World Wide Emission Trend 1950 to 2050
Road Transport and all Sources

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Emitrade - Herrsching

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States considered, Population Trend
Methodical Approach for the Emission Estimation of All Sources
Emission Trend for CO, NMHC, NOx and PM for All Sources
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Road Transport Vehicle and Mileage Trend
Emission Factors and Emission Standards
Emission Trend from Road Transport Emissions
Summary and Conclusion
Contribution of Intercontinental Transport to European Air Quality

Intercontinental Transport, Hemispheric Pollution

HEMISPHERIC POLLUTION BACKGROUND

Tropopause

Free troposphere

PBL

WCB

subsidence

Mixing

"Direct" intercontinental transport

Boundary layer advection

Asia

N. America

Europe

Ref: Jacob D. et al., Tracking global models of intercontinental pollution transport using aircraft and satellite observations, US-EPA/Germany, BMU-UBA-workshop, Bad Breisig, 11. Oktober 2002

Cluster Analysis Used for Long Range Transport

## World Wide Emission Trend 1950 to 2050

### Road Transport and all Sources

In total 187 States are considered

<table>
<thead>
<tr>
<th>Region</th>
<th>States</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CANADA</strong></td>
<td></td>
</tr>
<tr>
<td><strong>USA</strong></td>
<td></td>
</tr>
<tr>
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<td>Argentina, Brazil, Mexico, Chile, Colombia,</td>
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<td>Morocco, Congo, Algeria, Kenya, Cote d'Ivoire, Angola, Ghana, …</td>
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<td>EU-15, Switzerland, Norway</td>
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<td><strong>India</strong></td>
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</tr>
<tr>
<td>China</td>
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<tr>
<td>Japan</td>
<td></td>
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</table>
Evolution of World Population
Contribution of Industry and Developing Countries

Population growth in Billion
From 2000 on forecasted

1950 1.25
1960 1.92
1970 2.70
1980 3.70
1990 4.72
2000 5.28
2010 6.16
2020 7.03
2030 7.89
2040 8.67
2050 9.32

Industry Countries
32% (20%)
68% (80%)

Developing Countries

Inhabitants in Millionen (Estimations)

<table>
<thead>
<tr>
<th>Country</th>
<th>1995</th>
<th>2050</th>
</tr>
</thead>
<tbody>
<tr>
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<td>1,200</td>
<td>1,640</td>
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<td>Indonesia</td>
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<td>349</td>
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<td>Pakistan</td>
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<td>Japan</td>
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<td>Bangladesh</td>
<td>112</td>
<td>164</td>
</tr>
<tr>
<td>Nigeria</td>
<td>94</td>
<td>163</td>
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<tr>
<td>Germany</td>
<td>82</td>
<td>161</td>
</tr>
</tbody>
</table>

Quelle: Globus Sb-3637, v. 7.10.1996
Population: 1950-2050
Evolution of World Energy Demand

Methodology for the Estimation of Worldwide Total Emissions

\[ E_{\text{Total}} = \sum_{n=1}^{14} (E_{\text{Canada}} + E_{\text{USA}} + E_{\text{Latinamer.}} + E_{\text{Africa}} + E_{\text{West Europe}} + \ldots + E_{\text{Int.Ship.}}) \]

\[ E_{\text{State}} = \sum (E_{\text{Fossil Fuel}} + E_{\text{Biofuel}} + E_{\text{Industrial Processes}} + E_{\text{Landuse/Wastetreatment}}) \]

Fossil Fuel includes
- Industry, Power Generation, Residential, Road Transport, Non Road Transport

Landuse/Wastetreatment includes
- Deforestation, Biomass burning, Agricultural wasteburning

- Extrapolation from 1980 to 2004 on the basis of available OECD Data
- Forecast from 2005 to 2050 on the basis of experience of the past, Growth of population, of gross net product and political stability
Global Annual CO-Emission

- CO Emission [Mio t/year]:
  - Total: 1280 Mt CO/year
  - Biogenic: 35%
  - Anthropogenic: 65%

Range vs Most probable Estimate

Global CO-Emissions
Contribution of All Sources in 2000

- Biogenic CO Emissions:
  - Total: 450 x Mt/a
  - Oceans: 21%
  - Biomass Burning: 62%
  - Vegetation: 17%

- Anthropogenic CO Emissions:
  - Total: 830 x Mt/a
  - Biomass-Burning: 43%
  - HD and Busses: 3%
  - Power Plants and Industry: 5%
  - Residential + Small Utilities: 24%
  - PC: 23%

Trend of Worldwide CO-Emissions
All Sources in All Countries

CO in Mio t


East Asia and Africa

CO in Mio t


Latin America and India

CO in Mio t


USA and West Europe

CO in Mio t


Global Annual NMHC Emissions including Ranges

NMHC-Emissions in Mt/a

- **Range**
- **Most probable Estimate**

- **Global NMHC Emissions**
  - Contributions of all Sources in 2000
  - **Biogenic**
    - Total 1250 x Mt/a
    - **Terpene** 12%
    - **Isoprene** 36%
    - **Other reactive NMHC** 30%
  - **Anthropogenic**
    - Total 120 x Mt/a
    - **Passenger Cars** 14%
    - **Duty Veh.** 4%
    - **Fuel-Evap.** 5%
    - **Air plan.** 1%
    - **Other Traffic** 3%
    - **Stationary Sources** 9%
    - **Solvents** 9%
    - **Waste disp.** 7%
    - **Biomass-Woodburning** 18%
    - **Residential Small utilities** 14%
    - **Manmade bush fires** 3%
    - **Waste** 8%

Biogenic: 75.6%
Anthropogenic: 24.4%


Trend of Worldwide HC Emissions
All Sources in All Countries

Reference: World Road Statistics, Geneva, Welt in Zahlen.de

Trend of Worldwide NMHC-Emissions
All Sources - Trend in Different Countries

Reference: World Road Statistics, Geneva, Welt in Zahlen.de
Global Annual NO\textsubscript{x} Emissions including Ranges

**NO\textsubscript{x} Emissions in Mt/a**

- **Range** — most probable value
- **Total**: 182 Mt NO
- **biogenic**: 44 %
- **anthropogen**: 56 %

**Global NO\textsubscript{x} Emissions Share of Different Sources in 2000**

**Biogenic NO\textsubscript{x} Emissions**
- Total: 60 Mill. t/a

- Oxidation of NH\textsubscript{3}: 6%
- Lightning: 32%
- Combustion of Biomass: 19%
- Soil: 39%
- Ocean: 2%

**Anthropogenic NO\textsubscript{x} Emissions**
- Total: 110 Mt/a

- Combustion of Biomass: 14%
- Power Plants: 25%
- Industry: 12%
- Other Traffic: 2%
- Ships on Oceans: 5%
- Mineral-dust: 7%
- Passenger Cars: 9%
- Air Lines: 3%

**Quelle:** Kolar, J. (1990); OECD (1993, 1995); Streit, B. (1994); Walsh, P. M. (1990); Crutzen, P. M. (1983); Logan, J. A. (1983); Penner et al. (1991); IPCC (1995); Strand u. Hov (1995); Potter et al. (1996); Köhler et al. (1997); Müller et al. (1995); Schumann (1997), WG EL, Vienna
Worldwide NOx Emissions 1995
Contribution of Different Sources

- B10-INDUSTRY V3
- B20-POWER GENERATION V3
- B30-CHARCOAL PRODUCTION V3
- B40-RCO: RESIDENTIAL V3
- B51-ROAD TRANSPORT (ETH.) V3
- F10-INDUSTRIAL SECTOR V3+
- F20-POWER GENERATION V3
- F30-OTS (ALL) V3
- F40-RCO SECTOR(RES+COM+OTH) V3
- F51-ROAD TRANSP.(INCL. EVA) V3
- F54-TRANS. LAND NON-ROAD V3
- F57-AIR (ALL) V3
- F58-INTERN. SHIPPING V3
- F80-OIL PROD/(TRANSPORT)ANDL V3
- H10: IRO: IRON&STEEL
- I30: CHE: CHEMICALS V3
- I41-NME-CEMENT V3
- I50-PAP: PAPER PAPER V3
- L41-BB-DEFORESTATION(DIR.EFF.)
- L42-BB-SAVANNA BURNING
- L43-BB-AGRIC. WASTE BURNING
- L44-BB-VEGETATION FIRES(TEMP.)
- W4-WASTE INCINER.(NON-ENERGY)

Source: EDGAR 3.2, 2002

Worldwide NOx Emissions 1995
Contribution of Different Countries

- 01: CANADA
- 02: USA
- 03: OECD EUROPE
- 04: OCEANIA
- 05: JAPAN
- 06: EASTERN EUROPE
- 07: FORMER USSR
- 08: LATIN AMERICA
- 09: AFRICA
- 10: MIDDLE EAST
- 11: SOUTH ASIA
- 12: EAST ASIA
- 13: SOUTH EAST ASIA

Source: EDGAR 3.2, 2002
NO\textsubscript{x} from anthropogenic sources in 2000

Sources: EDGAR 3.2F:2000

Trend of Worldwide NO\textsubscript{x}-Emissions
All Sources in All Countries

Reference: World Road Statistics, Geneva, Welt in Zahlen.de
Trend of Worldwide NOx-Emissions
All Sources - Trend in Different Countries

- All Sources in USA, East Asia and West Europe
- All Sources in Former Soviet Union, India and Middle East
- All Sources in Africa and Latin America
- All Sources in Former Soviet Union, India and Middle East

Global Annual PM Emissions including Ranges

- Total: 1618 Mt/a
- Biogenic: 75.6%
- Anthropogenic: 24.4%
Global Annual PM-Emissions
Share of Different Sources

- **Biogenic PM-Emissions**
  - Total 3250 Mt/a
  - Sea salt 40%
  - Wind erosion 46%
  - Combustion of Biomass 2%
  - Vulcans 1%

- **Anthropogenic PM-Emissions**
  - Total 570 Mt/a
  - Combustion of Biomass 9%
  - Road dust 9%
  - Agriculture 7.5%
  - Industry 14%
  - Bulk-good Transport 25%
  - Secondary Particles 35%


Trend of Worldwide PM-Emissions
All Sources in Million t

[Reference: World Road Statistics, Geneva, Welt in Zahlen.de]
Methodology for the Estimation of Worldwide Road Transport Emissions

Methodology approach (Example for Passenger Cars)

\[ \sum \text{E}_\text{Veh.} = \sum \left( \text{E}_{\text{Canada}} + \text{E}_{\text{USA}} + \text{E}_{\text{Latamer}} + \text{E}_{\text{Africa}} + \text{E}_{\text{West Europe}} + \ldots + \text{E}_{\text{Int.Ship.}} \right) \]

\[ \text{E}_{\text{PC,USA}} = (\text{Reg. Cars}_{\text{USA}} \times \text{Av. Annual Mileage}_{\text{USA}} \times \text{relat. E-Factor}_{\text{USA}}) \]

Registered Passenger Car and goods vehicle numbers and average annual mileage from World Road statistics 1980 to 2004 of International Road Federation.

Emission Factors partly from measurements in some countries and literature survey.

Forecast from 2005 to 2050 on the basis of experience of the past, Growth of population, of gross net product and political stability.
**Worldwide Vehicle Trend**

**Passenger Cars 2005**

**PC Contribution of different countries in 2005**

- CANADA: 55.5
- USA: 12.7
- LAT. AM.: 19.2
- AFRICA: 6.9
- W. EUROPE: 37.2
- E. EUROPE: 34.7
- CIS(f.USSR): 37.2
- Middle EAST: 13.9
- INDIA+: 18.0
- CHINA+: 142.7
- E ASIA: 27.2
- OCEAN.: 54.0
- JAPAN: 13.9
- Total: 205.3

*Reference: World Road Statistics, Geneva, Welt in Zahlen.de*

**Trend of Worldwide Passenger Cars**

**All Countries**

<table>
<thead>
<tr>
<th>Year</th>
<th>Million</th>
</tr>
</thead>
<tbody>
<tr>
<td>1950</td>
<td>100</td>
</tr>
<tr>
<td>1960</td>
<td>200</td>
</tr>
<tr>
<td>1970</td>
<td>300</td>
</tr>
<tr>
<td>1980</td>
<td>400</td>
</tr>
<tr>
<td>1990</td>
<td>500</td>
</tr>
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<td>2000</td>
<td>600</td>
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<tr>
<td>2010</td>
<td>700</td>
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<td>2020</td>
<td>800</td>
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<tr>
<td>2030</td>
<td>900</td>
</tr>
<tr>
<td>2040</td>
<td>1000</td>
</tr>
<tr>
<td>2050</td>
<td>1100</td>
</tr>
</tbody>
</table>

*Reference: World Road Statistics, Geneva, Welt in Zahlen.de*
Worldwide Vehicle Trend
Duty Vehicles

Year
Million

Worldwide Vehicle Trend
Two Wheeler

Year
Million

Reference: World Road Statistics, Geneva, Welt in Zahlen.de
Total Mileage Trend Road Transport Worldwide

<table>
<thead>
<tr>
<th>Year</th>
<th>Passenger cars</th>
<th>Duty vehicles</th>
<th>Two wheelers</th>
</tr>
</thead>
<tbody>
<tr>
<td>1950</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1970</td>
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<td></td>
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<td>1990</td>
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<tr>
<td>2050</td>
<td></td>
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</tbody>
</table>

Reference: World Road Statistics, Geneva

Trend of Worldwide Emission Standards
Example EU Passenger Cars

<table>
<thead>
<tr>
<th>Standard</th>
<th>CO</th>
<th>HC</th>
<th>NOx</th>
<th>PM</th>
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<tbody>
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<td>100</td>
<td>100</td>
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<td>60</td>
<td>95</td>
<td>55</td>
<td>10</td>
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<tr>
<td>74/290/EWG</td>
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<td>68</td>
<td>34</td>
<td>19</td>
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<tr>
<td>77/102/EWG</td>
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<td>100</td>
<td>18</td>
<td></td>
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<tr>
<td>78/665/EWG</td>
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<td>85</td>
<td>68</td>
<td>34</td>
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<tr>
<td>83/351/EWG</td>
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<td>64</td>
<td>55</td>
<td></td>
</tr>
<tr>
<td>88/76/EWG</td>
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<td>55</td>
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<td>88/436/EWG</td>
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<td>EURO 1</td>
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<td>48</td>
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<td>EURO 2 Otto</td>
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<td>60</td>
<td>48</td>
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<tr>
<td>EURO 2 Diesel</td>
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<tr>
<td>EURO 3 Otto</td>
<td>100</td>
<td>60</td>
<td>48</td>
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<tr>
<td>EURO 3 Diesel</td>
<td>100</td>
<td>60</td>
<td>48</td>
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</tr>
<tr>
<td>EURO 4 Otto</td>
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<td>48</td>
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<tr>
<td>EURO 4 Diesel</td>
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<td>60</td>
<td>48</td>
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</tbody>
</table>

Reference: Schweinle G., Emission Standards

EU Driving Cycle
ECE Cycle

HARMO-10 Crete 2005
Trend of Worldwide NOx Emission Standards
And Fleet Emission Factor Example EU Duty Vehicles

<table>
<thead>
<tr>
<th>NOx Emission Standard</th>
<th>NOx Fleet Emission Factor in g/km</th>
</tr>
</thead>
<tbody>
<tr>
<td>[g/kWh]</td>
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<tr>
<td>1988</td>
<td>14.1</td>
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<td>1992</td>
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<td>1995</td>
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<td>2000</td>
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<tr>
<td>2005</td>
<td>3.5</td>
</tr>
<tr>
<td>2008</td>
<td>2.0</td>
</tr>
<tr>
<td>Euro 0 Euro 1 Euro 2 Euro 3 Euro 4 Euro 5</td>
<td></td>
</tr>
</tbody>
</table>

(Referenced: Schweinle G., Emission Standards)

Emission Requirements starting from EU and US spreading out worldwide

- Many asian Markets and Rest of the World
  - follow max. to EU- or US/California-Niveau
- Japan:
  - Further Stringency (max. to EU-Niveau)
- Europe:
  - EU4 + strong increasing Requirements with EU5 (especially Diesel)
- USA:
  - Fed.Standards Stage 2, Low Emission Vehicle II / ULEV II (California)
  - ZEV-Mandat in a few Federal States
  - valid similar for South Korea

(Referenced: me-50.13, me-50.14)

HARMO-10 Crete 2006
Trend of Worldwide CO Emissions
All Vehicles Together

Million metric tons CO/year


0 40 80 120 160


Trend of Worldwide CO Emissions in Mio t
Passenger Cars, Duty Vehicles and Two Wheeler

CO in Mio t


0 20 40 60 80 100 120 140

Duty vehicles
Two wheelers
Passenger cars

Reference: HARMO-10 Crete 2005
Trend of Worldwide CO-Emissions
All Vehicles Together

[Graph showing CO emissions for USA and West Europe, and Latin America and Japan over the years 1950 to 2050.]

Trend of Worldwide HC Emissions
All Vehicles Together

[Graph showing NMHC emissions for all vehicles over the years 1950 to 2050.]
**Trend of Worldwide NMHC-Emissions**

**Passenger Cars, Duty Vehicles and Two Wheeler**

- **NMHC in Mio t**

- **Duty vehicles**
- **Two wheelers**
- **Passenger cars**


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**Trend of Worldwide HC-Emissions**

**All Vehicles Together**

- **All Vehicles in USA and West Europe**
- **All Vehicles in Latin America, India and Japan**

**NMHC in Mio t**

- **USA**
- **West Europe**
- **India**
- **Latin America**
- **Japan**

Trend of Worldwide NOx-Emissions
All Vehicles Together

Million metric tons NOx/year


Trend of Worldwide NOx-Emissions
Passenger Cars, Duty Vehicles and Two Wheeler

NOx in Mio t


Duty vehicles
Two wheelers
Passenger cars

Reference: World Road Statistics, Geneva, Welt in Zahlen.de
Trend of Worldwide NOx-Emissions
All Vehicles Together

Trend of Worldwide PM-Emissions in Mio t
All Vehicles Worldwide

References:
Trend of Worldwide PM-Emissions
Passenger Cars, Duty Vehicles and Two Wheeler

PM in Mio t

Duty vehicles
Two wheelers
Passenger cars


Reference: World Road Statistics, Geneva, Welt in Zahlen.de

Trend of Worldwide PM-Emissions
Passenger Cars, Duty Vehicles and Two Wheeler

All Vehicles in USA and West Europe

PM in Mio t

West Europe
USA


India
Japan

All Vehicles in India and Japan

PM in Mio t


Canada
Africa

All Vehicles in Africa and Canada

PM in Mio t


Oceania
Latin America

All Vehicles in Latin America and Oceania

PM in Mio t


Reference: World Road Statistics, Geneva, Welt in Zahlen.de

HARMO-10 Crete 2005
Comparison of Road Transport Emissions
With Emissions of all Sources

Trend of Worldwide CO Emissions
Total and Road Transport

Million metric tons CO/a

Trend of Worldwide VOC and NOx\textsuperscript{-}Emissions Total and Road Transport

<table>
<thead>
<tr>
<th>Year</th>
<th>VOC</th>
<th>NOx</th>
</tr>
</thead>
<tbody>
<tr>
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<td>100</td>
<td>50</td>
</tr>
<tr>
<td>2005</td>
<td>300</td>
<td>150</td>
</tr>
</tbody>
</table>

Trend of Worldwide PM Emissions Total and Road Transport

<table>
<thead>
<tr>
<th>Year</th>
<th>PM</th>
</tr>
</thead>
<tbody>
<tr>
<td>1950</td>
<td>10</td>
</tr>
<tr>
<td>2005</td>
<td>30</td>
</tr>
</tbody>
</table>

Worldwide Emissions of All Sources Summary 1

- Ranges of global emissions are widespread. Manmade Emissions contribute from 12% to 65% dependend from the component.
- Estimations of CO emissions from all sources are highest in Africa, followed by Latin America, East Asia, India and USA.
- Estimations of NMHC emissions from all sources are highest in Latin America, followed by India, Africa, East Asia and USA.
- Estimations of NOx emissions from all sources are highest in USA, followed by East Asia, Africa, Latin America and India.
- Estimations of PM emissions from all sources are highest in China, followed by USA, Europe, Japan and Latin America.

Road Transport Emissions Summary 2

- Road Transport Vehicle stock and Mileage increase steadily.
- Due to Emission Standards in all Countries Emissions decrease after 1990 for Road Transport and after 2020 for all Sources.
- Estimations of CO emissions from Road Transport are highest in USA followed by Europe
- Estimations of NMHC emissions from Road Transport are highest in USA and Europe
- Estimations of NOx emissions from Road Transport are highest in USA followed by Europe
- Estimations of PM emissions from Road Transport are highest in USA followed by Europe and Latin America
Summary 3 and Conclusion

- CO Emissions have been critical 30 years ago in Industrial States.

- NMHC Emissions together with NOx Emissions especially from Stationary Sources still have to be decreased, due to their Ozon forming Potential.

- Passenger Car NOx-Emissions are diminishing, while Duty Vehicles have a slight decreasing trend after 1990.

- PM-Emissions from Duty vehicles are dominating by far and decrease after 1998. In USA the level in 2000 is three times higher as in Europe.

- In Industrial States the decreasing trend is starting about 5 to 10 years earlier as in Emerging and Developing States.

- Therefore a harmonized emission standardization of stationary and mobile Sources is the most effective strategy to solve remaining Air Quality Problems.

Anthropogene Partikel-Emissionen in der Europäischen Union

PM-Emissionen 3530 [kt/a] Bezugsjahr 2000
- Industrieprozesse: 20%
- Straßenverkehr: 33%
- Landwirtschaft: 9%
- Müllverbrennung: 8%
- übriger Verkehr: 3%
- Industriefeuerung: 9%
- Haushalte und Kleinverbraucher: 11%
- Kraft Heizwerke: 7%

PM_{10}-Emissionen 1820 [kt/a] Bezugsjahr 2000
- Industrieprozesse: 20%
- Straßenverkehr: 15%
- Landwirtschaft: 10%
- Industriefeuerung: 9%
- Müllverbrennung: 11%
- Kraft Heizwerke: 9%
- Haushalte und Kleinverbraucher: 10%

PM_{2,5}-Emissionen 1120 [kt/a] Bezugsjahr 2000
- Industrieprozesse: 24%
- Straßenverkehr: 17%
- Müllverbrennung: 12%
- Landwirtschaft: 8%
- Industriefeuerung: 5%
- Haushalte und Kleinverbraucher: 15%

PM_{0,1}-Emissionen 270 [kt/a] Bezugsjahr 2000
- Industrieprozesse: 26%
- Straßenverkehr: 27%
- Müllverbrennung: 11%
- Industriefeuerung: 3%
- Landwirtschaft: 3%
- Haushalte und Kleinverbraucher: 10%

### Worldwide NO\textsubscript{x}- Emissions

**Passenger Cars statewise in 1980 and 2010**

<table>
<thead>
<tr>
<th>Region</th>
<th>Million metric tons NO\textsubscript{x}/a from PC in 1980</th>
<th>Million metric tons NO\textsubscript{x}/a from PC in 2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>JAPAN</td>
<td></td>
<td></td>
</tr>
<tr>
<td>OCEAN.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>E ASIA</td>
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<td></td>
</tr>
<tr>
<td>CHINA+</td>
<td></td>
<td></td>
</tr>
<tr>
<td>INDIA+</td>
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</tr>
<tr>
<td>Middle EAST</td>
<td></td>
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<tr>
<td>CIS(f.USSR)</td>
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</tr>
<tr>
<td>E. EUROPE</td>
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<tr>
<td>W. EUROPE</td>
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<tr>
<td>AFRICA</td>
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<tr>
<td>LAT. AM.</td>
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<tr>
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<tr>
<td>CANADA</td>
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### Worldwide PM- Emissions

**Passenger Cars statewise in 1980 and 2010**

<table>
<thead>
<tr>
<th>Region</th>
<th>Million metric tons PM/a from PC in 1980</th>
<th>Million metric tons PM/a from PC in 2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>JAPAN</td>
<td></td>
<td></td>
</tr>
<tr>
<td>OCEAN.</td>
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<td></td>
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<tr>
<td>E ASIA</td>
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<tr>
<td>CHINA+</td>
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</tr>
<tr>
<td>INDIA+</td>
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<tr>
<td>Middle EAST</td>
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<tr>
<td>CIS(f.USSR)</td>
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<tr>
<td>E. EUROPE</td>
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<td>W. EUROPE</td>
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<tr>
<td>LAT. AM.</td>
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<td>USA</td>
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<tr>
<td>CANADA</td>
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</table>

References:

[Image of bar charts showing emissions data]
Entwicklung der Emissionen aller Quellen in Europa (EU15)

(Empfänger: AOP II 1999)

**Carbon monoxide Emissions in kt**

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<tr>
<th></th>
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<td>573</td>
<td>567</td>
<td>561</td>
<td>555</td>
<td>550</td>
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<td>651</td>
<td>690</td>
<td>728</td>
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<td>808</td>
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<td>3108</td>
<td>3013</td>
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<td>5901</td>
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<td>19280</td>
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**Change from 1995**

-14%  0%  16%  31%  41%  47%  49%

**Nitrogen oxides Emissions in kt**

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<td>779</td>
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<td>Combustion: non-industry</td>
<td>571</td>
<td>584</td>
<td>596</td>
<td>608</td>
<td>620</td>
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<td>Road transport</td>
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<td>5131</td>
<td>3925</td>
<td>2678</td>
<td>1631</td>
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<td>985</td>
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**Change from 1995**

-10%  0%  15%  29%  43%  47%  48%

**Particulate matter < 10 microns Emissions in kt**

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<td>461</td>
<td>437</td>
<td>414</td>
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<td>481</td>
<td>436</td>
<td>391</td>
<td>346</td>
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<td>Road transport: Diesel exhaust</td>
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<td>245</td>
<td>177</td>
<td>115</td>
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<td>68</td>
<td>36</td>
<td>34</td>
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<td>37</td>
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<td>Road transport: Non exhaust</td>
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<td>41</td>
<td>47</td>
<td>53</td>
<td>58</td>
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<tr>
<td>Waste</td>
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</table>

**Change from 1995**

-7%  0%  11%  20%  29%  30%  29%

**Non methane volatile organic compounds Emissions in kt**

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<td>244</td>
<td>236</td>
<td>228</td>
<td>220</td>
<td>220</td>
<td>220</td>
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<td>Combustion: industry</td>
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<td>54</td>
<td>57</td>
<td>60</td>
<td>63</td>
<td>63</td>
<td>63</td>
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<tr>
<td>Combustion: non-industry</td>
<td>655</td>
<td>654</td>
<td>652</td>
<td>649</td>
<td>649</td>
<td>649</td>
<td>649</td>
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<tr>
<td>Fuel extraction</td>
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<td>865</td>
<td>803</td>
<td>736</td>
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**Change from 1995**

-12%  0%  17%  31%  40%  42%  42%

**Trend of Worldwide Emission Standards**

**Example EU Duty Vehicles**

<table>
<thead>
<tr>
<th>Jahre</th>
<th>Euro 0</th>
<th>Euro 1</th>
<th>Euro 2</th>
<th>Euro 3</th>
<th>Euro 4</th>
<th>Euro 5</th>
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<tr>
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<td>7,0</td>
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<tr>
<td>1992</td>
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<td>7,0</td>
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<td>3,5</td>
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<tr>
<td>1995</td>
<td>14,5</td>
<td>9,0</td>
<td>7,0</td>
<td>5,0</td>
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<tr>
<td>2000</td>
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<td>9,0</td>
<td>7,0</td>
<td>5,0</td>
<td>3,5</td>
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<tr>
<td>2005</td>
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<td>7,0</td>
<td>5,0</td>
<td>3,5</td>
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</tr>
<tr>
<td>2010</td>
<td>14,5</td>
<td>9,0</td>
<td>7,0</td>
<td>5,0</td>
<td>3,5</td>
<td>2,0</td>
</tr>
</tbody>
</table>

**Reference:** Schweinle G., Emission Standards
Worldwide VOC- and NOx-Emission Trend

Ref: M. Amann, emission trend of anthropogenic air pollutants in the northern hemisphere, US-EPA/German_BMU-UBA-workshop, Bad Breisig, 11.Oktober 2002

Emission Factors for Passenger Cars for NOx

Ref: Lenz H.P.  AK-EL, 98, Wien
**Emission Factors for Passenger Cars for PM**

![Graph](image1)

*) Change of Driving Cycle

**PM Emission Standards and Emission Factors for Heavy Duty Vehicles**

![Graph](image2)
**Reserves of Oil and Gas - Trend since 1980**

[Graph showing the trend of worldwide oil and gas reserves since 1980.]

**Global Annual VOC-, NOx-, PM- and SO2 - Emissions including Ranges**

- **NMHC-Emissions in [Mt/a]**
  - Total: 1420 [Mt NMHC/a] (biogenic: 88%, anthropogenic: 12%)
  - Range: 70 to 170

- **NOx - Emissions in [Mt/a]**
  - Total: 162 [Mt NOx/a] (biogenic: 85%, anthropogenic: 15%)
  - Range: 65 to 127

- **SO2 - Emissions in [Mt/a]**
  - Total: 1618 Mt/a (biogenic: 39.4%, anthropogenic: 60.6%)
  - Range: 163 to 251

Globale jährliche CO₂-Emissionen
Anteil verschiedener Quellen

Biogenic CO₂ Emissions
Total 770 Billion t/a

- Oceans 43%
- Vegetation 28%
- Soil 28%
- Biomass Burning <1%

Anthropogenic CO₂ Emissions
Total 28 Billion t/a

- Power Plants 25%
- Residential burn.
- Small utilities 23%
- Industry 15%
- Passenger cars 5.5%
- Duty Vehicles 6%
- Air Planes 3%
- Ships on Sea 1.5%
- Traffic 2%
- Biomass Burning 1%
- Other 1.5%