CO$_2$-Emissions of the Traffic Sector: Technical and Economical Conditions for Political Actions

The Board of Academic Advisers to the Federal Minister of Transport, Building and Housing
Prof. Dr. Volker Schindler (TU Berlin)
• In Europe traffic contributes about a quarter to total anthropogenic CO$_2$-emissions.

• **Most prominent emitters are passenger cars.**

• Growth is expected in **road haulage** and **air traffic**.

• Emissions from **seagoing vessels** also give cause for concern.
Energy use in road vehicles causes undesirable side effects:

• Local effects of emissions
  – CO, HC, NOx, SO$_2$, Pb, …
  – particles
  – (noise)
• Global effects of emission
• Finiteness of fossil resources
• Political disposability of fossil resources
Trends in tail pipe emissions in Germany

- Benzol
  - Benzol-Emissionen [kt/a]

- Kohlenwasserstoffe
  - Kohlenwasserstoff-Emissionen [kt/a]

- Kohlenmonoxid
  - Kohlenmonoxid-Emissionen [kt/a]

- Stickoxide
  - Stickoxid-Emissionen [kt/a]

- Dieselpartikel
  - Partikel-Emissionen [kt/a]

Quelle: IFEU im Auftrag des UBA
Break down of emissions from the tail pipe of a gasoline car (Euro II)

- Stickstoff N₂ 72,9 %
- Kohlendioxid CO₂ 13,6 %
- Wasserdampf H₂O 12,6 %
- Weitere 0,12 %
  - Sauerstoff und Edelgase 0,8 %
- CO Kohlenmonoxid 13,6 %
- HC unverbrannte Kohlenwasserstoffe
- NOx Stickstoffoxide
## What has been achieved?

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Achievements</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO</td>
<td>✓ Combustion process, Exhaust gas after treatment</td>
</tr>
<tr>
<td>Pb - lead</td>
<td>✓ Abdication of Pb in fuels</td>
</tr>
<tr>
<td>SO\textsubscript{2}</td>
<td>✓ Desulfurisation of fuels</td>
</tr>
<tr>
<td>NO\textsubscript{x}</td>
<td>✓ Gasoline engines with closed-loop 3-way catalys, Diesel engines with refined combustion process, SCR in heavy commercial vehicles</td>
</tr>
<tr>
<td>Ozone-percursors</td>
<td>✓ Refinements in fuel composition, Exhaust gas after treatment</td>
</tr>
<tr>
<td>Benzene</td>
<td>✓ Partial abdication of benzene in fuels, Exhaust gas after treatment</td>
</tr>
<tr>
<td>CO\textsubscript{2}</td>
<td>Reduction of specific and absolute fuel consumption, Non-fossil fuels</td>
</tr>
<tr>
<td>Fine Particles</td>
<td>✓ Combustion process, Diesel particulate filter, improved fuels</td>
</tr>
</tbody>
</table>
What can be done?

• Less road transport:
  ➔  life styles, land use and spatial structure, division of labour, logistics, …

• More efficient use of vehicles:
  ➔  driver training, driver assistance systems

• Use of more efficient vehicles:
  ➔  vehicle and drive train technologies, fuel technologies, …

• Usage of smaller and less consuming vehicles:
  ➔  live styles, vehicle and drive train technologies, safety in mixed traffic, industry, policies, …

• Fuels based on material and energy poor in fossil carbon:
  ➔  energy technologies and energy economy, agriculture, land use, vehicle and drive train technologies,

• Policy:
  ➔  Creation of an appropriate economic framework: taxes, road pricing, administrative rules were necessary: minimal standards, …. long term reliability
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What determines mileage?

- Consumption of auxiliaries
- Efficiency of on-board energy conversion

- For a given technical means an increase in mileage is rarely more than a few percent.
- Costs become a serious issue: All low hanging fruits already have been reaped.
Where are the limits of mileage?

- < 30 g/km
- 127 g/km
- < 60 g/km
- 65 g/km
- 87 g/km
Specific CO$_2$-emission of the German new car fleet
What does ECE-fuel consumption say about real mileage?

Ruling based on test procedures inevitably becomes an objective of engineering optimisation.

Real life effectiveness can very much be questioned.
Intermediate result:

• It is possible to increase mileage by a considerable amount.

• This requires quite expensive technologies and/or a switch to smaller cars.

• Timing has to be agreed realistically.
What else can be done?

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• Gasoline and diesel as fuels offer a very well balanced trade-off of properties.

• Remaining deficits:
  1. Ex-engine emissions of harmful substances makes aftertreatment systems necessary.
  2. Doubts concerning long term availability of crude
  3. Greenhouse gas emissions

• Is it possible to retain their advantages and to avoid their problems?
  
  Yes, in principle
The refinery process in a nutshell

Crude oil → chemical processing → Syngas → Steam generation → Electricity generation → Hydrogen generation → Gasoline

Gasoline → Diesel

Crude oil → Gasoline → Diesel
Fuel can be made from a lot of sources in principle ...

- Crude oil
- Natural gas
- Biomass
- Biogas-aufbereitung
- Synthesegas
- Chemische Umwandlung
- CNG
- LNG
- Gasoline
- Disel
- Nuclear heat
- Solar heat
- Water power
- Wind power
- Photovoltaic power
- Wärmeerzeugung
- Stromerzeugung
- Wasserstoff-erzeugung
- Hydrogen
- Electricity
A future refinery process?

Crude oil → chemical processing → Syngas → Steam generation → Electricity generation → Hydrogen generation → Syngas

Biomass → chemical processing → Syngas

Gasoline Diesel

Hydrogen generation
Intermediate result:

- A change to another material and energy basis for gasoline and diesel is possible in principle.
- An obvious choice is biomass.
- But:
  - It will become quite expensive.
  - We will have to restructure huge areas.
  - Adverse consequences to food production and to ecological objectives seem to be hardly avoidable.
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<table>
<thead>
<tr>
<th>Streckenverbrauch</th>
<th>Kraftstoff</th>
<th>jährliche Fahrleistung [km]</th>
<th>Gesamtfahrleistung [km]</th>
<th>Haltedauer [a]</th>
<th>Gegenwartswert von 1l/100 km Minderverbrauch [€]</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>Benzin</td>
<td>11,000</td>
<td>121,000</td>
<td>11</td>
<td>1.457</td>
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<td>8</td>
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<td>294,000</td>
<td>1,470,000</td>
<td>5</td>
<td>17.045</td>
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</tbody>
</table>
Should fuel taxes be increased further?

Yes, in principle. But this would result in uneconomical usage of scarce resources!

Taxes on all usage of fossil carbon should be harmonised!
Intellectual Game:

All taxes on fuels at the current level for gasoline

![Graph showing the comparison of different fuels and their respective taxes in millions of €. The chart includes categories such as 'leichtes Heizöl', 'schweres Heizöl', 'Erdgas', 'Flüssiggas', 'Benzin', 'Diesel', and 'Gesamt'. Each category has bars for specific energy taxes and a uniform tax rate of €277.33 per ton CO2 emissions.](image-url)
Intellectual Game:
The sum of taxes on fuels unchanged, but adjusted to equal €/g CO$_2$
A rational policy should consider,

- to aim at an **equal level of taxation per used amount of fossil carbon** for all uses,
- to create a **coalition between car makers, car users, and policy** with the goal, to make energy users able and ready to invest in energy saving, but more expensive technology (e.g. cars) instead of paying high prices for fossil fuels.