW were installed in Germany in 2017. This represents an increase of 15% over the previous year. This makes 2017 the strongest year in terms of expansion since the start of wind energy development in Germany.

**Figure 4.6: Development of wholesale prices for electricity and EEG levy 2000 to 2018**




* As of February 12, 2018 (average 2nd quarter 2018 to 1st quarter 2019)

Source: EEX and information platform of German transmission system operators

According to the data collected, the gross addition contains 315 repowering plants with an output of 952 MW; repowering in this statistic refers to WEA for the construction of which an old plant was dismantled in the same or adjacent district. In addition, 387 wind turbines with a total capacity of 467 MW were dismantled in 2017. This results in a net capacity increase of 4,867 MW for 2017. As at 31.12.2017, the cumulative onshore wind turbine inventory rose to 28,675 WEA with 50,251 MW.

2017 is the strongest new-build year since the beginning of wind energy development in Germany.

The average onshore wind turbine built in 2017 had a capacity of 2,976 kW, a rotor diameter of 113 m and a hub height of 128 m.

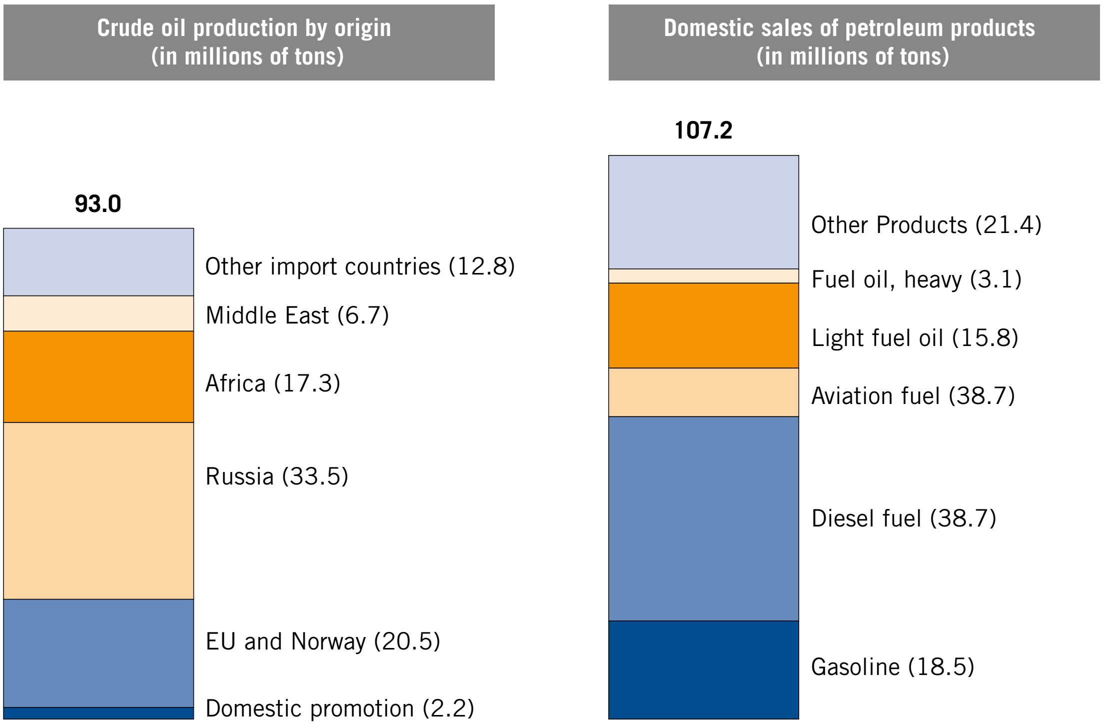
The distribution of the additional wind energy capacity in the federal states in 2017 is as follows: In Lower Saxony, around 1,436 MW or 27% of the total newly installed capacity in Germany in 2017 were built. North Rhine-Westphalia takes second place in a nationwide comparison with 870 MW newly installed capacity. Schleswig-Holstein ranks third with 552 MW, followed by Brandenburg with 535 MW, Baden-Württemberg with 401 MW, Hesse with 280 MW and Bavaria with 261 MW. These seven federal states account for 81% of the total nationwide expansion.

Lower Saxony leads the list with 10,582 MW. Second and third place are Schleswig-Holstein with 6,863 MW and Brandenburg with 6,794 MW installed capacity. This is followed by North Rhine-Westphalia with 5,449 MW, Saxony-Anhalt with 5,118 MW, Rhineland-Palatinate with 3,400 MW, Mecklenburg-Western Pomerania with 3,253 MW and Bavaria with 2,493 MW.

According to Deutsche WindGuard GmbH, 222 offshore wind turbines (OWEA) with a capacity of 1,250 MW fed into the grid for the first time in 2017. In addition, the nominal capacity of six existing plants was increased by a total of 29 MW in the course of 2017. As a result, the total capacity of the OWEA feeding into the grid increased to 5,429 MW by the end of 2017.

The average capacity of the systems with grid feed-in is 4,609 kW. The plants, which fed into the grid for the first time in 2017, have an average installed nominal output of 5,644 kW. The average rotor diameter of these new plants

**Figure 4.7: Origin of crude oil and domestic sales in Germany in 2017**




Source: BAFA

is 138 m. The average elevation of the facilities added in 2017 is 96 m above sea level. The average distance to the coast of all feeding OWEA in Germany is 64 km. On average, these OWEA are located in 29 m deep water.

**50% of the installed electricity generation capacities of renewable energies are wind farms.**

The installed photovoltaic capacity increased from 41,275 MW at the end of 2016 to 43,300 MW at the end of 2017.

The capacity of all plants installed on the basis of renewable energies increased to 112,404 MW by the end of 2017. Wind farms account for half of the total electricity generation capacity installed in Germany on the basis of renewable energies.

The total feed-in volumes supported by the Renewable Energy Sources Act (EEG) were forecast for 2017 at 187.2 TWh (2016 according to subsequent annual accounts: 161.5 TWh). The EEG levy amount relevant for the EEG levy increased from €22.9 billion in 2016 (actual revenue from EEG levy according to subsequent annual accounts) to €24 billion in 2017 (according to the forecast of the transmission system operators of October 16, 2017). It consists of three components, which are estimated as follows for 2017[6]:

- the EEG differential costs for renewable energies forecast for the following calendar year (€24.4 billion),
- the liquidity reserve, a provision for possible deviations from the forecast (€1.5 billion), and
- the account settlement as of September 30 of the previous year (€-1.9 billion).

The total ex ante EEG remuneration payments for 2017 amount to €30 billion (calculated ex post for 2016: €27.5 billion). The remuneration payments are offset by a calculated market value of €4.7 billion (ex ante forecast) for EEG electricity volumes. In 2016, the figure was €4.3 billion (ex-post). Taking into account the avoided grid fees and other costs and income of €0.9 billion (2016: €1 billion), differential costs of €24.4 billion (ex ante) for 2017 compared to €22.2 billion (ex post) in 2016, which does not include the account settlement and liquidity reserve, which reflect the pure promotion costs of the respective calendar year. The EEG levy to be paid by non-privileged final consumers, which amounted to 6.88 ct/kWh in 2017 (2016: 6.35 ct/kWh), has been reduced to 6.792 ct/kWh for 2018.

The final energy consumption of renewable energies totaling 21.8 million tce in 2017 was distributed by consumption sectors as follows:

- Industry: 4 million tce
- Transport: 3.8 million tce
- Households and commercial/ trade/services: 14 million tce

Biomass and waste attributed to renewable energies were used in industry. In the transport sector, biofuels were used by blending them with petrol and diesel fuels. In the household and commercial/trade/services sectors, the use of biomass dominated, followed by geothermal and solar energy.

## Mineral Oil

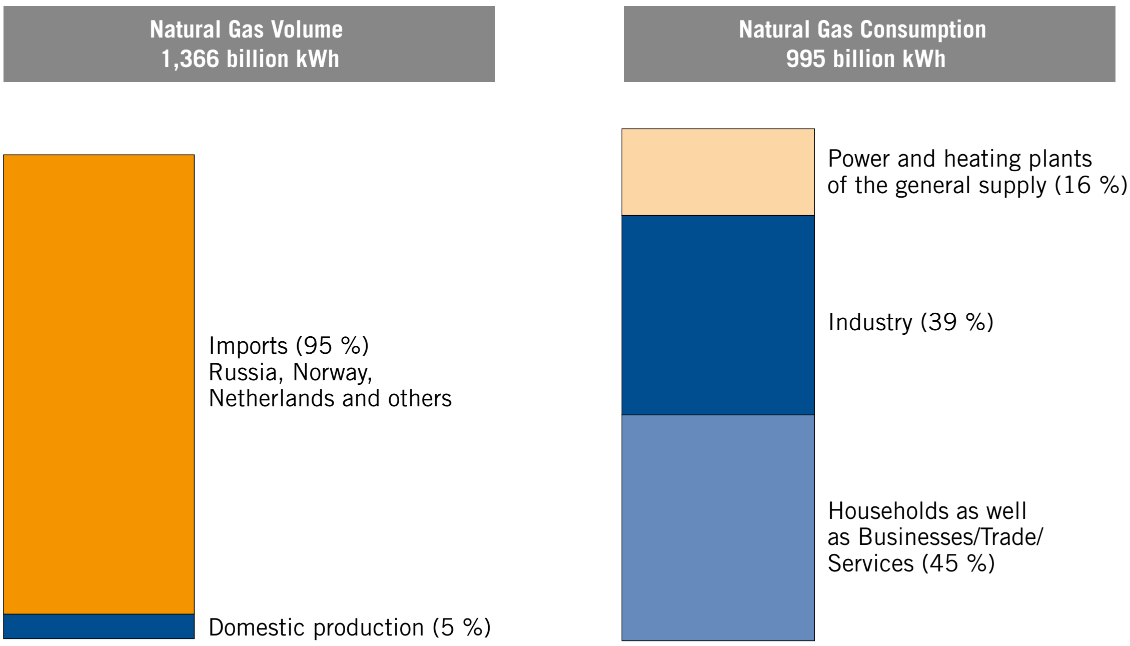
The basis for the supply is crude oil imports, as only 2% of requirements can be covered by domestic production. In 2017 (2016) they amounted to 90.7 (91.2) million tons. In addition, imports of mineral oil products contributed 41.7 (38.8) million tons to meeting demand.

In 2017, 23% of crude oil imports came from Western and Central Europe (mainly the North Sea), 49% from Eastern Europe/Asia, 19% from Africa, 7% from the Middle East and 2% from America. The OPEC share was 24%.

In Germany, crude oil and semi-finished products are processed in 13 refineries. With crude oil processing capacity of 102.1 million tons per year as of December 31, 2017, refinery capacity utilization reached 90.6%. Refinery production amounted to 104.6 million tons.

Domestic sales of mineral oil products (including biofuels: 3.4 million tons) amounted to around 107.2 million tons in 2017. The main products are fuels mainly used in road transport (gasoline: 18.53 million tons; diesel: 38.65 million tons), light heating oil with a focus on the space heating market (15.85 million tons), crude petrol (16.64

**Figure 4.8: Natural gas volume and consumption in Germany in 2017**




Source: BDEW

million tons), aviation fuel (9.74 million tons), liquid gas (4.5 million tons) and heavy heating oil (3.14 million tons).

**In 2017, 23% of crude oil imports came from Western and Central Europe (mainly the North Sea), 49% from Eastern Europe/Asia, 19% from Africa, 7% from the Middle East and 2% from America.**

Gasoline sales increased by 1.6% in 2017 compared with 2016. Demand for diesel fuel increased by 2%. This is primarily the result of increased demand from the transport industry due to the favorable economic situation. Sales of light heating oil rose by 0.3% in 2017 compared with the previous year. Deliveries of raw gasoline in 2017 were 5.3% higher than in 2016. Sales of jet fuel, which had amounted to around 9.2 million tons in 2016, increased by 6.1% compared with the previous year. Heavy heating oil grew by 8.3%. According to the Federal Office of Economics and Export Control (BAFA) surveys, a particularly strong increase of 45.3% compared to 2016 was recorded for liquefied petroleum gas.

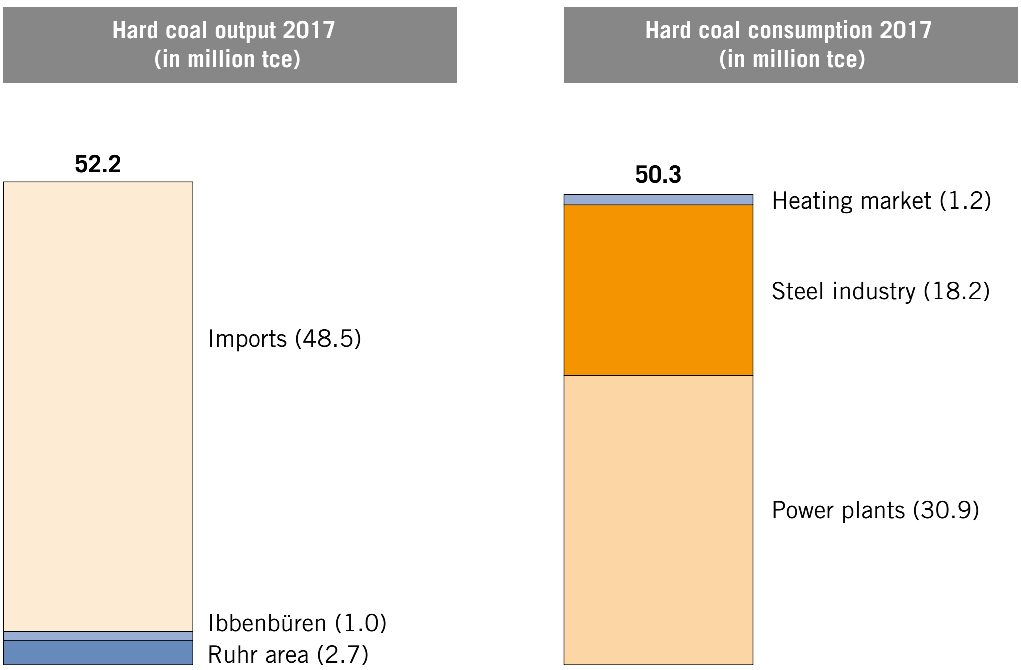
The breakdown of total domestic sales volumes by consumption areas in 2017 was as follows:

- Transport: 60%
- Industry: 21%
- Households and small consumers: 17%
- Power plants: 2%

## Natural Gas

Natural gas consumption in 2017 (2016) was around 995 (936) TWh, corresponding to 101.8 (95.8) billion $Nm^3$. 45% was consumed by households and small-scale consumption (HuK). This is due not least to the large number of gas-heated apartments. At the end of 2017, around 50% of all apartments had natural gas heating. Industry accounted for 39% of natural gas consumption. The use in power plants of electricity and heat

**Figure 4.9: Hard coal production and consumption in Germany in 2017**




* The difference between production and consumption is explained by changes in inventories.

Source: Statistics of the Coal Industry e. V.; as of February 2018 suppliers accounted for 16%. The main reasons for the 6% increase in consumption in 2017 compared to the previous year were the increased demand for natural gas from industry and the HuK sector as well as the increased use of natural gas in power plants for electricity and heat generation as a result of improved margins in power generation.

Natural gas supplies in Germany are based on a diversified reference base. In 2017, 5% of the 1,366 TWh of natural gas came from domestic production and 95% from imports from various sources: Russia is the most important supplier, followed by Norway and the Netherlands. With the liberalization of the energy markets, spot and futures markets for natural gas have developed rapidly. Gas trading at the European hubs is growing significantly overall. At today's virtual trading points, significant supply and demand-based price signals are generated for the European and thus also German market.

In 2017, 5% of the natural gas volume of 1,366 TWh came from domestic production and 95% from imports from various sources.

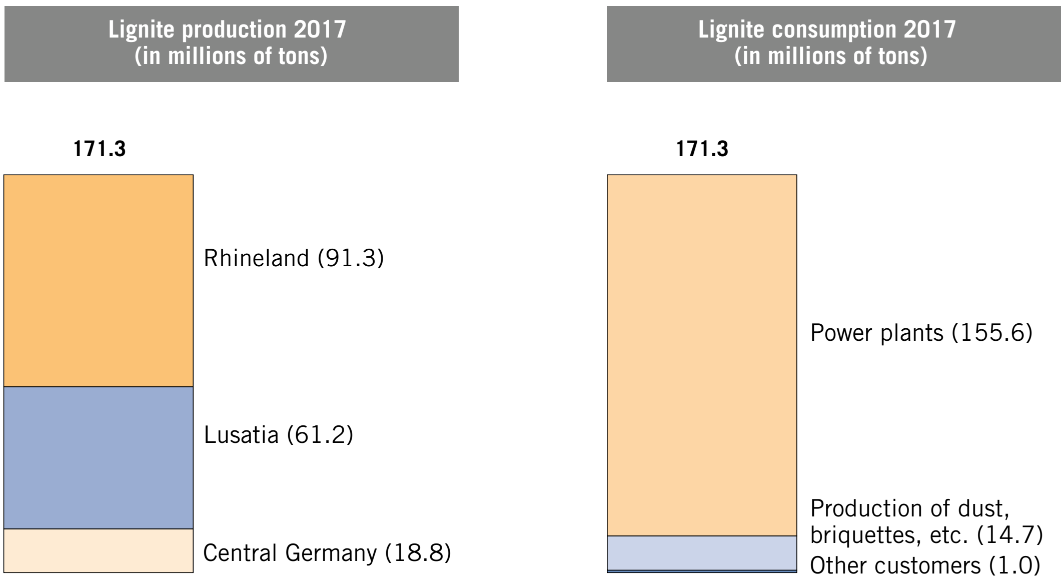
An extensive pipeline network with a total length of around 500,000 km is available for the transport and distribution of natural gas and is integrated into the European transport systems. The infrastructure also includes a large number of underground storage facilities. As part of the 2017 monitoring, the Federal Network Agency and the Federal Cartel Office recorded 37 underground natural gas storage facilities with a maximum usable working gas volume of 25.3 billion $Nm^3$. Cavern storage facilities account for 11.8 billion $Nm^3$, porous storage facilities for 11.5 billion $Nm^3$ and other storage facilities for 2 billion m3. This corresponds to a quarter of the amount of natural gas consumed annually in Germany. The German gas industry thus has the largest storage volume in the EU.

## Hard Coal

In Germany, around 3.7 million tce hard coal were mined in 2017. The Ruhr area accounted for 73% and Ibbenbüren colliery for 27%.

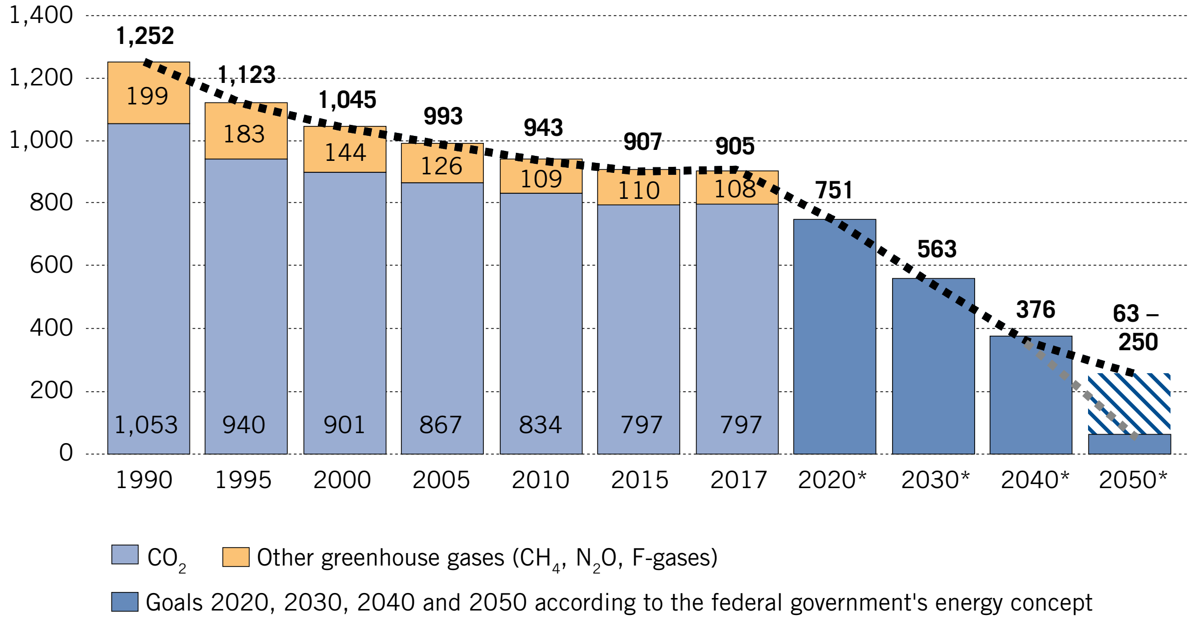
Following the closure of the Auguste Victoria mine on January 1, 2016, two pits are still in operation in Germany. These are Ibbenbüren colliery and Prosper-Haniel colliery in Bottrop.

**Figure 4.10: Lignite production and consumption in Germany in 2017**




Source: DEBRIV

**Figure 4.11: Emissions of greenhouse gases in Germany 1990 to 2017 and targets until 2050**
in million t $CO_2$ equivalents




* Reduction of 40% by 2020, 55% by 2030, 70% by 2040 and 80% to 95% by 2050 – each compared with 1990 levels.

Source: Federal Environment Agency, National Greenhouse Gas Inventory 1990–2016, EU submission, as of January 2018

In 2017, 48.5 million tce hard coal were imported into Germany. This corresponded to 93% of total hard coal production. With a share of 35.2%, Russia further expanded its position as the most important supplier country in 2017. With a share of 18.4%, the United States came in second place. Australia ranked third in the German coal import ranking with a share of 13%. Imports from Colombia accounted for 11.1%. Therefore, more than three quarters of Germany's total imports of hard coal and coke came from the four countries of origin mentioned.

With a share of 35.2%, Russia further expanded its position as the most important supplier country in 2017.

Total coal consumption in Germany in 2017 amounted to 50.3 million tce. It was distributed to power plants with 30.9 million tce, to the steel industry with 18.2 million tce and to the heating market with 1.2 million tce.

As part of the gradual phasing-out process, the last two mines will be shut down at the end of 2018.

## Lignite

In Germany, around 171.3 million tons of lignite – corresponding to 52.6 million tce – were mined in 2017, exclusively in opencast mining. 0.023 million tce were imported. Domestic production thus accounted for 99.9% of total production.

German lignite production in 2017 was concentrated in three regions: The Rhenish district in the west of Cologne, the Lusatian district in the north-east of Dresden and the Central German district in the vicinity of Leipzig. In 2017, 53.3% of total funding went to the Rhineland, 35.7% to the Lausitz region and 11% to central Germany.

The main focus of lignite use is electricity generation. In 2017, 153.2 million tons of lignite were delivered to power plants for general supply. This corresponded to almost 90% of total domestic production.

## Table 4.2: Greenhouse gas emissions in Germany 1990 to 2017

| | 1990 | 2000 | 2005 | 2010 | 2016 | 2017 |
|---|---|---|---|---|---|---|
| **Greenhouse gas emissions** | | | **million t $CO_2$ equivalents** | | | |
| Carbon dioxide ($CO_2$) | 1,053.0 | 901.0 | 867.2 | 833.7 | 801.8 | 797.3 |
| Methane ($CH_4$) | 120.2 | 87.7 | 68.4 | 58.1 | 54.4 | 54.1 |
| Nitrous oxide ($N_2O$) | 65.0 | 43.1 | 43.3 | 36.6 | 37.9 | 38.1 |
| HFC‘s | 5.9 | 8.2 | 10.0 | 10.8 | 11.1 | 15.3 |
| PFC‘s | 3.1 | 1.0 | 0.8 | 0.3 | 0.3 | |
| Sulphur hexafluoride ($SF_6$) | 4.4 | 4.1 | 3.3 | 3.2 | 3.9 | |
| Nitrogen trifluoride ($NF_3$)** | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | |
| **Total emissions** | **1,251.7** | **1045.0** | **993.1** | **942.8** | **909.4** | **904.7** |
| **Carbon dioxide emissions** | | | **million t** | | | |
| **Energy** | **989.8** | **840.1** | **812.1** | **784.7** | **754.1** | **748.7** |
| *from combustion of fuels* | **985.7** | **836.8** | **808.8** | **781.9** | **751.7** | **746.3** |
| Mineral oils | 319.0 | 317.4 | 288.2 | 259.6 | 252.1 | 258.1 |
| Natural gas and mine gas | 116.9 | 158.4 | 165.1 | 176.0 | 168.2 | 176.2 |
| Hard coal | 202.1 | 178.7 | 164.8 | 159.4 | 142.0 | 124.0 |
| Lignite | 339.4 | 170.4 | 176.3 | 166.6 | 167.4 | 166.4 |
| Others | 8.2 | 11.9 | 14.5 | 20.2 | 22.0 | 21.5 |
| *diffuse (fugitive) emissions* | 4.1 | 3.3 | 3.2 | 2.8 | 2.4 | 2.4 |
| **Industry** | **60.0** | **58.1** | **52.8** | **46.7** | **44.9** | **45.9** |
| Mineral products | 23.5 | 23.4 | 20.3 | 19.2 | 19.6 | 20.0 |
| Chemical Industry | 8.1 | 8.4 | 8.8 | 8.3 | 5.6 | 5.6 |
| Manufacture of basic metals | 25.1 | 23.5 | 21.1 | 16.4 | 17.1 | 17.7 |
| Non-energy fuel products | 3.3 | 2.8 | 2.6 | 2.7 | 2.5 | 2.5 |
| **Agriculture*** ** | **3.2** | **2.8** | **2.3** | **2.3** | **2.8** | **2.8** |
| **Total******** | **1,053.0** | **901.0** | **867.2** | **833.7** | **801.8** | **797.3** |
| **Carbon dioxide emissions** | | | **million t** | | | |
| **Emissions trading sector*** ** | ** | ** | **474.0** | **454.8** | **452.9** | **437.7** |
| Including: | | | | | | |
| Energy | ** | ** | 379.0 | 357.2 | 329.6 | 311.8 |
| Industry | ** | ** | 95.0 | 97.6 | 123.3 | 125.9 |
| **Non-emissions trading sector** | ** | ** | **393.2** | **378.9** | **348.8** | **359.9** |
| Including: | | | | | | |
| Transport | 161.9 | 180.7 | 160.0 | 152.8 | 165.0 | 168.8 |
| Private households | 128.6 | 117.8 | 111.0 | 105.5 | 90.3 | 90.3 |
| Businesses/trading/services | 64.1 | 45.5 | 40.0 | 40.0 | 37.4 | |
| Others****** | ** | ** | 82.2 | 80.6 | 56.1 | 100.5 |
| **Total** | **1,053.0** | **901.0** | **867.2** | **833.7** | **801.8** | **797.3** |

* No information available at the time of going to press.

** European Emissions Trading Scheme from 2005

*** $CO_2$ emissions from agriculture include emissions from soil liming and the use of urea.

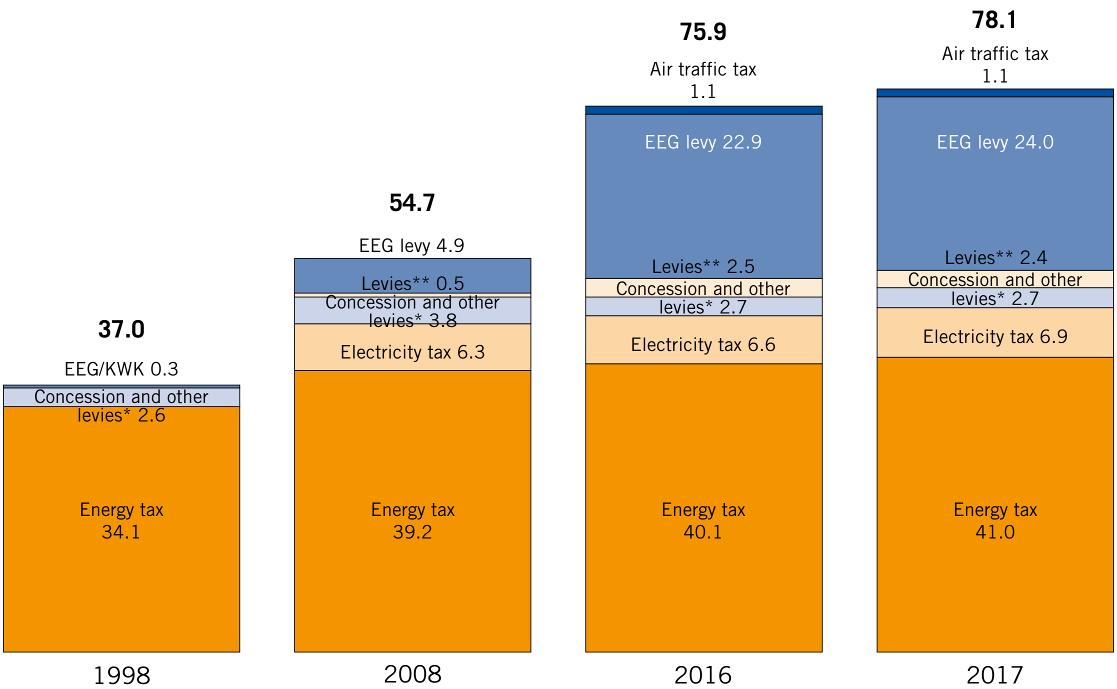
**** Total emissions excluding land use, land-use change and forestry.

***** From 2008 including plants in the chemical industry and „further processing of steel“.

****** Industrial plants and energy conversion outside emissions trading (e.g. plants FWL below 20 MW).

Sources: Federal Environment Agency, National Greenhouse Gas Inventory 1990-2016, EU submission, January 2018; DEHSt, evaluation of the first trading period 2005 to 2007; VET Report 2010 and VET Report 2016, Greenhouse gas emissions from stationary installations subject to emissions trading and in the air traffic in Germany in 2016, May 2017; Federal Environment Agency, Press Release No. 4 of 23 January 2018; for 2017: Federal Environment Agency, Press Release No. 8/2018 of 26 March 2018 and No. 9/2018 of 10 April 2018.

**Figure 4.12: Energy taxes and levies in Germany 1998 to 2017**
in billion Euros




* Figures partly estimated; of which: concession fees €2.0 billion in 1998, €2.17 billion in 2008 and €2.15 billion in each year 2016 and 2017; production levy for natural gas and crude oil: 1998: €0.14 billion, 2008: €1.22 billion, 2016: €0.234 billion, 2017: €0.249 billion and crude oil stockholding levy: €0.5 billion in 1998, €0.35 billion in 2007/08, €0.37 billion in 2008/09, €0.285 billion in the financial year 2014/15, €0.293 billion in 2015/16 and €0.281 billion in 2016/17 (excluding VAT).

**KWG G, § 19-StromNEV levy, offshore liability levy and levy for loads that can be switched off

**The main focus of lignite use is electricity generation.**

After the power plants of the general supply, the processing plants represent the most important acceptance area of raw lignite. In 2017, 14.7 million tons of lignite were used to produce solid products and 2.5 million tons in lignite mining power plants. From this 6.7 million tons of marketable products such as briquette, brown coal dust, fluidized bed coal and coke were produced in the refining plants of the mining industry. Sales to other customers amounted to 0.9 million tons.

Total gross electricity generation from lignite amounted to 147.5 TWh in 2017. In 2017, the breakdown by federal states was as follows: North Rhine-Westphalia: 75.4 TWh, Brandenburg: 32.7 TWh, Saxony: 32.2 TWh, Saxony-Anhalt: 6.7 TWh and Lower Saxony, Berlin, Hesse, Bavaria and Baden-Württemberg: 0.5 TWh.

## $CO_2$-Emissions

$CO_2$ emissions in Germany fell slightly in 2017 – including industrial processes and agriculture – compared with 2016. The positive economic trend in particular led to a slight increase in energy consumption. Increased fuel consumption is an indication that $CO_2$ emissions in the transport sector have increased. The situation is different in power generation, where $CO_2$ emissions are expected to have fallen by 14 million tons to around 292 million tons in 2017 from 306 million tons in 2016, according to the Federal Environment Agency.

The main reasons for this were the ongoing expansion of plants, particularly on the basis of wind and PV, and good wind conditions. The resulting significant increase in electricity generation based on renewable energies was offset by a decline in electricity production, primarily from hard coal. Over the entire period 1990 to 2017, total non-temperature-adjusted $CO_2$ emissions fell by 256 million tons, corresponding to 24.3% to 797 million tons.

Total greenhouse gas emissions – including other greenhouse gases such as methane – fell by 27.7% from 1,252 million tons of $CO_2$ equivalents in 1990 to 905 million tons of $CO_2$ equivalents.

## Energy taxes and other charges

In total, the federal government generated €49,087 million from the collection of excise duties on energy in 2017, €1,353 million more than in 2016, €36,594 million of which was accounted for by fuels in 2017, or around 75%. Natural gas contributed €3,184 million to the total volume. Heating fuels other than natural gas – in particular heating oil – generated revenues of €1,244 million.

An amount of €6,944 million has been determined for electricity tax. The federal government generated revenues of €1,121 million from the air traffic tax levy in 2017. The revenues from nuclear fuel tax, which – like the air traffic tax – had been introduced on 1 January 2011, had to be repaid to the nuclear power plant operators in 2017 due to a decision of the Federal Constitutional Court. This was €7,262 million. The cash outflow from specific energy taxation adjusted for this repayment thus amounted to €41,825 million in 2017.

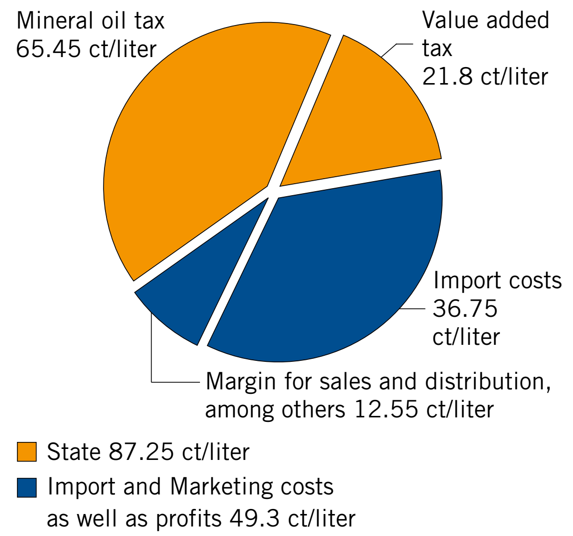
**In total, the federal government generated €49,087 million – in relation to 2017 – from the collection of excise duties on energy, which is €1,353 million more than in 2016.**

Excise duties account for a varying share of product prices. A mineral oil tax of 65.45 ct/liter is levied on gasoline. The corresponding value for diesel fuel (also for sulphur-free goods) is 47.04 ct/liter. If VAT is also taken into account (since January 1, 2007: 19%), a tax share of 65% (super gasoline) or 57% (diesel fuel) of the product price is calculated for 2017.

For light heating oil, the share of taxes (consumption tax and value added tax) – measured in terms of the product price to be paid by private households – amounted to 27% in 2017. For natural gas, taxes and duties (natural gas tax, concession fees and value added tax) accounted for 26% of the 2017 household customer price.

The electricity price, which is estimated to average 29.86 ct/kWh (April 1,2016: 29.80 ct/kWh) for private households with annual consumption between 2,500 and 5,000 kWh as of April 1, 2017, is composed as follows (volume-weighted price level for all contract categories in ct/kWh):

**Figure 4.13: Gasoline price 2017: State share of 64%**
Average price of super gasoline: 136.55 ct/liter



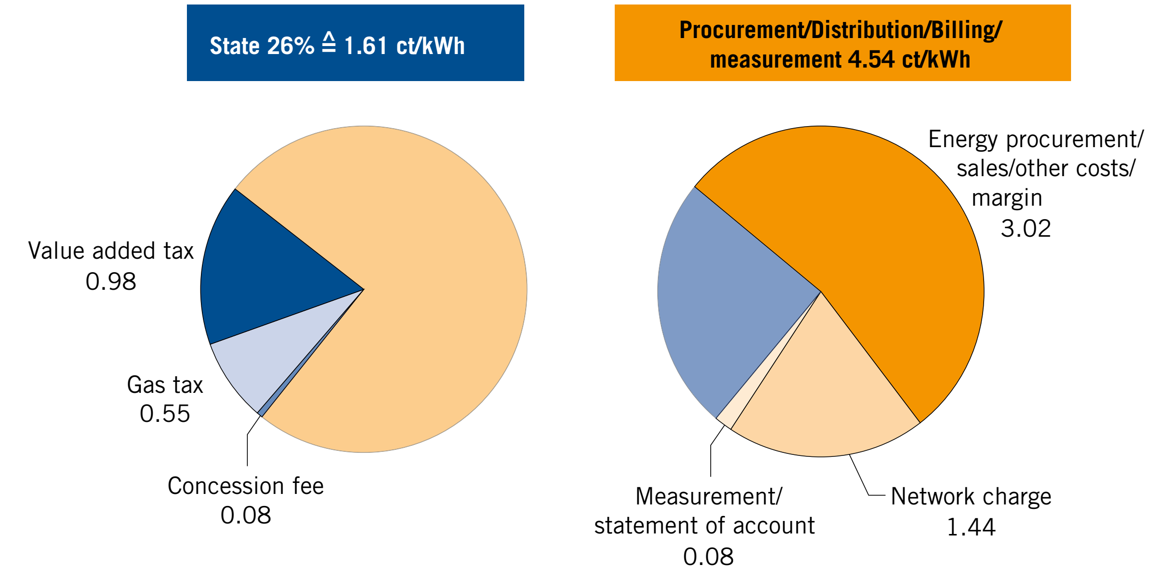

* Marketing costs (domestic transport, warehousing, legal stockpiling, administration, distribution and costs for the admixture of biocomponents) and profit; as of February 2018

Source: Mineralölwirtschaftsverband

| | |
|---|---|
| • Energy procurement, sales and margin: | 6.42 (2016: 7.34) |
| • Net network charge including settlement: | 6.99 (2016: 6.45) |
| • Fees for measurement and measuring point operation: | 0.32 (2016: 0.34) |
| • Concession fee: | 1.62 (2016: 1.65) |
| • EEG levy: | 6.88 (2016: 6.35) |
| • KWKG levy: | 0.44 (2016: 0.45) |
| • § 19 Electricity NEV levy: | 0.39 (2016: 0.38) |
| • Offshore liability charge: | – 0.03 (2016: 0.04) |
| • Allocation for loads that can be switched off: | 0.01 (2016: 0.00) |
| • Electricity tax: | 2.05 (2016: 2.05) |
| • Value added tax: | 4.77 (2016: 4.76) |

Thus, the state-induced share of the household electricity price amounted to 54% in 2017 (2016: 52.6%).

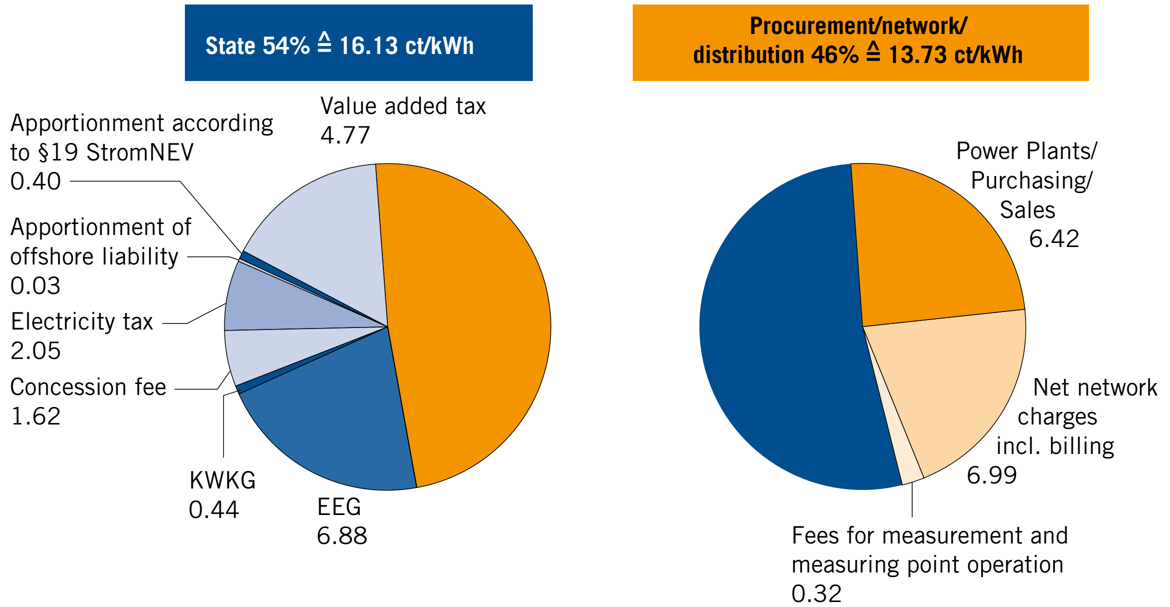
**Figure 4.14: Composition of the price of gas used to supply household customers in 2017**
(6.15 ct/kWh)




Quantity-weighted average value for deliveries by the basic supplier within the scope of special contracts for the case of purchase between 5,556 kWh and 55,556 kWh per year as of 1 April 2017

Source: Monitoring Report 2017 of the Federal Network Agency and the Federal Cartel Office, Bonn, 2017, p. 390

**Figure 4.15: Composition of electricity prices for private households 2017**
(29.86 ct/kWh)




* including levy for loads that can be switched off

Quantity-weighted average over all contract categories with annual consumption between 2,500 and 5,000 kWh as of 1 April 2017

Source: Monitoring Report 2017 of the Federal Network Agency and the Federal Cartel Office, Bonn, November 2017, p. 231

# WEC intern

World Energy Council und Weltenergierat – Deutschland

5.1 Boards of the World Energy Council – Germany

5

## World Energy Council

The World Energy Council (WEC) was founded in London in 1923. Today it comprises around 100 national committees representing over 90% of the world's energy production. The WEC is the platform for the discussion of global and long-term issues in the energy industry, energy policy and energy technology. As a non-governmental, non-profit organization, the WEC forms a global competence network that is represented in industrialized, emerging and developing countries in all regions.

The activities of the WEC cover the entire spectrum of energy sources and the associated environmental and climate issues. This makes it the only cross-energy global network of its kind. Since its foundation, its goal has been to promote the sustainable use of all forms of energy – for the benefit of all people.

To this end, the WEC conducts studies and technical and regional programs. Every three years the WEC hosts the most important international energy conference, the World Energy Congress. The aim of this multi-day event is to promote a better understanding of energy industry issues and solutions from a global perspective.

www.worldenergy.org

## Weltenergierat – Deutschland

The World Energy Council – Germany (Weltenergierat – Deutschland) represents the German energy industry in the World Energy Council (WEC). It includes companies in the energy industry, associations, scientific institutions and individuals. As a non-profit association, WEC Germany is independent in its opinion-forming. All energy sources are represented in the Presidium of the association.

Aim of WEC Germany is the implementation and dissemination of the WEC results in Germany, in particular to ensure that the global and longer-term aspects of energy and environmental policy are also taken into account in national discussions.

To this end, WEC Germany is working intensively on the positions and studies of the WEC. In addition, it organizes its own events, conducts its own studies and provides an annual overview of the most important energy industry data and perspectives for the world, Europe and Germany in its publication “Energy for Germany”.

www.weltenergierat.de

# 5.1 Boards of the World Energy Council – Germany

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