CO$_2$ regulation in Europe

A compendium – Version 4.3
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CO₂-Regulation in Europe  2
The core theses: Brief overview

Climate protection

1. Europe’s share of the worldwide CO₂ emissions is low and continuously decreasing. (100)

2. No solution without China: Europe’s reduction of emissions is being eaten up by growth in emerging economies. (103)

3. Motor vehicles account for approximately one-seventh of the CO₂ emissions in the EU. Their share in transportation emissions is declining. (106)

CO₂ regulation for motor vehicles

4. New vehicles in Europe have become considerably more efficient in recent years. (108)

5. CO₂ legislation in Europe shows the most stringent target values in an international comparison. (110)

6. Europe has once again tightened the reins on the CO₂ limit values for motor vehicles and is requiring a further reduction of CO₂ within an even shorter span of time. (112)

7. Der Pkw-Sektor ist auch ohne eine weitere Verschärfung der CO₂-Grenzwerte nach 2020 auf Kurs, um die Ziele der EU-Klimapolitik bis 2030 zu erfüllen. (114)

8. Vehicle fleet limit values under 95 grams cannot be achieved with conventional engine types, and the market success of alternative engine types is still uncertain. (116)

9. EU environmental legislation is not coherent and, for a long time, had other priorities than CO₂ reduction. This had various consequences, including an increase of CO₂ emissions. (119)

10. Today’s CO₂ laws regulate only new vehicles, completely disregarding the remaining vehicle fleet. (122)

11. An effective reduction of CO₂ emissions cannot address new vehicles alone but must take a much broader approach. (124)

Balance between climate protection and industrial policy

12. The EU is targeting a 20% industry share of GDP for the year 2020. This goal is presently a long way away, since industrial and climate protection policy are not yet aligned. (126)

13. The CO₂ abatement costs vary greatly between sectors and are most pronounced in the automotive sector. (129)

14. Emissions trading as the most economically efficient form of CO₂ regulation can easily be applied to road traffic. (131)
Agenda

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4. Other sectors
5. Outlook
The carbon cycle

Carbon reservoirs in billions of tonnes

- Atmosphere: 750
- Fossil fuels and cement production: 4,000
- Surface water: 1,020
- Deep sea: 38,100
- Sediments: 150
- Sea organisms: 3
- Vegetation: 610
- Soil: 1,580
- Photosynthesis and respiration
- Gas exchange between the ocean and atmosphere
- Combustion
- Dissolved organic carbon: <700

Megatrends:
- CO\textsubscript{2}-emissions
- Fuels
- Globalisation
- Political framework
- Transportation sector
- Other sectors
- Outlook

CO\textsubscript{2}-Regulation in Europe
Paris Climate accord: Urgent action required

Global Emissions in Gigatons CO$_2$eq

Quelle: Climate Action Tracker Project, September 2019
CO₂ emissions: Europe’s share sharply decreasing

Emissions from fuel use, in millions of tonnes

Compared to the year 1990, the absolute CO₂ emissions are decreasing in the EU only. Between 1990 and 2016 the EU decreased the emissions by approximately 815 Million tons.

At the current edge the US emissions are falling. In 2016 the emissions are converging to the emissions of 1990.

The impact of European regulations on global CO₂ emissions continues to decline.

Source: IEA, CO₂ Emissions from Fuel Combustion – 2019
Reduction in Europe, strong increase in Asia

Emissions from fuel use* – Changes between 1990 and 2017 in Millions of tonnes

While China shows an increase of 338 per cent during the years 1990–2017, the EU shows a decrease of 20.3 per cent.

In 2017 alone, China’s emissions increased by 200 million tonnes.

India increased its emissions since 1990 by 310 Percent and this value is still increasing.

* Corresponding to category 1A according to the UNFCCC classification system
EU passenger cars – Relevant, yet not crucial

CO₂ emissions in millions of tons

Relevant: Europe’s total passenger car traffic 2017 emitted 543 million tonnes of CO₂, an upward trend compared to 2015.

Crucial? China, on the other hand, is showing a strong upwards trend in its use of fossil fuels – emitting nearly 526 million tonnes of CO₂ in just three weeks.

Dynamic: between 2014 and 2015 the plus in China was about 60 millions of tons. In the following year the emissions increased by 8 million tons.

Sources: EEA, 2020 (v23; IEA, CO₂ Emissions from Fuel Combustion – 2020)
10 countries, two-thirds of the CO₂ emissions

CO₂ emissions for the year 2016, in millions of tonnes

- China: 9.302
- USA: 4.761
- India: 2.162
- Russia: 1.537
- Japan: 1.132
- Germany: 719
- Korea: 600
- Iran: 567
- Canada: 548
- Saudi Arabia: 532

Source: IEA, CO₂ Emissions from Fuel Combustion – 2019
Road transport is a major source in Europe

Emissions in the EU in the year 2018 in Megatons

1.110

873

950 Mt

3.953 Mt

503

517

Total Greenhouse Gas Emissions ¹)

Emissions of the Transport Sector ²)

232 Mt

113 Mt

543 Mt

Emissions of Road Transport

Energy

Industry

Transport

Agriculture

Other

Rail

Air (inland)

Road

Inland Waterways

HDV and Bus

Motorcycle

Car

LDV

Other

¹) With sinks
²) Without international Air and Sea traffic
Quelle: EEA, 2020 (V23)
Sector development

Greenhouse gas emissions in the EU 28 by sector, in millions of tonnes

Split development after the fall of the Iron Curtain

Traffic emissions increased quickly after 1990, since Eastern Europe was integrated into the European Economic Area. Emissions have been decreasing since 2007, even in the transportation sector, but began to rise again in 2014.

In the early 1990s, considerable reductions were visible in the industry and energy generation sectors. Their emissions levels stagnated until around 2007, then dropped with the economic crisis.

Source: EEA, 2020 (v23)
Global CO$_2$ emissions are continuously increasing, especially in Asia.

CO$_2$ emissions are declining only in Europe.

The reduction of emissions in Europe is hardly significant when viewed against the increase of emissions in Asia.

Today, European regulations have relatively little influence on global CO$_2$ emissions, and the influence is continuing to decline.

From the perspective of climate research, it is the overall volume of emissions at the global level which is relevant. The country or specific source of the emissions is essentially insignificant.
### Fuels: Well-to-wheel emissions are what counts

Comparison of emissions and alternative fuels

<table>
<thead>
<tr>
<th>Fuel</th>
<th>Consumption per 100 km (Vehicle from compact-class in NEDC)</th>
<th>price in € per</th>
<th>TTW CO₂ Emissions ln g CO₂ / Km</th>
<th>WTW GHG-Emissions ln g CO₂eq / km</th>
<th>price* in Euro per 100 km</th>
</tr>
</thead>
<tbody>
<tr>
<td>Super E5 (conventional)</td>
<td>4,9 L</td>
<td>1,40 L</td>
<td>115,72</td>
<td>144,93</td>
<td>6,86 €</td>
</tr>
<tr>
<td>Diesel B7 (conventional)</td>
<td>3,9 L</td>
<td>1,14 L</td>
<td>102,86</td>
<td>128,74</td>
<td>4,45 €</td>
</tr>
<tr>
<td>PHEV (Benzin E5 + Conv. Strom)</td>
<td></td>
<td>49,59</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LPG (Remote well)</td>
<td>6,4 L</td>
<td>1,57 L</td>
<td>104,37</td>
<td>127,93</td>
<td>3,66 €</td>
</tr>
<tr>
<td>Natural Gas (H-Gas, EU-Mix)</td>
<td>3,5 Kg</td>
<td>1,09 Kg</td>
<td>88,9</td>
<td>109,42</td>
<td>3,81 €</td>
</tr>
<tr>
<td>Electricity (D-Mix 2015)</td>
<td>12,7 kW/h</td>
<td>0,29 kW/h</td>
<td>0,0</td>
<td>74,55</td>
<td>3,71 €</td>
</tr>
<tr>
<td>Hydrogen (EU Mix)</td>
<td>0,97 Kg</td>
<td>9,50 Kg</td>
<td>0,0</td>
<td>134,2</td>
<td>9,22 €</td>
</tr>
<tr>
<td>Bioethanol E85 (wood)</td>
<td>5,88 L</td>
<td>0,99 L</td>
<td>112,31</td>
<td>35,91</td>
<td>5,81 €</td>
</tr>
<tr>
<td>Bioethanol E85 (grain)</td>
<td>5,88 L</td>
<td>0,99 L</td>
<td>112,31</td>
<td>119,69</td>
<td>5,81 €</td>
</tr>
<tr>
<td>Biodiesel B100 (Rapeseed)</td>
<td>4,29 L</td>
<td>1,43 L</td>
<td>121,41</td>
<td>85,99</td>
<td>6,13 €</td>
</tr>
<tr>
<td>Electricity (Regenerativ)</td>
<td>12,7 kW/h</td>
<td>0,29 kW/h</td>
<td>0,0</td>
<td>5,33</td>
<td>3,71 €</td>
</tr>
<tr>
<td>Hydrogen (Aircraft)</td>
<td>0,97 Kg</td>
<td>9,50 Kg</td>
<td>0,0</td>
<td>15,14</td>
<td>9,22 €</td>
</tr>
<tr>
<td>E-Gas (Regenerativ)</td>
<td>3,5 Kg</td>
<td>- Kg</td>
<td>88,9</td>
<td>5,21</td>
<td>n.e.</td>
</tr>
<tr>
<td>Synthetical diesel (Reg.)</td>
<td>3,9 L</td>
<td>- L</td>
<td>102,86</td>
<td>2,18</td>
<td>n.e. (not yet commercially available)</td>
</tr>
</tbody>
</table>

**Legend:**
- TTW: Tank-to-Wheel
- WTW: Well-to-Wheel
- CO₂eq – CO₂ Äquivalent

*price* indicates the price based on the emissions and fuel consumption.
High oil prices: Incentive for more efficient motor vehicles

Oil prices rise again in 2018
In US Dollar

But the supply is already declining
Number of active drilling towers in the USA

► Oil prices have greatly increased from the year 2000 till 2014.
► As a result of fracking in the USA, oil prices started to diverge in 2010.
► The supply side in the US is strongly linked with oil prices. Rising prices lead to an increase in active oil rigs and vice versa.

Source: Bloomberg, Baker Hughes (Stand June 2020)
Summary: Fuels

Various fuel types reveal a very different carbon footprint in the well-to-wheel analysis. Today, electricity and natural gas are the alternatives with the most favourable ratio of emission reductions to fuel costs.

The EU has a very high rate of dependence on imported energy carriers. This leads to cases of political dependence. Avoiding such dependencies is a key driver for European policy in the field of primary energy supply.

The development of oil prices creates innovative pressure on motor vehicle manufacturers, since fuel consumption is a key selling point. Even without regulation measures, customers would increasingly demand efficient vehicles.
The weights are shifting in the world GDP
1991 – 2017

Share of the world GDP* as percentage

The dominance of the industrialised countries is crumbling.
China’s significance is rapidly growing.

*Partly estimates or forecasts by the IWF
Source: IMF, 2019
Direct investments propel globalisation

Index for economic relations, 1980 = 100
1980 = 100, nominal figures

Globalisation means the establishment of global production structures through direct investments.

► Since 1980, the inventory of direct investments has grown at least five times as fast as international trade.

► Approximately one-third of international trade is already taking place in corporate networks.
The emphasis of the world economy is shifting more and more towards Asia. This trend is being fuelled by the establishment of production locations near the market. Already today, the European locations are in strong competition with the countries in the growth regions, and many European locations are losing ground. The significance of regulation in Europe is declining with the significance of the European economies. If European industrial locations are to survive in terms of global competition, the EU must provide better local conditions.
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The EU plans to clearly increase its pace

Stipulated reduction compared to 2005, as percentage

<table>
<thead>
<tr>
<th>Year</th>
<th>ETS*-Sektor</th>
<th>EU GHG target (Basis: 2005)</th>
<th>Non-ETS sector</th>
</tr>
</thead>
<tbody>
<tr>
<td>2020</td>
<td>-21%</td>
<td>-12%</td>
<td>-10%</td>
</tr>
<tr>
<td>2030</td>
<td>-43%</td>
<td></td>
<td>-30%</td>
</tr>
</tbody>
</table>

How?

- Emissions trading
- Establishment of a market stabilisation reserve
- Avoidance of relocation effects
- Incorporating binding national targets
- Supporting measures, e.g. emissions standards

After 2020, the non-ETS sector is expected to reduce twice as much in 10 years as it did during the previous 15.

The cost per reduced tonne of CO₂ will increase considerably.
The EU moves forward undeterred

The EU’s long-term targets, as percentage; base year 1990

- Reduction of greenhouse gas emissions
  - Target 2020: -20%
  - Forecast 2020: -21%
  - Proposal 2030: -40%

- Market share of renewable energy on gross final energy consumption
  - Target 2020: 20%
  - Forecast 2020: 21%
  - Proposal 2030: 27%

- Efficiency target: reduction of energy consumption per unit of GDP
  - Target 2020: -20%
  - Forecast 2020: -17%
  - Proposal 2030: -27%

Sources: BMWi, UBA, AGEB

- The European Commission predicts that the climate targets for 2020 will largely be reached.
- Even if the rest of the world has not joined in so far, the EU plans to increase its targets considerably after 2020.
Ten years faster: The German federal government exceeds EU targets

German federal government reduction targets, as percentage; base year 1990

- Market share of renewable energy on gross final energy consumption: Status 2018: 17%, Target 2020: 18%, Proposal 2030: 30%
- Reduction of primary energy consumption compared to 2008: Status 2018: -20%, Target 2020: -9%

Sources: BMWi, UBA, AGEB

► The German federal government is currently demanding additional efforts to reach the target for 2020.
► For the period after 2020, the stipulated pace of change will be dramatically increased.

CO₂-Regulation in Europe
Buildings and traffic

German federal government reduction targets, as percentage

- The target value for road traffic is 136–141 million tonnes of CO₂; value in 2016: 160.2 million tonnes of CO₂.
- The building sector will likely miss its target considerably.
- On January 1st 2018 53,861 battery electric cars and 44,419 Plug-In-Hybrids were licensed.

Sources: BMWi, IW Köln, KBA, UNFCCC, AGEB
Global climate policy is currently experiencing a crisis.

The EU enthusiastically advanced in the Kyoto process, but no one followed. Outside the EU, only the transition countries met their targets, which were very soft in the first place.

The EU will reach its climate targets – even after the economic distortions following 2008 – and plans to considerably increase its pace in climate protection in the period after 2020.

The federal government wants to go further than the EU. While traffic emissions are essentially on track, areas such as the building sector are far from being able to reach its targets.
The EU industrial sector: Collapse rather than rebirth

The manufacturing industry’s share of the gross value, as percentage

Source: Eurostat 2019

- EU target: The industrial sector is expected to have a 20 per cent share of the GDP in 2020
- Germany is reaching this target. The UK, Italy and France give cause for concern.
- Countries outside of Europe are improving quickly. Europe must respond in order to secure its position.
Progress in noise and safety targets

Noise targets: Noise emissions are expected to decline by up to 75 per cent.
EU vehicle noise limit values in dB (A)

Traffic safety: Ambitious targets
Road traffic fatalities in the EU 28 countries

- Since 1990, the EU has shown considerable progress and has set ambitious regulations concerning noise emissions and safety.
- Additional sound reduction and safety devices bring extra weight and changes to the car body.
- The further targets result in a measurable overconsumption of new vehicles.

Sources: EU, Eurostat
Nitrogen oxide emissions dropped by 46 per cent

Data for EU 28* in kilo tonnes, $\text{NO}_x$ emissions converted in $\text{NO}_2$

*Source: enep, 2019
Nitrogen oxide emissions in the EU 28

Data of 2017, in per cent of the No\textsubscript{x} emissions converted in NO\textsubscript{2}

**Emissions by Sector\(^1\)**

- **Public Energy and Heat Supply**: 13\%
- **Industry**: 26\%
- **Other Sectors**: 18\%
- **Households**: 8\%
- **Agriculture**: 8\%

**Transport by Modes**

- **Passenger Cars**: 25\%
- **Inland Air**: 11\%
- **Int. Air**: 28\%
- **Int. Shipping**: 28\%
- **Rail**: 6\%
- **Inland Waterways**: 9\%
- **HDV**: 17\%
- **LDV**: 13\%

Quelle: emep, 2019
NO$_2$: A European Problem

The 12 cities of the EU with the highest level of NO$_2$-Immissions in 2018

<table>
<thead>
<tr>
<th>Stadt</th>
<th>2018 in µg/m³</th>
<th>2010 in µg/m³</th>
<th>2006 in µg/m³</th>
</tr>
</thead>
<tbody>
<tr>
<td>London</td>
<td>84,7</td>
<td>98,3</td>
<td>110,6</td>
</tr>
<tr>
<td>Paris</td>
<td>80,2</td>
<td>95,5</td>
<td>91,1</td>
</tr>
<tr>
<td>Athens</td>
<td>70,9</td>
<td>83,2</td>
<td>85,7</td>
</tr>
<tr>
<td>Stuttgart</td>
<td>70,8</td>
<td>99,9</td>
<td>121,3</td>
</tr>
<tr>
<td>Darmstadt</td>
<td>66,6</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
<tr>
<td>Lyon</td>
<td>66,3</td>
<td>89,8</td>
<td>n.a.</td>
</tr>
<tr>
<td>Munich</td>
<td>66,2</td>
<td>98,7</td>
<td>97,5</td>
</tr>
<tr>
<td>Bukarest</td>
<td>62,8</td>
<td>65,2</td>
<td>126,4</td>
</tr>
<tr>
<td>Porto</td>
<td>62,4</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
<tr>
<td>Glasgow</td>
<td>60,6</td>
<td>84,0</td>
<td>68,4</td>
</tr>
<tr>
<td>Kiel</td>
<td>60,3</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
<tr>
<td>Florenz</td>
<td>60,1</td>
<td>101,8</td>
<td>71,6</td>
</tr>
</tbody>
</table>

Quelle: EEA – Air Quality Statistics, 2019
PM10 emissions in the EU 28
Data of 2017, in kilo tonnes fine dust (PM10)

Emissions by sectors

Transportation sector by transport modes

Source: enep, 2019
PM2,5 emissions in the EU 28
Data of 2017, in kilo tonnes of ultrafine dust (PM2,5)

Emissions by sectors

Transportation sector by transport modes

Source: enep, 2019
Summary: Regulation density and conflicting goals

$\text{CO}_2$ reduction is only one of the traffic-related targets being pursued by the EU.

In the past, traffic-related regulation measures were focused on exhaust emissions and transportation safety.

Huge advancements have been made in regard to safety and harmful emissions of motor vehicles; but this has resulted in a higher consumption of energy.

The top priority for the future should be the reduction of $\text{CO}_2$ emissions from motor vehicles.
Agenda

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Trucks are facilitating the Single European Market

The merging of the EU triggered tremendous growth in the area of freight transport.

- The creation of the Single European Market fuelled growth on both road and rail.
- Over 70 per cent of Europe’s freight is transported by truck.
- Between 2007 and 2014, freight transport in Europe has decreased by 9 per cent but now it is rising again.

Source: Eurostat, Transport in Figures 2019
High level of dynamics in air transport, but cars are the backbone

- Strong growth in air transport since the fall of the government monopoly.
- Considerable growth in rail transport since the EU started promoting national rail transport markets.
- Over 80 per cent of traffic is attributable to passenger transportation on roads. A stagnation has been evident since 2004

Source: Eurostat, Transport in Figures 2019
Official forecasts for freight transport in 2030

Trucks will continue to dominate the considerably growing transport market in billions of tonne kilometres

There is some evidence that the PRIMES Prognosis from 2013 is outdated. It predicts an increase in goods traffic between 2010 and 2015, while it actually heavily decreased (Folie 42).

Sources: EU, Trends to 2050, 2013; BMVI, Verflechtungsprognose 2030, 2014
Current forecasts for freight transport in 2030

Limited increase in road transport in comparison to the official prognosis

in billions of tonnes kilometres

The current prognosis covers 12 EU Countries with about 92 percent of total road transport. The coverage of rail and inland waterways is less sufficient.

Growth rates after 2015 hardly differ from the official forecast.

Official passenger transport forecasts for 2030

Cars will form the backbone of passenger transport for the long term

in billions of passenger kilometres

- Over the next 20 years, passenger transport will show a slower rate of growth than freight transport.
- Rail transport is expected to show substantial growth and to gain market shares.
- But: In passenger kilometres, between now and 2030, motor vehicle transport in the EU will increase by more than the total rail traffic being transported in 2030.

Sources: EU, Trends to 2050, 2014; BMVI, Verflechtungsprognose 2030, 2014
Limit values affect only new vehicles

Existing vehicles are not covered by the regulation

Approx. **15.1 million new vehicles** were licensed in the EU in 2015.

Each year, only about 5 per cent of the vehicle fleet in the EU is replaced.
Existing vehicles hold huge potential for CO₂ reduction.
That is why measures for replacing the existing vehicle fleet are essential

Altogether, **approx. 255 million cars** are licensed in the EU.

Source: ACEA, 2017; VDA ,2017
The existing vehicle fleet represents the technology from 10 years ago.

- Licensed cars in Europe are 9.6 years old, on average – and the trend is increasing.
- The average age of cars in several member states is more than 10 years.
- But: The best method for reducing CO₂ is to speed up the rate at which existing vehicles are replaced.

Sources: ACEA Report Vehicles in Use, 2019; ACEA Pocketbook 2017/2018
In its reduction of CO₂, Europe relies on diesel

Since the mid-90s, Europe’s fleet of new vehicles had a growing share of cars that run on diesel but now it is declining.

Diesel plays a significant part in Europe’s CO₂ reduction progress.

Diesel motors are primarily used in vehicles that are expected to have high mileage.

Sources: EEA, Monitoring CO₂ Emissions from new passenger cars, 2019; ACEA, 2019; ACEA, 2016
Road traffic is the indispensable backbone of mobility for passengers and freight in Europe.

According to official forecasts, the dominance of roads in Europe will not change between now and 2030.

Since 2007, traffic volumes on the road have declined. Today, these volumes are often below the projected levels; and even the official growth expectations must be questioned.

The replacement of Europe’s existing vehicles is an effective measure for reducing emissions; but it will be another ten years before the more efficient new vehicles dominate the fleet.
The turnaround came in Germany first

CO$_{2\text{EQ}}$-Emissions of road traffic, 1990 = 100

- Since 1999, emissions in Germany have declined by 24 million tonnes and then rose again.
- From 2000 on, an increase in emissions could primarily be seen in Eastern and Southern Europe.
- The turnaround in the EU 28 did not begin until the crisis of 2008.
- In the years 2014 till 2017 emissions increased significantly.

Quelle: EEA, 2017 (v20)
Passenger Cars in the EU: CO$_2$-Emissions are rising again

Absolute CO$_{2EQ}$-Emissionen, 1990 = 100

Quelle: EEA, 2020 (v23)
Emissions from new vehicles decreasing rapidly

<table>
<thead>
<tr>
<th>Country</th>
<th>Average CO₂ emissions of newly registered cars in 2018, in g per km</th>
<th>Change from 2007 to 2018, as percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Netherlands</td>
<td>105.5</td>
<td>-35.98</td>
</tr>
<tr>
<td>Portugal</td>
<td>106.1</td>
<td>-26.42</td>
</tr>
<tr>
<td>Malta</td>
<td>107.7</td>
<td>-27.13</td>
</tr>
<tr>
<td>Denmark</td>
<td>109.6</td>
<td>-31.41</td>
</tr>
<tr>
<td>Greece</td>
<td>111.4</td>
<td>-32.60</td>
</tr>
<tr>
<td>France</td>
<td>112.2</td>
<td>-24.89</td>
</tr>
<tr>
<td>Ireland</td>
<td>113.3</td>
<td>-29.89</td>
</tr>
<tr>
<td>Croatia</td>
<td>115.3</td>
<td>k.A.</td>
</tr>
<tr>
<td>Italy</td>
<td>115.9</td>
<td>-20.89</td>
</tr>
<tr>
<td>Finland</td>
<td>116.7</td>
<td>-34.18</td>
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<tr>
<td>Spain</td>
<td>118.1</td>
<td>-22.91</td>
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<td>Belgium</td>
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<td>-21.86</td>
</tr>
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<td>Slovenia</td>
<td>120.9</td>
<td>-22.65</td>
</tr>
<tr>
<td>Romania</td>
<td>121.5</td>
<td>-21.51</td>
</tr>
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<td>Sweden</td>
<td>122.2</td>
<td>-32.63</td>
</tr>
<tr>
<td>Austria</td>
<td>123.0</td>
<td>-24.49</td>
</tr>
<tr>
<td>Cyprus</td>
<td>123.4</td>
<td>-27.58</td>
</tr>
<tr>
<td>UK</td>
<td>124.6</td>
<td>-24.35</td>
</tr>
<tr>
<td>Czech Republik</td>
<td>126.0</td>
<td>-18.29</td>
</tr>
<tr>
<td>Bulgaria</td>
<td>126.7</td>
<td>-26.16</td>
</tr>
<tr>
<td>Slowakia</td>
<td>127.6</td>
<td>-16.44</td>
</tr>
<tr>
<td>Hungary</td>
<td>127.9</td>
<td>-17.48</td>
</tr>
<tr>
<td>Lithuania</td>
<td>128.6</td>
<td>-27.14</td>
</tr>
<tr>
<td>Latvia</td>
<td>128.8</td>
<td>-29.81</td>
</tr>
<tr>
<td>Germany</td>
<td>129.5</td>
<td>-27.14</td>
</tr>
<tr>
<td>Poland</td>
<td>129.8</td>
<td>-27.82</td>
</tr>
<tr>
<td>Luxembourg</td>
<td>131.4</td>
<td>-20.75</td>
</tr>
<tr>
<td>Estonia</td>
<td>132.4</td>
<td>-27.09</td>
</tr>
</tbody>
</table>
The share of emissions from freight transport has significantly increased
In millions of tonnes of CO$_2$EQ

Since 2007, the CO2 emissions of road traffic in the EU have been declining. But since 2013 they are rising again.

- Between 1990 and 2007, emissions from truck traffic in particular saw a rapid increase.
- Since 2007, emissions from freight transport have been declining again.
- The increase of emissions from car traffic was relatively moderate. Emissions have stagnated since around 2004 and have been declining from 2007 till 2012. Since 2013 they are rising again.

Source: EEA, 2020 (v23)
High-emission cars are being phased out

CO₂ emissions of new vehicles in the EU, as percentage

The broad range of today’s new vehicles already emits less than 130 g CO₂/km.
- Vehicles with high emissions are on the decline.
- In 1995 80 per cent of the new cars emitted more than 160 g CO₂/km.
- Vehicles with emissions under 95 g CO₂/km are now entering the market.
- More than 1/10th out of the new cars already meet the target for 2021.

Source: ACEA, 2016
Diesel- and petrol-powered vehicles are reducing their emissions

CO₂-emissions of new vehicles in the EU by engine type, in g of CO₂ per km

- Petrol-powered vehicles are showing great advancements and are catching up with diesel engines.
  - But: Diesel engines dominate more among larger vehicles, while petrol engines dominate among smaller vehicles.
  - The advancements among diesel engines appear stronger, since diesel vehicles spend more time on the road each year.
  - In 2017 Diesel Emissions climbed for the first time.

Source: EEA, Monitoring CO₂ Emissions from new passenger cars, 2019
## Heavy trucks: clear progress in practical test

Scientifically evaluated road test of comparable heavy trucks of different years of construction for determining the real CO₂ emissions

<table>
<thead>
<tr>
<th>Company</th>
<th>1996/1997</th>
<th>2016</th>
<th>Reduction (%)</th>
<th>Reduction per year (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daimler DEKRA</td>
<td>436 PS</td>
<td>450 PS</td>
<td>-22%</td>
<td>-1,10%</td>
</tr>
<tr>
<td>Scania AVL</td>
<td>500 PS</td>
<td>500 PS</td>
<td>-25%</td>
<td>-1,04%</td>
</tr>
<tr>
<td>Volvo AVL</td>
<td>405 PS</td>
<td>460 PS</td>
<td>-19%</td>
<td>-0,76%</td>
</tr>
<tr>
<td>MAN TÜV Süd</td>
<td>402 PS</td>
<td>460 PS</td>
<td>-31,5%</td>
<td>-1,45%</td>
</tr>
<tr>
<td>Iveco AVL</td>
<td>514 PS</td>
<td>571 PS</td>
<td>-21%</td>
<td>-0,95%</td>
</tr>
</tbody>
</table>

Summary: CO$_2$ emissions on the road

The CO$_2$ emissions of road traffic in the EU have been decreasing for years. Compared to 1990, the emissions from truck traffic in particular increased dynamically but have been decreasing again since 2007. Emissions from car traffic have stagnated since 2004 and have shown a clear decline since 2007.

The increased distribution of more fuel-efficient new vehicles accounts for the decline in car emissions.

The increased use of diesel engines – especially in the case of larger vehicles – was a key driver in the reduction of emissions.
The use of energy per unit of output has reduced considerably in European road traffic since 2000.

But: Since 2007, truck traffic in the EU has relinquished a portion of its efficiency gains. Two new EU standards related to the reduction of pollutants were introduced in this time period, which likely led to the increased consumption of new vehicles.

The increased efficiency of cars has accelerated considerably since 2007.

Source: Odyssee Database, 2020
EU freight transport between 2000 and 2017

Increases in efficiency are obscured by growth in the quantity of freight transported

Development of energy consumption by impact, in terawatt hours (TWh)

- More traffic: +256
- Efficiency: -240
- Other, Modal shift: +45
- Overall impact: +61

More efficient vehicles and routing help to offset approximately the increased consumption resulting from other factors.

Modal shift effects play a subordinate role with an additional consumption of 29 TWH.

Source: Odyssee Database January 2020
Car traffic between 2000 und 2017

More efficient vehicles have a growing impact on energy consumption levels

In terawatt hours (TWh)

- More traffic: 290.73 TWh
- Energy reduction measures: 225.91 TWh
- Other: 47.81 TWh
- Overall impact: 112.7 TWh

Source: Odyssee Database January 2020

As a result of increasing traffic volumes, energy consumption in car traffic has increased significantly since the year 2000.

But: The dominant impact came about through more efficient vehicles.

The total energy consumption in the year 2015 was on the same level as in the base year 2000.
Car traffic between 2000 and 2017

More efficient vehicles have a growing impact on energy consumption levels

2000 – 2007 in terawatt hours (TWh)

- Energy saving measurements
  - Total impact

2007 – 2017 in terawatt hours (TWh)

- Energy saving measurements
  - Total impact

- Other

Around the turn of the millennium, additional traffic led to an increase in energy consumption. This effect has changed course in the last seven years.

During the second half of the reported period, the reduction effect became dominant against the effect of additional traffic, driven by the increased distribution of more efficient vehicles.

Source: Odyssee Database January 2020
Diesel ensures lower emissions from large cars

New car registrations in Germany
Market shares by segment and engine type, in %

<table>
<thead>
<tr>
<th>Segment</th>
<th>Diesel</th>
<th>Petrol</th>
<th>Alternative</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mini</td>
<td>1%</td>
<td>87%</td>
<td>96%</td>
</tr>
<tr>
<td>Small</td>
<td>6%</td>
<td>69%</td>
<td>38%</td>
</tr>
<tr>
<td>Compact</td>
<td>25%</td>
<td>22%</td>
<td>11%</td>
</tr>
<tr>
<td>Medium</td>
<td>55%</td>
<td>29%</td>
<td>37%</td>
</tr>
<tr>
<td>Upper Medium</td>
<td>66%</td>
<td>62%</td>
<td>40%</td>
</tr>
<tr>
<td>Luxury</td>
<td>34%</td>
<td>91%</td>
<td>71%</td>
</tr>
<tr>
<td>Off road</td>
<td>34%</td>
<td>40%</td>
<td>77%</td>
</tr>
<tr>
<td>Sports car</td>
<td>7%</td>
<td>24%</td>
<td>19%</td>
</tr>
<tr>
<td>Mini Van</td>
<td>23%</td>
<td>71%</td>
<td>40%</td>
</tr>
<tr>
<td>Large Van</td>
<td>59%</td>
<td>66%</td>
<td>75%</td>
</tr>
<tr>
<td>Utility</td>
<td>75%</td>
<td>34%</td>
<td>34%</td>
</tr>
<tr>
<td>Other</td>
<td>77%</td>
<td>77%</td>
<td>19%</td>
</tr>
</tbody>
</table>

Increased efficiency 2004 – 2017

- Ø vehicle mass in kg
- Ø CO₂-Emissions in g

Diesel is increasingly becoming the preferred engine for large vehicles that spend the most time on the road, while petrol engines still dominate the smaller car classes.

- As a result of this trend diesel engines have become heavier (more powerful), and petrol engines have been catching up in terms of standard fuel consumption. In 2016 a diesel car was 300 kg heavier than a petrol car.

- Fuel efficiency has in fact improved at essentially the same rate for both engine types.

- Luxury Class has by the highest share of alternative fuels.

Sources: KBA 2016; EEA, Monitoring CO₂ Emissions from new passenger cars, 2019
Where would Germany be without diesel?

**CO₂ emissions of newly registered cars in 2018**
By segment and engine type, in g per km

- **Diesel emissions are lower than those of petrol in all vehicle segments.**
- **Diesel engines dominate the larger classes of vehicles.**
- The emissions level of new vehicles would be significantly higher without the use of diesel engines.

Source: own calculations
Transport growth dominates the balance

Development of road transport performance and CO₂-Emissions of road transport in Germany since 2000

The calculation of the transport performance is carried out according to method of the Arbeitsgemeinschaft Energiebilanzen; Calculation factor 1tkm = 10 pkm

Source: Umweltbundesamt; Kraftfahrbundesamt; Own Calculations
The driver determines the fuel consumption

Shifting gears early saves fuel: the fuel consumption curve of a Golf 1.4 TFSI (90 kW) in relation to its speed

Fuel saving training courses: Following the course, participants used approximately 20 per cent less fuel than before. In Germany alone, the reduction potential from fuel-efficient driving is estimated at 12 million tonnes of CO₂.

Gear shifting support is particularly effective in urban traffic: when driving at a speed of 50 km per hour, the test vehicle consumes 1.2 litres less in fifth gear than in third.
Make 3 on 2 – Bigger Loading volume cuts fuel consumption

Two long trucks are able to transport as much load as three standard trucks.

Low fuel consumption

The long truck rides more efficient than other trucks. Consequence: less fuel consumption per load.

<table>
<thead>
<tr>
<th>Standard truck 1</th>
<th>Standard truck 2</th>
<th>Standard truck 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Standard truck 1</th>
<th>Standard truck 2</th>
<th>Standard truck 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>+50%</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Standard truck 1</th>
<th>Standard truck 2</th>
<th>Standard truck 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>+50%</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Load</th>
<th>Long truck 1</th>
<th>Long truck 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Conventional semitrailer

-10% CO₂

Long semitrailer

17,8 m

-25% CO₂

Long truck

25,25 m

Route network

Long truck
Long trucks: 15 per cent efficiency improvements confirmed in practical test*

- Long trucks are significantly more efficient in transporting high load volumes than conventional semitrailers.
- The advance in efficiency of a good 15 per cent lasts as long as the load volume will be fully used.
- Heavy loads can be transported much more efficiently than with normal trucks.
- A long truck consumes more fuel than a conventional semitrailer. This does only pay for the carrier, if he moves more load than the today's truck can carry.

* Results from a field experiment of the federal government; loads were transported with a density of 0,72 kg/dm³ (paper: 0,8 kg/dm³)
Source: BMVI
Summary: Efficiency on the road

More fuel efficient vehicles have led to a considerable increase in the overall efficiency of road traffic since the year 2000.

Increased traffic volumes have long prevented the more efficient vehicle technology from actually lowering the overall level of emissions.

Diesel engines were a major driver of the increasing efficiency. They have led to considerably lower emissions, particularly in the case of larger vehicles.

Low-cost possibilities for increasing efficiency are being wasted. Fuel saving training courses can reduce consumption by 20 per cent.

The licensing of larger trucks could also save a lot of fuel.
The most stringent CO₂ target values for new vehicles in g CO₂/km under the New European Driving Cycle (NEDC)

The EU emission standard for 2030 is the most stringent standard in the world.

- In the US passenger cars only make up a third of the vehicle market. Light Trucks dominate and their limit value is considerably higher (140 g/km in 2025)
- In November 2017 the EU Kommission proposed to lower the limit value within the period of 2021 until 2025 by 15 per cent and to codify a minus of 37.5 per cent until 2030.

* Gasoline only
Source: ICCT, 2020
CO₂ target values for 2021: High demands on the automotive industry

in g CO₂/km

- Independent of vehicle weight, manufacturers of large cars have to show greater reductions than high-volume manufacturers.
- In the nine years from 2006 to 2015, a reduction of the average emissions by 30 g CO₂/km was required of new vehicles – from 160 g CO₂/km down to 130 g CO₂/km.
- Speeding up the pace: In the six years from 2015 to 2021, average emissions must be reduced by 35 g CO₂/km – from 130 g CO₂/km down to 95 g CO₂/km. For 2025 a suggestion has been raised by the commission of 81 g CO₂/km, that is a minus of 14 g CO₂/km in four years.

Sources: EU, EEA
High CO$_2$ emissions mean high payments:

Fuel related taxes per litre, in euro
– status as of: 01. June 2020

Source: EU Kommission DG Transport, Weekly Oil Bulletin
Electric cars: Quite different markets
New vehicles and top-selling models of the year 2019

New vehicles BEV/PHEV: 325,000
1. Tesla Model 3
2. Toyota Prius PHV
3. Tesla Model X
4. Chevrolet Volt
5. Tesla Model S

New vehicles BEV/PHEV: 79,640
1. Tesla Model 3
2. Volkswagen E Golf
3. Nissan Leaf
4. Audi e-tron
5. Mitsubishi Outlander

New vehicles BEV/PHEV: 564,206
1. Tesla Model 3
2. Renault Zoe
3. Mitsubishi Outlander
4. Nissan Leaf
5. BMW i3

New vehicles BEV/PHEV: 1,177,421
1. BAIC EC Series
2. BYD Yuan
3. SAIC Baojun EV
4. Cherry EQ
5. BYD Tang

Source: ev-sales.blogspot, 2019
Market share forecasts for electric vehicles

Current forecasts for the global market share in the year 2025

All forecasts predict a higher market share in Europe

Typically BEV and FCEV make up for 55 to 60 percent of the electric vehicles.

These numbers include BEV, FCV and PHEV
Emissions from PHEV are calculated on the basis of the emissions in combustion operations and of the electric coverage of the car.

Firstly, the PHEV participates in the European testing cycle (NEDC) in combustion operations.

Then it runs the cycle driven on electrical energy as long as the battery lasts.

Depending on the such determined coverage of the car a pro rata deduction from the emissions in pure combustion operations is applied.
Speed makes the difference

CO₂ emissions of a middle class car with different drive versions and speed

HBEFA cycles with 0 % gradient

<table>
<thead>
<tr>
<th>CO₂ in g/km</th>
<th>v in km/h</th>
</tr>
</thead>
<tbody>
<tr>
<td>250</td>
<td>0</td>
</tr>
<tr>
<td>220</td>
<td>20</td>
</tr>
<tr>
<td>190</td>
<td>40</td>
</tr>
<tr>
<td>160</td>
<td>60</td>
</tr>
<tr>
<td>130</td>
<td>80</td>
</tr>
<tr>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>70</td>
<td>120</td>
</tr>
<tr>
<td>40</td>
<td>140</td>
</tr>
</tbody>
</table>

Source: TU Graz, 2018
Electricity mix will decide on climate friendliness

CO₂ emissions of power production and electric cars

CO₂ emissions or power production in gCO₂/kWh

With a fuel consumption of 20 kWh/100km an electric car emits ... gCO₂/km

Source: IEA, Co2-Emissions from Fuel Combustion, 2019, own calculations
Lithium is highly reactive and is therefore traded in the form of lithium carbonate.

Only four plants account for 80 per cent of the worldwide production of lithium.
Bargain prices for cobalt have risen since March 2015 by a good 200 per cent and went down since May 2018.

Cobalt is mostly a by-product of the nickel and copper mining.

Falling prices of nickel and copper dampen cobalt production.
Use of Lithium according to applications

Status quo versus Forecast 2025

2015 (Roskill)

- Rechargeable batteries: 10.2%
- Ceramics: 7.9%
- Lubricants: 5.1%
- Metallpowders: 4.5%
- Glass Ceramics: 3.1%
- Polymers: 2.5%
- Air processing: 13.4%
- Non-chargeable Batteries: 2.5%
- Other: 0.4%
- Total: 37.4%

2025 (DERA)

- Rechargeable batteries: 1.4%
- Ceramics: 6.4%
- Lubricants: 7.1%
- Metallpowders: 0%
- Glass Ceramics: 4.9%
- Polymers: 2.7%
- Air processing: 2.5%
- Non-chargeable Batteries: 0.1%
- Other: 4.2%
- Total: 66.6%

Quellen: Deutsche Rohstoffagentur (DERA), 2016, 2017 (Ursprungsdaten), eigene Darstellung
Use of Cobalt

Usage in 2014 (CDI) and prognosis to 2035 (DERA)

Quellen: Cobalt Development Institute (CDI), 2016; Deutsche Rohstoffagentur (DERA), 2016 (Ursprungsdaten), eigene Darstellung
New battery types are required
In a world with 100 per cent of electric cars of present design ...

the demand for raw materials would be ... per cent higher.

per year... per cent of the reserves would be eaten up.

Source: UBS Evidence Lab, Mai 2017
Battery cells: China propels capacity building

Cell production in GWh, consisting and developing

Source: Bloomberg Intelligence, 2017
Summary: regulation on the road

The EU has waived the world’s most stringent CO₂ emission levels for cars. In 2021, the limit values will be one-third lower than those of the USA.

CO₂ emissions from road traffic are priced higher by the EU than emissions from other sources.

The “low-hanging fruits” have already been picked – and it will become more expensive in the future.

The manufacturers of large vehicles, in particular, have to gradually focus on the switch to electric powertrains. But: Today, the market run-up for electric cars and plug-in hybrids is slowing down. And no one knows how the market for these vehicles will develop in the future.
Agenda

1. Megatrends
2. Political framework
3. Transportation sector
4. Other sectors
5. Outlook
In the EU, the emissions from public heat and power generation are approximately 15 per cent less than the levels in 1990.

› More efficient power plants and a changing power mix help to cover the overconsumption.

Power generation underlies European emissions trading. Emissions trading consists of two components:

› A prescribed cap on emission volumes that will continuously decrease up to the year 2020.

› A tool for distributing the burden (trade). The market for carbon credits ensures that the EU will meet the prescribed emission volumes at low costs.
The reduction can be credited to Eastern Europe in particular

$\text{CO}_2\text{EQ}$- emissions of public heat and power generation, $1990 = 100$

Source: EEA, 2017 (v20)
Power generation – consumption of fossil primary energy declining

in Terawatt hours (TWh) of primary energy use; changes from 2000 – 2017

Electricity consumption in Europe is persistently increasing.

Yet fewer fossil primary energy carriers are being consumed.

Power generation is not an end in itself; it facilitates production and consumption in the industrial sector and in homes.

Source: Odyssee Database January 2020
Cap: A government-prescribed reduction

Volume of carbon credits in the EU Emissions Trading System (ETS), in millions of tonnes

- Specific: The emissions target of -21 per cent is sure to be met on account of the decreasing cap.
- Apportioned: The initial auctioning of 20 per cent is expected to increase to 60 per cent by 2020.
- Flexible: It is not stipulated which trade participant will bring about the reduction.

Sources: EU, DIW
Trade: Emissions trading ensures an efficient distribution of the reduction burden

<table>
<thead>
<tr>
<th>Case 1: Emission restrictions</th>
<th>Case 2: Emissions trading: Carbon credit price at 30 euros per tonne</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exhaust up to now, in tonnes</td>
<td>Exhaust up to now, in tonnes</td>
</tr>
<tr>
<td>Permissible exhaust in the future, in tonnes</td>
<td>Permissible exhaust in the future, in tonnes</td>
</tr>
<tr>
<td>Reduction costs per tonne</td>
<td>Carbon credits received, in tonnes</td>
</tr>
<tr>
<td>Total costs</td>
<td>Reduced costs per tonne</td>
</tr>
<tr>
<td></td>
<td>Achieved reduction, in tonnes</td>
</tr>
<tr>
<td></td>
<td>Cost for the reduction</td>
</tr>
<tr>
<td></td>
<td>Trade, in tonnes</td>
</tr>
<tr>
<td></td>
<td>Trade in euros</td>
</tr>
<tr>
<td></td>
<td>Total costs by trade</td>
</tr>
<tr>
<td>5,000</td>
<td>5,000</td>
</tr>
<tr>
<td>4,500</td>
<td>Insg. 9,000</td>
</tr>
<tr>
<td>20</td>
<td>4,500</td>
</tr>
<tr>
<td>10,000</td>
<td>20</td>
</tr>
<tr>
<td>5,000</td>
<td>1,000</td>
</tr>
<tr>
<td>4,500</td>
<td>20,000</td>
</tr>
<tr>
<td>50</td>
<td>0</td>
</tr>
<tr>
<td>25,000</td>
<td>0</td>
</tr>
<tr>
<td>10,000</td>
<td>500</td>
</tr>
<tr>
<td>9,000</td>
<td>15,000</td>
</tr>
<tr>
<td>35,000</td>
<td>20,000</td>
</tr>
</tbody>
</table>

In the example above, Plant 1 renders the entire reduction but has three-fourths of the costs reimbursed through emissions trading. The example shows that both plants save thousands of euros compared to a restriction on emissions.

The specific distribution of the reduction burden arises from the carbon credit price and the particular reduction costs.

Participants with high abatement costs help to finance other participants’ reduction efforts.
Germany’s energy transition: Unexpected results

The subsidisation of renewable energies leads to an increasing export of electricity

Power generation: CO₂ emissions are still on the rise, in spite of the increasing share of renewable energies.

- The reason: Renewable energies are, in particular, replacing natural gas and coal-fired power plants; nuclear energy use is also declining. Lignite is filling the resulting base load gap.
- The subsidisation of renewable energies has resulted in an increased volatility of supply. This frequently results in surplus power that has to be exported outside the country at a cheap rate.

Source: Arbeitsgemeinschaft Energiebilanzen 2020, EEA 2020 (v23)
CO₂ in other sectors: industry

The CO₂ emissions of the industrial sector have declined by one-fourth in the last 20 years.

› Increased efficiency: Emissions in the industrial sector decreased by one-third per euro of added value.

The industrial sector is governed by various regulations:

› Electricity consumption is subject to emissions trading and a high rate of taxation. In the USA, industrial energy costs only about half as much as the EU average.

› The EU Ecodesign Directive sets maximum tolerances for the energy consumption of consumer products such as lamps and household appliances. Products that do not meet the standard have to be removed from the market. The most noticeable target: light bulbs.
Industry in the EU 28: Decreased emissions, greatly improved efficiency

CO₂ emissions in the industrial sector are declining: -25% since 1995 in millions of tonnes of CO₂

Improved efficiency: One-third fewer emissions per euro of added value since 1995 in kg CO₂/Euro 2010

- Regulation: The largest share of CO₂ emissions caused by industrial activities is subject to emissions trading.
- Increased efficiency: The emissions per unit of gross value have decreased by a good third since 1995.
- Deindustrialisation: The movement of industrial activities out of many European countries has resulted in a decrease of CO₂ emissions in the EU.

Source: Odyssee Database January 2020
Industrial energy prices in the second half of 2019: Much less expensive in the USA

In cent pro kWh for companies with a consumption of 20 to 70 gigawatt hours

- Industrial energy prices in Europe are much higher than those of international competitors.
- The biggest difference is in comparison to the USA, where a kWh costs approximately 45 per cent less than in Europe.
- The highest prices apply in the UK and Italy. But for totally different reasons.
- Recoverable taxes – such as VAT – are viewed as transitory items for the company.

* For information only
Sources: Eurostat 2020, BDI
CO₂ in other sectors: Households

Household CO₂ emissions have decreased by 13 per cent since 1990.
› In the same reporting period, the number of households and the living space per person increased substantially.

The key to future emission reductions is in the area of heating.
› Heating constitutes 70 per cent of a household’s total energy consumption.
› In spite of the EU Ecodesign Directive, consumption has greatly increased through the use of electric appliances, since households contain an increasing number of them.

The installation of new heating units results in very low CO₂ abatement costs, but it rarely pays off for home owners without subsidisation.
Households: Decreasing CO₂ emissions despite higher demands in living spaces

CO₂-Emissions
in millions of tonnes

Changes in household energy consumption between 2000 and 2016
in terawatt hours (TWh)

-22%  -21%

Climatic faktor

More households

More electric appliances per household

Larger living spaces

Energy savings

Other

Overall impact

Nearly half of household emissions fall under emissions trading.

The trend is leaning towards more households and larger apartments, which increases emissions.

Besides emissions trading, households are impacted by electricity taxes and energy consumption regulations for buildings.

Source: Odyssee Database January 2020
Energy consumption: the potential lies in the heating market

The heating system is the key to lower emissions in terawatt hours (TWh)

Significant progress per square metre of living space
1990 = 100

- Heating systems consume about 70 per cent of the final energy in households.
- Advancements in heating efficiency are almost entirely eaten up by increased living space.
- Electric appliances only play a minor role; however, due to the increasing number of appliances per household, overall energy consumption has risen by 45 per cent since 1990.

Source: Odyssee Database January 2020
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3. Transportation sector
4. Other sectors
5. Outlook
Today, Europe regulates a car’s emissions potential in grams per kilometre.

However, the actual target is the avoidance of CO₂ emissions in tonnes.

There is no direct connection between emissions potential and actual emissions. The real impact is determined by the user.

Result: Today’s regulation is not precise and does not correspond to the regulation in other sectors.

**CO₂ savings, in tonnes:**

\[ 4 \text{ g/km} \times 200,000 \text{ km} = 800,000 \text{ g} = 0.8 \text{ tonnes} \]

**Investment costs, in euros per tonne:**

\[ \frac{200 \text{ €}}{0.8 \text{ tonnes}} = 250 \text{ € per tonne} \]
CO₂ avoidance in cars is expensive and would be cheaper to obtain in other sectors

Problem: CO₂ avoidance in cars is already comparatively expensive

Expensive CO₂ avoidance leads to excess burden

- The reduction costs differ greatly from sector to sector.
- The avoidance of car emissions by means of improved technologies is relatively expensive, and these costs will continue to increase.
- Sector-based reduction targets lead to high additional costs in the economy.
- In the EU Emissions Trading System (ETS), permissible emissions are offset by carbon credits. One credit allows the emission of a tonne of CO₂.
- The trade with carbon credits ensures that the emission volume stipulated by the EU is generated where the reductions are least expensive.

* Extrapolation from published reports ** Calculated based on the average value of the respective line.
Sources: AGFW, IKA Institut für Kraftfahrzeuge Aachen, EU
Efficient new vehicles impact the vehicle fleet

Based on model calculation. With today’s regulation, an emissions reduction of 30 per cent is achievable between 2005 and 2030. This corresponds to the EU target for non-ETS sectors.

Relative car emissions

Absolute car emissions

in g CO₂/km

in millions of tonnes of CO₂

The average consumption of the existing fleet is only gradually reacting to the more efficient new vehicles. That is why a difference can be seen between the emissions of new vehicles and the entire fleet.

The gap will close once most of the older vehicles with higher emissions are taken off the roads.

Based on a conservative estimate, the ongoing replacement of old vehicles will result in car traffic emissions in Europe decreasing by approximately 30 per cent by 2030, compared to the year 2005.

Until 2014, the fleet was dominated by vehicles built before 2005. Several million of these vehicles will still be on the road in 2030.

The advancements of recent years will long continue to have an impact on the vehicle fleet. Even if new vehicles were to hardly show improvements after 2021, the fleet emissions would continue to decrease.

In regard to cars, the EU target can be achieved with the existing regulation.

Source: Daimler
WLTP: A new test requires new limit values

NEDC: Introduced in 1996 to calculate exhaust emissions

WLTP: Depiction of a car ride, based on worldwide averages

A test cycle should facilitate legally compliant comparability.

► There are various cycles today. The EU and China use the NEDC, while the USA and Japan have their own tests.
► The figures on car emissions depend heavily on the test cycle; they are not simply convertible.
► Trials show that higher emissions levels are identified in the WLTP than in the NEDC. With the introduction of the WLTP, the regulation of limit values will have to start completely afresh.
► But: Even WLTP is “only” a test. It facilitates comparability under standardised conditions; hence, it represents an approximation of global driving behaviour, yet does not determine a value that is achievable in all contexts.

Sources: EU, UN
RDE Tests: wide dispersion even with maximum standardization

Limits of standardization in RDE consumption measuring

1. Measurement technology
   - Standardised PEMS-systems per vehicle (homogeneous within the measuring organisation)
   - Calibration of the PEMS-system by aligning with test bed measurements
   - But: the achievable measurement inaccuracy using the up-to-date technique lies around ± 2.5 per cent.
   - **Expected dispersion of the results:** $8 \text{ gCO}_2/\text{km}$

2. Environment & driver
   - Defined environmental conditions (moderate temperatures, favourable weather, gentle wind at maximum)
   - Trained driver, who refer to the shift point display and create reproducible results
   - But: Slight variations, for example in wind and driving style lead to visible deviations.
   - **Expected dispersion of the results:** $10 \text{ gCO}_2/\text{km}$

3. Route
   - Trips on a reference line in the same time and driving direction
   - No fixed time slots but adaption to comparable traffic volume on the reference line
   - But: density of traffic, average speed and shares of start/stop are not reproducible.
   - **Expected dispersion of the results:** $12 \text{ gCO}_2/\text{km}$

4. Vehicle
   - Comparable vehicle, as far as the status of running-in, technical upgrades, inflation pressure etc. is concerned
   - Comparable use of vehicles: additional load, electrical consumers, window opening or driving mode
   - But: reactions to environmental conditions (e.g. temperature) affect the consumption.
   - **Expected dispersion of the results:** $6 \text{ gCO}_2/\text{km}$
Summary: Limits of the system

The system of regulating limit values levels exhibits structural problems.

Inaccurate: The greatest disadvantage is the lack of precision, since the regulations affect potential emissions rather than actual emissions.

Expensive: Technology-driven savings in road traffic represent one of the most expensive possibilities for reducing CO$_2$ emissions.

Long-dated: It will still take years before the full impact of already-achieved improvements is reflected in statistics.

An acute continuation of the regulation of limit values does not currently appear very promising. Alternatives to the current system must be sought.
Improved regulation: Emissions standards for vehicles fall too short

To reduce emissions, drivers and the government need to be involved in the process.

Integrated approach: Include all areas in the regulation process

Total emissions in tonnes = Consumption in litres * Emissions factor in kg CO₂/litre * Mileage

- Optimisation of combustion engine
- Alternative fuels
- Lightweight construction
- Switching to electric powertrains
- Use of digitalisation (avoidance of parking-related traffic)

- Infrastructure conditions
- Construction site management
- Promotion of transmissions and fuels that produce fewer emissions
- Replacement of existing vehicles

- Route (how much?)
- Driving style (how?)
- Vehicle selection (with what?)

- Vehicle limit values only regulate potential emissions.
- The actual emissions are determined just as much by drivers as by the infrastructure.
An integrated approach prevents rebound effects and can considerably increase savings.

Various instruments are needed in order to enhance all potential savings.

Source: ACEA
Emissions trading in road traffic: Is that possible?

One stop towards an integrated approach would be the inclusion of road traffic in emissions trading. Fuel consumption can be precisely calculated in emissions. Heavy trucks cannot be integrated in the existing system of limit values; this is not a problem in emissions trading. The question remains as to who should make the carbon credits available.

**Upstream – Tankstellenbetreiber**

The corresponding carbon credits must be purchased for every litre sold.

- 1L Benzin = 2,3 kg CO₂
- 1L Diesel = 2,6 kg CO₂

**Pros**
- Easy to implement technically
- Little demand from the well-financed
- Actual emissions are limited

**Cons**
- It only indirectly addresses those who are actually generating the emissions. The connection to the driver is the price signal, as in the case of a fuel tax.

**Midstream – Autohersteller**

When a new vehicle is sold, a volume of carbon credits must be purchased that corresponds to the car’s expected emissions in its lifetime.

- In the case of 130 g CO₂/km und 200.000 km: carbon credits for 26 tonnes

**Pros**
- Little demand from the well-financed

**Cons**
- Inaccurate: The purchased amount represents a theoretical volume.
- The manufacturer only determines the potential emissions, not the actual emissions.
- The manufacturer only has an indirect influence over actual CO₂ emissions.
Emissions trading: A useful supplement

The inclusion of road traffic in emissions trading offers certain benefits

▶ Simple: The necessary amount of carbon credits per tank filling is easy to calculate. The required purchase can be paid for with the fuel.

▶ Inexpensive for the driver: Based on the EU’s targeted price of 30 euros per carbon credit in the year 2020, a litre of petrol would cost 7 euro cent more.

▶ Inexpensive for society: The abatement costs of road traffic are far above 30 euros per tonne. Emissions are avoided where it is cheaper to do so.

▶ But: Since the transportation sector would be purchasing so many carbon credits, other sectors would have to substantially step up their reduction efforts. Good judgment will be necessary in order to avoid an overload in the other sectors.

▶ Thus: Emissions trading is a useful supplement to today’s limit values.
The inclusion of road traffic in emissions trading serves as a useful supplement to the prevailing system of limit values.

› Emissions trading would increase the precision of the regulation, since it factors in the influence of the driver on the emissions that are produced.

› Emissions trading would also apply to freight transport – an area that is difficult to incorporate in the current system of limit values.

› Emissions trading would lead to lower reduction costs for the overall economy, since road traffic would enter the carbon credit market as more of a buyer.

But: Oil prices continue to create pressure to innovate, but there are several factors that speak in favour of setting a new limit value for the long term.
The core theses: Brief overview

**Climate protection**

1. Europe’s share of the worldwide CO₂ emissions is low and continuously decreasing. (100)

2. No solution without China: Europe’s reduction of emissions is being eaten up by growth in emerging economies. (103)

3. Motor vehicles account for approximately one-seventh of the CO₂ emissions in the EU. Their share in transportation emissions is declining. (106)

**CO₂ regulation for motor vehicles**

4. New vehicles in Europe have become considerably more efficient in recent years. (108)

5. CO₂ legislation in Europe shows the most stringent target values in an international comparison. (110)

6. Europe has once again tightened the reins on the CO₂ limit values for motor vehicles and is requiring a further reduction of CO₂ within an even shorter span of time. (112)

7. Even without a further tightening of the CO₂ limit values after 2020, the motor vehicle industry is still on track to meet the EU’s climate policy targets by 2030. (114)

8. Vehicle fleet limit values under 95 grams cannot be achieved with conventional engine types, and the market success of alternative engine types is still uncertain. (116)

9. EU environmental legislation is not coherent and, for a long time, had other priorities than CO₂ reduction. This had various consequences, including an increase of CO₂ emissions. (119)

10. Today’s CO₂ laws regulate only new vehicles, completely disregarding the remaining vehicle fleet. (122)

11. An effective reduction of CO₂ emissions cannot address new vehicles alone but must take a much broader approach. (124)

**Balance between climate protection and industrial policy**

12. The EU is targeting a 20% industry share of GDP for the year 2020. This goal is presently a long way away, since industrial and climate protection policy are not yet aligned. (126)

13. The CO₂ abatement costs vary greatly between sectors and are most pronounced in the automotive sector. (129)

14. Emissions trading as the most economically efficient form of CO₂ regulation can easily be applied to road traffic. (131)
Core theses: Climate protection

Europe’s share of the worldwide CO$_2$ emissions is low and continuously decreasing.
CO₂ emissions: Europe’s share sharply decreasing

Emissions from fuel use, in millions of tonnes

Compared to the year 1990, the absolute CO₂ emissions are decreasing in the EU only. Between 1990 and 2016 the EU decreased the emissions by approximately 815 Million tons.

At the current edge the US emissions are falling. In 2016 the emissions are converging to the emissions of 1990.

The impact of European regulations on global CO₂ emissions continues to decline.

Source: IEA, CO₂ Emissions from Fuel Combustion – 2019
Reduction in Europe, strong increase in Asia

Emissions from fuel use* – Changes between 1990 and 2017 in Millions of tonnes

While China shows an increase of 338 per cent during the years 1990–2017, the EU shows a decrease of 20.3 per cent.

In 2017 alone, China’s emissions increased by 200 million tonnes.

India increased its emissions since 1990 by 310 Percent and this value is still increasing.

* Corresponding to category 1A according to the UNFCCC classification system

Source: IEA, CO₂ Emissions from Fuel Combustion – 2020
Core theses: Climate protection

No solution without China: Europe’s reduction of emissions is being eaten up by growth in emerging economies.
EU passenger cars – Relevant, yet not crucial
CO₂ emissions in millions of tons

Relevant: Europe’s total passenger car traffic 2017 emitted 543 million tonnes of CO₂, an upward trend compared to 2015.

Crucial? China, on the other hand, is showing a strong upwards trend in its use of fossil fuels – emitting nearly 526 million tonnes of CO₂ in just three weeks.

Dynamic: between 2014 and 2015 the plus in China was about 60 millions of tons. In the following year the emissions increased by 8 million tons.

Sources: EEA, 2019 (v23; IEA, CO₂ Emissions from Fuel Combustion – 2020)
Motor vehicles account for approximately one-seventh of the CO₂ emissions in the EU. Their share in transportation emissions is declining.
Road transport is a major source in Europe

Emissions in the EU in the year 2018 in Megatons

1. Emissions of the Transport Sector 2)
   - Rail
   - Air (inland)
   - Road
   - Inland Waterways

2. Emissions of Road Transport
   - HDV and Bus
   - Motorcycle
   - Car
   - Other

Total Greenhouse Gas Emissions 1)
- Energy
- Industry
- Transport
- Agriculture
- Other

In total 3.953 Mt
- 1.110 Mt
- 873 Mt
- 503 Mt
- 517 Mt
- 950 Mt

899 Mt

232 Mt

113 Mt

543 Mt

1) With sinks
2) Without international Air and Sea traffic
Quelle: EEA, 2020 (V23)
Passenger Cars in the EU: CO₂-Emissions are rising again

Absolute CO₂EQ-Emissionen, 1990 = 100
Core theses: CO₂ regulation for motor vehicles

New vehicles in Europe have become considerably more efficient in recent years.
### Emissions from new vehicles decreasing rapidly

<table>
<thead>
<tr>
<th>Country</th>
<th>Average CO₂ emissions of newly registered cars in 2018, in g per km</th>
<th>Change from 2007 to 2018, as percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Netherlands</td>
<td>105.5</td>
<td>-35.98</td>
</tr>
<tr>
<td>Portugal</td>
<td>106.1</td>
<td>-26.42</td>
</tr>
<tr>
<td>Malta</td>
<td>107.7</td>
<td>-27.13</td>
</tr>
<tr>
<td>Denmark</td>
<td>109.6</td>
<td>-31.41</td>
</tr>
<tr>
<td>Greece</td>
<td>111.4</td>
<td>-32.60</td>
</tr>
<tr>
<td>France</td>
<td>112.2</td>
<td>-24.89</td>
</tr>
<tr>
<td>Ireland</td>
<td>113.3</td>
<td>-29.89</td>
</tr>
<tr>
<td>Croatia</td>
<td>115.3</td>
<td>k.A.</td>
</tr>
<tr>
<td>Italy</td>
<td>115.9</td>
<td>-20.89</td>
</tr>
<tr>
<td>Finland</td>
<td>116.7</td>
<td>-34.18</td>
</tr>
<tr>
<td>Spain</td>
<td>118.1</td>
<td>-22.91</td>
</tr>
<tr>
<td>Belgium</td>
<td>119.4</td>
<td>-21.86</td>
</tr>
<tr>
<td>Slovenia</td>
<td>120.9</td>
<td>-22.65</td>
</tr>
<tr>
<td>Romania</td>
<td>121.5</td>
<td>-21.51</td>
</tr>
<tr>
<td>Sweden</td>
<td>122.2</td>
<td>-32.63</td>
</tr>
<tr>
<td>Austria</td>
<td>123.0</td>
<td>-24.49</td>
</tr>
<tr>
<td>Cyprus</td>
<td>123.4</td>
<td>-27.58</td>
</tr>
<tr>
<td>UK</td>
<td>124.6</td>
<td>-24.35</td>
</tr>
<tr>
<td>Czech Republik</td>
<td>126.0</td>
<td>-18.29</td>
</tr>
<tr>
<td>Bulgaria</td>
<td>126.7</td>
<td>-26.16</td>
</tr>
<tr>
<td>Slowakia</td>
<td>127.6</td>
<td>-16.44</td>
</tr>
<tr>
<td>Hungary</td>
<td>127.9</td>
<td>-17.48</td>
</tr>
<tr>
<td>Lithuania</td>
<td>128.6</td>
<td>-27.14</td>
</tr>
<tr>
<td>Latvia</td>
<td>128.8</td>
<td>-29.81</td>
</tr>
<tr>
<td>Germany</td>
<td>129.5</td>
<td>-27.14</td>
</tr>
<tr>
<td>Poland</td>
<td>129.8</td>
<td>-27.82</td>
</tr>
<tr>
<td>Luxembourg</td>
<td>131.4</td>
<td>-20.75</td>
</tr>
<tr>
<td>Estonia</td>
<td>132.4</td>
<td>-27.09</td>
</tr>
</tbody>
</table>

Higher emissions in the East. Four EU countries below 110

**Country**

- **Netherlands**
- **Portugal**
- **Malta**
- **Denmark**
- **Greece**
- **France**
- **Ireland**
- **Croatia**
- **Italy**
- **Finland**
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- **Cyprus**
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- **Bulgaria**
- **Slowakia**
- **Hungary**
- **Lithuania**
- **Latvia**
- **Germany**
- **Poland**
- **Luxembourg**
- **Estonia**

Source: EEA, 2020
High-emission cars are on the decline

$\text{CO}_2$-emissions of new cars in the EU in per cent

- Already today the mass of new cars emits clearly less than 130 g $\text{CO}_2$/km.
- High-emission cars are on the decline. In 1995 80 per cent of the new cars emitted more than 160 g $\text{CO}_2$/km.
- More than 1/10 of the new cars already reach the target of the year 2021.

Source: ACEA, 2016
Core theses: CO$_2$ regulation for motor vehicles

CO$_2$ legislation in Europe shows the most stringent target values in an international comparison.
The most stringent CO$_2$ target values for new vehicles in g CO$_2$/km under the New European Driving Cycle (NEDC)

- The EU emission standard for 2030 is the most stringent standard in the world.
- In the US passenger cars only make up a third of the vehicle market. Light Trucks dominate and their limit Value is considerably higher (140 g/km in 2025)
- In November 2017 the EU Kommission proposed to lower the limit value within the period of 2021 until 2025 by 15 per cent and to codify a minus of 37.5 per cent until 2030.

* Gasoline only
Source: ICCT, 2020
Core theses: CO₂ regulation for motor vehicles

Europe has once again tightened the reins on the CO₂ limit values for motor vehicles and is requiring a further reduction of CO₂ within an even shorter span of time.
CO₂ target values for 2021: High demands on the automotive industry

in g CO₂/km

Independent of vehicle weight, manufacturers of large cars have to show greater reductions than high-volume manufacturers.

In the nine years from 2006 to 2015, a reduction of the average emissions by 30 g CO₂/km was required of new vehicles – from 160 g CO₂/km down to 130 g CO₂/km.

Speeding up the pace: In the six years from 2015 to 2021, average emissions must be reduced by 35 g CO₂/km – from 130 g CO₂/km down to 95 g CO₂/km. For 2025 a suggestion has been raised by the commission of 81 g CO₂/km, that is a minus of 14 g CO₂/km in four years.

Sources: EU, EEA

Average weight of new passenger cars in kg

- Independent of vehicle weight, manufacturers of large cars have to show greater reductions than high-volume manufacturers.
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Efficient new vehicles impact the vehicle fleet

Based on model calculation. With today’s regulation, an emissions reduction of 30 per cent is achievable between 2005 and 2030. This corresponds to the EU target for non-ETS sectors.

- The average consumption of the existing fleet is only gradually reacting to the more efficient new vehicles. That is why a difference can be seen between the emissions of new vehicles and the entire fleet.
- The gap will close once most of the older vehicles with higher emissions are taken off the roads.
- Based on a conservative estimate, the ongoing replacement of old vehicles will result in car traffic emissions in Europe decreasing by approximately 30 per cent by 2030, compared to the year 2005.
- Until 2014, the fleet was dominated by vehicles built before 2005. Several million of these vehicles will still be on the road in 2030.
- The advancements of recent years will long continue to have an impact on the vehicle fleet. Even if new vehicles were to hardly show improvements after 2021, the fleet emissions would continue to decrease.
- In regard to cars, the EU target can be achieved with the existing regulation.

Source: Daimler
Vehicle fleet limit values under 95 grams cannot be achieved with conventional engine types, and the market success of alternative engine types is still uncertain.
Speed makes the difference

\[ \text{CO}_2 \text{ emissions of a middle class car depending on different drives types and speed} \]

\[ \text{HBEFA Cycles with 0\% gradient} \]

\[ \begin{align*}
\text{CO}_2 \text{ in g/km} & \quad \text{v in km/h} \\
0 & \quad 0 \\
50 & \quad 20 \\
100 & \quad 40 \\
150 & \quad 60 \\
200 & \quad 80 \\
250 & \quad 100 \\
\end{align*} \]

\[ \begin{align*}
\text{Euro 6 Diesel} & \quad \text{Plug-In-Hybrid Tank-to-Wheel} \\
\text{Euro 6 Petrol} & \quad \text{Plug-In-Hybrid Well-to-Wheel} \\
\end{align*} \]

Source: TU Graz, 2018
Emissions from PHEV are calculated on the basis of the emissions in combustion operations and of the electric coverage of the car.

Firstly, the PHEV participates in the European testing cycle (NEDC) in combustion operations:

Then it runs the cycle driven on electrical energy as long as the battery lasts.

Depending on the such determined coverage of the car a pro rata deduction from the emissions in pure combustion operations is applied.

Source: EU Komission, Own calculations
Electric cars: Quite different markets
New vehicles and top-selling models of the year 2019

**New vehicles BEV/PHEV: 325,000**
1. Tesla Model 3
2. Toyota Prius PHV
3. Tesla Model X
4. Chevrolet Volt
5. Tesla Model S

**World 2019**
2,209,831

**New vehicles BEV/PHEV: 79,640**
1. Tesla Model 3
2. Volkswagen E Golf
3. Nissan Leaf
4. Audi e-tron
5. Mitsubishi Outlander

**Market share**
5.5%

**New vehicles BEV/PHEV: 564,206**
1. Tesla Model 3
2. Renault Zoe
3. Mitsubishi Outlander
4. Nissan Leaf
5. BMW i3

**Market share**
4.4%

**New vehicles BEV/PHEV: 1,177,421**
1. BAIC EC Series
2. BYD Yuan
3. SAIC Baojun EV
4. Cherry EQ
5. BYD Tang

**Market share**
56.0%

Source: ev-sales.blogspot, 2019
Core theses: CO$_2$ regulation for motor vehicles

An effective reduction of CO$_2$ emissions cannot address new vehicles alone but must take a much broader approach.
Limit values affect only new vehicles
Existing vehicles are not covered by the regulation

Approx. **15.1 million new vehicles** are licensed in the EU each year.

Each year, only about 5 per cent of the vehicle fleet in the EU is replaced.
Existing vehicles hold huge potential for CO2 reduction.
That is why measures for replacing the existing vehicle fleet are essential.

Quelle: ACEA, 2017; VDA, 2017
Improved regulation: Emissions standards for vehicles fall too short

To reduce emissions, drivers and the government need to be involved in the process.

Vehicle limit values only regulate potential emissions. The actual emissions are determined just as much by drivers as by the infrastructure.
Core theses: Balance between climate protection and industrial policy

The EU is targeting a 20% industry share of GDP for the year 2020. This goal is presently a long way away, since industrial and climate protection policy are not yet aligned.
The EU industrial sector: Collapse rather than rebirth

The manufacturing industry’s share of the gross value, as percentage

EU target: The industrial sector is expected to have a 20 per cent share of the GDP in 2020.

- Germany is reaching this target. The UK, Italy and France give cause for concern.
- Countries outside of Europe are improving quickly. Europe must respond in order to secure its position.

Source: Eurostat
Core theses: Balance between climate protection and industrial policy

The CO$_2$ abatement costs vary greatly between sectors and are most pronounced in the automotive sector.
CO₂ avoidance in cars is expensive and would be cheaper to obtain in other sectors

Problem: CO₂ avoidance in cars is already comparatively expensive.

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Emissions trading as the most economically efficient form of CO$_2$ regulation can easily be applied to road traffic.
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The inclusion of road traffic in emissions trading offers certain benefits

- Simple: The necessary amount of carbon credits per tank filling is easy to calculate. The required purchase can be paid for with the fuel.
- Inexpensive for the driver: Based on the EU’s targeted price of 30 euros per carbon credit in the year 2020, a litre of petrol would cost 7 euro cent more.
- Inexpensive for society: The abatement costs of road traffic are far above 30 euros per tonne. Emissions are avoided where it is cheaper to do so.
- But: Since the transportation sector would be purchasing so many carbon credits, other sectors would have to substantially step up their reduction efforts. Good judgment will be necessary in order to avoid an overload in the other sectors.
- Thus: Emissions trading is a useful supplement to today’s limit values.
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Annex

Gestrichene Folien, die nicht mehr aktualisiert werden
Rohstoffe: Hohe Importabhängigkeit der EU

Der Verbrauch an Öl und Gas kann nicht aus heimischen Quellen gedeckt werden

Anteil importierter Primärenergieträger am Verbrauch in Prozent

- Kaum Reserven: Die EU verfügt nur über 1-3 Prozent der Reserven an fossilen Primärenergieträgern.
- Problem: Auch wenn der Verbrauch sinkt, bestehen politische Abhängigkeiten von den Förderländern.

Quelle: Europäische Kommission
Aufholprozess in Asien setzt sich fort

Wachstumsprognosen in Prozent

- Das globale Wachstum bleibt auf Asien fokussiert.
- Die OECD-Länder verlieren weiter an Gewicht.

<table>
<thead>
<tr>
<th>Länder</th>
<th>2017</th>
<th>2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>OECD</td>
<td>2,0</td>
<td>2,0</td>
</tr>
<tr>
<td>Eurozone</td>
<td>1,7</td>
<td>1,6</td>
</tr>
<tr>
<td>Deutschland</td>
<td>1,6</td>
<td>1,5</td>
</tr>
<tr>
<td>USA</td>
<td>2,3</td>
<td>2,5</td>
</tr>
<tr>
<td>Großbritannien</td>
<td>1,5</td>
<td>2,0</td>
</tr>
<tr>
<td>China</td>
<td>2,6</td>
<td>6,2</td>
</tr>
<tr>
<td>Südkorea</td>
<td>3,0</td>
<td>7,2</td>
</tr>
<tr>
<td>Indien</td>
<td>5,0</td>
<td>7,7</td>
</tr>
<tr>
<td>ASEAN 5*</td>
<td>5,2</td>
<td>7,7</td>
</tr>
</tbody>
</table>

*Indonesia, Malaysia, Philippines, Thailand, Vietnam
Quelle: Internationaler Währungsfonds, World Economic Outlook April 2017
Niveau und Dynamik der Standortqualität

Der Standortvorteil vieler OECD-Staaten schrumpft

China holt qualitativ zu den etablierten Industrieländern auf.

Gemessen am globalen Durchschnitt haben sich viele OECD-Standorte seit 1995 auf ihrer starken Stellung ausgeruht.

Quelle: IW Consult (2014)
Die Regelungsdichte in Europa ist sehr hoch und wird immer dichter

Anzahl der EU-Vorschriften für Gesundheit, Sicherheit und Umwelt

Die ohnehin schon hohe Regelungsdichte in der EU nimmt immer weiter zu.

Die verschiedenen Ziele und Regulierungen der EU neigen dazu, sich zu widersprechen.

Um alle Ziele zu verfolgen, braucht es vor allem eine bessere Regulierung.
Der Straßenverkehr ist sauberer geworden – trotz gestiegener Verkehrsmengen

Schadstoffemissionen in der EU-27 in Tonnen

Seit Ende der 80er Jahre lag der Fokus der Politik auf der Schadstoffreduktion. Schadstoffe sind bei Kontakt gesundheitsgefährdend. Das Treibhausgas CO₂ ist somit kein Schadstoff.

Obwohl die Fahrleistungen stark gewachsen sind, gehen die Schadstoffemissionen der Kfz deutlich zurück.

Quelle: EU (TREMOVE)
Der Kraftstoffverbrauch der Fahrzeuge sinkt langsamer

Verbrauchsentwicklung schwerer Lkw im Praxistest* in Liter Diesel auf 100 km


Die gefahrene Ø Geschwindigkeit stieg aber weiter an und die Schadstoffemissionen nahmen drastisch ab.

Aber: Kein wissenschaftlicher Vergleichstest, denn die von Markt nachgefragten und getesteten Fahrzeuge (Leistung, Fahrzeughöhe) und Verkehrslage auf den Teststraßen (Geschwindigkeit, Staugefahr) haben sich im Zeitalauf stark verändert.

* 800 km Rundkurs auf deutschen Straßen
Quelle: transaktuell 10/2014
Gut 22 Prozent weniger Verbrauch vergleichbarer Lkw

Technische Daten des Tests

Verbrauchsrelevante Faktoren

Lkw von 1996: Euro 2
Testgewicht: 39.240 kg
Nennleistung: 435 PS
Ø Geschwindigkeit: 83,7 km/h

Lkw von 2003: Euro 3
Testgewicht: 39.420 kg
Nennleistung: 456 PS
Ø Geschwindigkeit: 84,7 km/h

Lkw von 2015: Euro 6
Testgewicht: 39.820 kg
Nennleistung: 449 PS
Ø Geschwindigkeit: 84,0 km/h

Kraftstoffverbräuche

Nach Streckenart in Litern pro 100 km

Schwere Strecke | Leichte Strecke | Strecke | Durchschnitt im Test
--- | --- | --- | ---
46,4 | 42,6 | 36,7 | 35,6 | 32,4 | 40,8 | 37,4 | 31,9

-21% | -23% | -22%

Von der DEKRA begleiteter Straßentest (Dauer: 4 Tage; Fahrleistung: ca. 2.000 km je Testfahrzeug).
Die Test-Lkw repräsentieren drei unterschiedliche Fahrzeuggenerationen des selben Herstellers.
Die getesteten Fahrzeuge entsprechen in Bezug auf die Leistung den heute üblichen Anforderungen.
Moderne Technik und Assistenzsysteme unterstützen den Fahrer beim verbrauchsarmen Fahren.

Quelle: lastauto omnibus, Heft 10/2016
CO₂-Reduktion: Künftig wird es teurer

CO₂-Einsparung pro Euro Herstellungskosten

Die einfachen und billigen Optionen werden zuerst ergriffen, daher ist die permanente Beschleunigung des Reduktionstempos ein Problem.

Der Verbrauch lässt sich nicht beliebig reduzieren. Ohne Elektrifizierung werden neue Grenzwerte nicht zu schaffen sein, Hersteller großer Pkw müssen bereits jetzt elektrifizieren.

Quelle: BMW
Aber: Der Markthochlauf stockt

Sparsam ist gefragt.*
Frage: What is the fuel economy you will expect in your new car as an average range of liter per 100 km?

E-Autos: Nur ohne Mehrkosten*
Frage: How much would you be prepared to pay for a hybrid drive / electric drive?

* Befragung von 1.500 Neuwageninteressenten in den drei größten Märkten Europas
Quelle: PwC
Lithium: Batteries dominate demand

Demand for lithium in the year 2016 according to specific application

- Energy storage: 50%
- Chemical syntheses: 26%
- Lubricants: 10%
- Glass/Ceramic: 10%
- Other: 6%

Source: Bloomberg Intelligence, 2017
Relevant raw materials increase in price

Change in prices from January 2017 to March 2018 in per cent

- Graphit Anode S: 58%
- Mangan 99.7%: 33%
- Neodymoxid 99%: 40%
- Terbiumoxid 99.9%: 16%
- Dysprosiumoxid 99%: 0%

Source: MBI E-Mobility Materials, Nr. 13 2017
Ökodesignrichtlinie: Verbot von starken Stromverbrauchern


**Energieverbrauchssenkung**

<table>
<thead>
<tr>
<th>Energieverbrauchsersenkung bis zu ... Prozent</th>
<th>Kühlschränke</th>
<th>Gefriergeräte</th>
<th>Waschmaschinen</th>
<th>Geschirrspüler</th>
<th>Trockner</th>
</tr>
</thead>
<tbody>
<tr>
<td>-80%</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>-60%</td>
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<tr>
<td>-40%</td>
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<tr>
<td>-20%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0%</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

**Verbreitung in Europa auf 100 Haushalte kommen ... Geräte**

- Kühlschränke: 105
- Gefriergeräte: 64
- Waschmaschinen: 92
- Geschirrspüler: 56
- Trockner: 34

**Stromaufnahmeleistung von Staubsaugern in Watt**

- Durchschnitt 2013: 2000 Watt
- Grenzwert 2014: 1000 Watt
- Grenzwert 2017: 600 Watt

-44% Energieverbrauchssenkung bis zu ... Prozent

- Kühlschränke: -80%
- Gefriergeräte: -60%
- Waschmaschinen: -40%
- Geschirrspüler: -20%
- Trockner: 0%

**Megatrends**

- Die Ökodesignrichtlinie legt Anforderungen für energieverbrauchsrelevante Produkte fest.
- Ein Produkt, welches zu viel Strom verbraucht, darf nicht mehr ausgeliefert werden.
- Die Effizienz des Ansatzes ist umstritten. Strom unterliegt bereits dem Emissionshandel und der Beitrag durch effizientere Haushaltsgeräte ist gering.

Quellen: Bosch, Odyssee Database 2014
Viel Potenzial für relativ geringe Kosten

Beispielfall

Mehrfamilienhaus
Baujahr 1972
Fläche: 62.030 m²
Finanzierung: Zinssatz 4% über 15 Jahre

Vermeidungskosten pro Tonne CO₂ in Euro

- Maßnahme 1: Umrüstung von Nachtspeicher auf Zentralheizung
- Maßnahme 2: Zentrale Trinkwasserwärmung
- Maßnahme 3: Komplette Bausanierung

CO₂-Reduktion
- Maßnahme 1: -54%
- Maßnahme 2: -61%
- Maßnahme 1+2: -74%
- Maßnahme 1+2+3: 223

Vermeidungskosten sind immer Ergebnis einer Einzelfallbetrachtung.
Es gilt das Prinzip der fallenden Grenzerträge: Je mehr man einspart, desto teurer wird der nächste Schritt.
Problem: Volllsanierungen lohnen sich ohne Förderung nur selten. Auch energetische Sanierungen scheitern oft an den Kosten.
Folge: Das Tempo der energetischen Sanierungen ist zu gering. Es müsste etwa verdoppelt werden, um die Ziele der Politik bis 2020 zu erreichen.

Quelle: Hochtief, 2012
Fossil energy in the USA

Fracking has changed the rules of the game

Gasprice
in US-$ per 1,000m³

US production and import of oil and natural gas
Index, 1990 = 100

- Fracking has strongly impacted the world market for fossil fuels.
- Favourable: The Gas price sank since 2005 clearly under the European level.
- The USA has greatly increased its domestic production of oil and natural gas.
- Independency: This greatly reduced the USA’s need to import fuel.

Sources: Weltbank, Economic Monitor (GEM) Commodities, 2017; IEA, World Energy Statistics, 2018
Kyoto-Protocol

Only Europe really joined in

Almost all of the world’s nations entered into the Kyoto agreement.

Kyoto signatories
Kyoto-Protocol

Only Europe really joined in

- Almost all of the world’s nations entered into the Kyoto agreement.
- Only a few countries accepted emission targets.

Kyoto signatories with emission target
Kyoto-Protocol

Only Europe really joined in

- Almost all of the world’s nations entered into the Kyoto agreement.
- Only a few countries accepted emission targets.
- Soft targets, in some cases: countries of the former Eastern bloc merely aimed to not exceed their figures from 1990.

Kyoto signatories who kept their emission target
Real-Driving-Emissions NO$_x$ – Fast progress

The gap between RDE and laboratory is closing

The first RDE tests of passenger cars were conducted in 2014. The performance of the up to date cars in RDE tests is much better. The Values taken from AMS show the same model with two engine generations. The technology to meet the limit values is on the market.

Sources: ICCT, 2014; Kraftfahrtbundesamt (KBA), 2016; Deutsche Umwelthilfe (DUH), 2016; Auto Motor Sport (AMS), 2015; Auto Motor Sport (AMS), 2016; Bosch
**CO₂ from cars comes at a high cost in the EU**

A penalty of 95 euros will apply for each gram that exceeds the target, for each vehicle sold. This corresponds to approximately 475 euros per tonne of CO₂.

<table>
<thead>
<tr>
<th>CO₂-Prices</th>
<th>in euros pro tonne</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon credits (as of Novembel 2019)</td>
<td>24.6</td>
</tr>
<tr>
<td>Carbon credits (target for 2020)</td>
<td>30</td>
</tr>
<tr>
<td>Damage costs 2010 (UBA)</td>
<td>80</td>
</tr>
<tr>
<td>Damage costs 2030 (UBA)</td>
<td>145</td>
</tr>
<tr>
<td>Petrol Taxation (EU average)</td>
<td>371</td>
</tr>
<tr>
<td>Emission standard for cars</td>
<td>475</td>
</tr>
</tbody>
</table>

Sources: EU, UBA, Weekly Oil Bulletin, own calculations

- From 2021, full penalty fees will apply to car manufacturers who do not reach their specific target.
- If a car drives 200,000 km, a reduction by 1g/km corresponds to an emissions reduction of 200 kg over the life of the vehicle.
- Based on this assumption, the manufacturer will pay a penalty of 475 euros per tonne of CO₂.
- This cost is considerably higher than what others have to pay.
The potential for further reduction exists but is becoming harder to achieve.

Due to the technologies needed for boosting efficiency, new vehicles will cost approximately 2,700 euros more in 2020.

This expense will be offset, however, by savings resulting from lower fuel consumption. These savings are spread across the entire life of the vehicle (17 years on average); so, the first customer will only enjoy part of this benefit but will carry the full cost of the new technologies when purchasing the vehicle.

Source: IKA Aachen