10th Internat. Conference on Harmonization within Atmospheric Dispersion Modelling for Regulatory Purposes Crete, Sissi (Malia), 17. – 20. October 2005

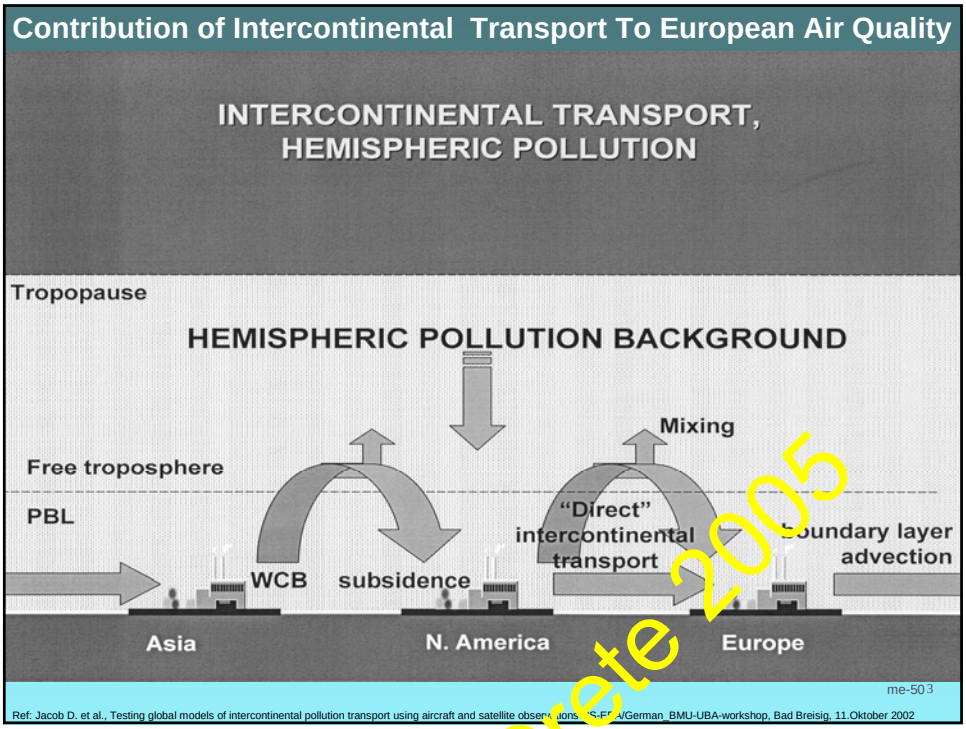
World Wide Emission Trend 1950 to 2050 Road Transport and all Sources

Dr. Ing. Norbert Metz
Emitrade - Herrsching

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

Contents

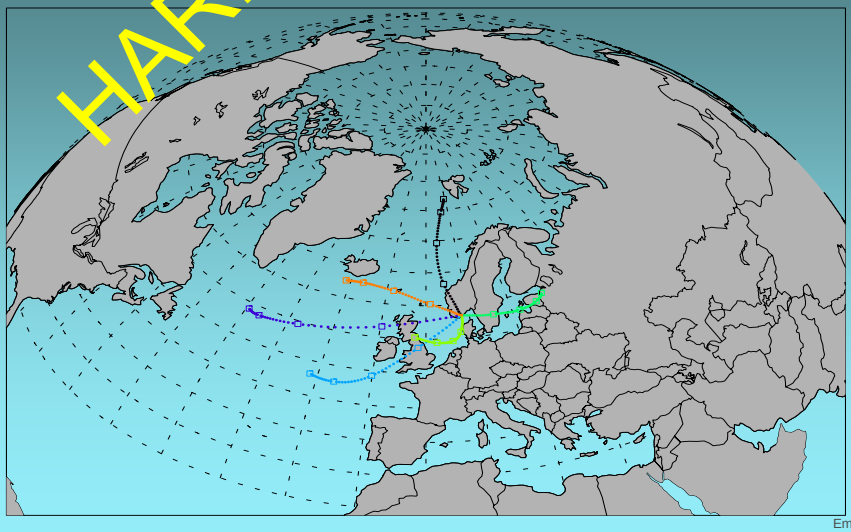
Contribution of Intercontinental Transport To European Air Quality



me-50 3

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

Cluster Analysis used for Long Range Transport



Ref: S. Solberg, M. Kahnert, O, Hov, Episodes and climatology of ozone and transport patterns based on EMEP monitory data and trajectory statistics, US-EPA/German_BMU-UBA-workshop, Bad Breisig, 11.Oktober 2002

Emitrade
me-50 4

Harmonisation within Atmospheric Dispersion Modellling for Regulatory Purpose

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

In total 187 States are considered

CANADA
USA
Latin America: Argentina, Brazil, Mexico, Chile, Colombia, Peru, Guatemala, …
Africa : Morocco, Congo, Algeria, Kenya, Cote d`Ivoire, Angola, Ghana, …
West Europe : EU-15, Switzerland, Norway
East Europe : Poland, Romania, Bulgaria, Czech Rep., Croatia, Baltic States, …
Former Sovjet Union : Russian Fed., Ukraine, Uzbekistan, Kazakhstan, …
Middle East : Israel, Lebanon, Egypt, Kuwait, Iran, Iraq, Jordan, Bahrain, …
India
China
East Asia : Taipei, Indonesia, Malaysia, Thailand, Pakistan, Philippines, …
Oceania : Australia, New Zealand, Fiji, Micronesia, Papua New Guinea, …
Japan

States

Harmonisation within Atmospheric Dispersion Modellling for Regulatory Purpose

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

Population Trend

reported in Worldbank data profiles for 1998 to 2004

for all States together with other relevant economic Data

Emission Inventory Data reported in EDGAR 3.2

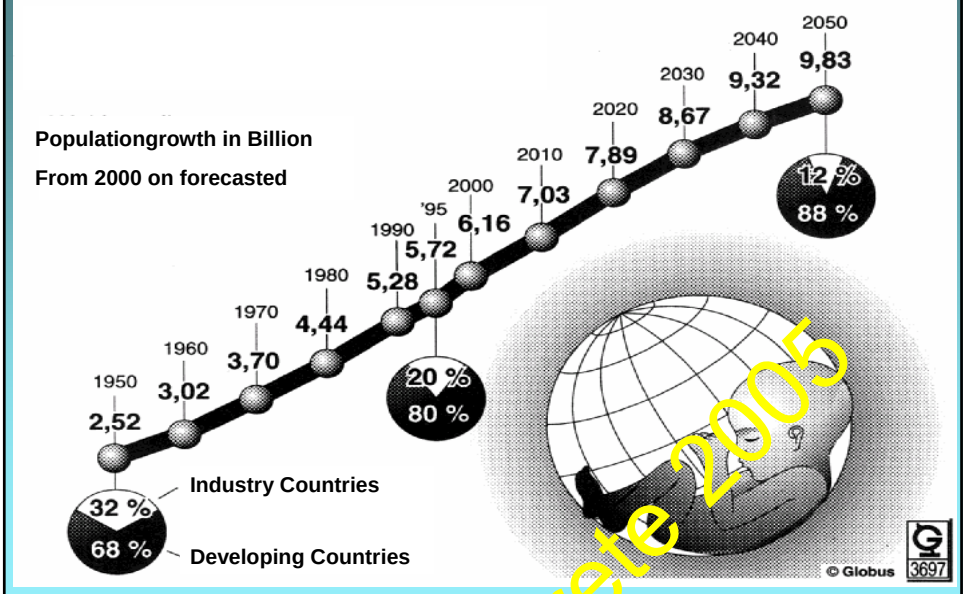
Extrapolated before and after this time period until 2050

Road Transport Data

reported in World Road Statistics, Eurostat, OECD, Welt in Zahlen.de

Population

Evolution of World Population
Contribution of Industry and Developing Countries



Ref. : Globus Sb-3697, v. 7.10.1996

Population 1950-2050

Evolution of Worlds Population
Contribution of the most populated States

Inhabitants in Millionen (Estimations)

1995		2050	
1 200	China	India	1 640
936	India	China	1 606
263	USA	381	Pakistan
198	Indonesia	349	USA
162	Brasilia	339	Nigeria
147	Russian Fed.	319	Indonesia
140	Pakistan	264	Brasilia
125	Japan	239	Bangladesch
120	Bangladesch	194	Äthiopia
112	Nigeria	164	Zaire
94	Mexico	163	Iran
82	Germany	161	Mexico

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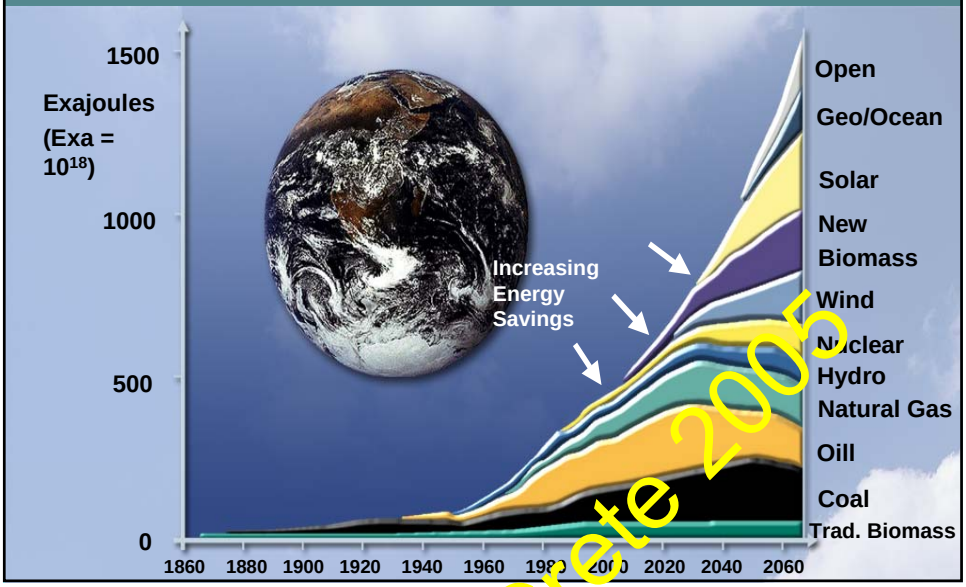
Quelle:Globus Sb-3937

Population

Evolution of World Energy Demand



Methodology for the Estimation of Worldwide Total Emissions

$$E_{Total} = \sum_{n=1}^{n=4} (E_{Canada} + E_{USA} + E_{Latinamer.} + E_{Africa} + E_{West\ Europe} + \ldots + E_{Int.Ship.})$$

$$E_{State} = \sum (E_{Fossil\ Fuel} + E_{Biofuel} + E_{Industrial\ Processes.} + E_{Landuse/Wastetreatment})$$

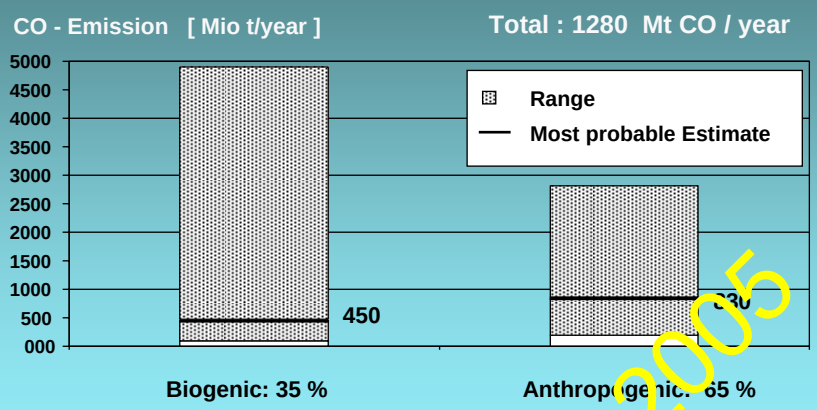
Fossil Fuel includes
Industry, Power Generation, Residentials, Road Transport, Non Road Transport

Landuse/Wastetratment includes
Deforestation, Biomass burning, Agrcultural 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

Emitrade
me-50 10
Methodo all

Global Annual CO-Emission



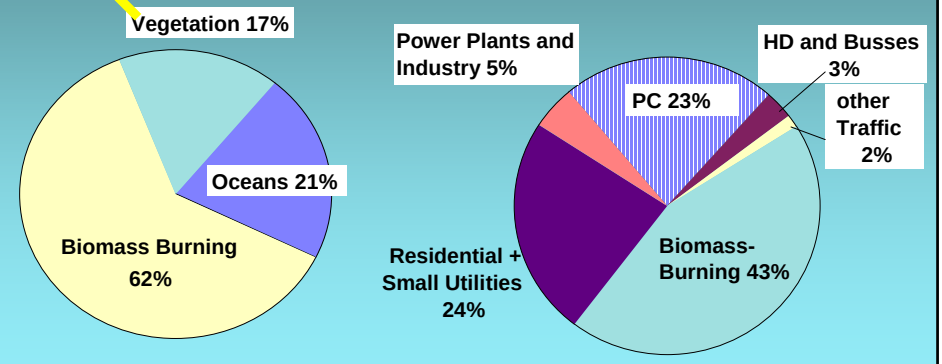
[Reference: OECD 1993, 1995; Conrad, R. 1982; Crutzen, P.M. 1983; Streit, B. 1994; Walsh, P.M. 1990; Garnier, C. et al. 1996, Olivier, J.G.J. et al. 1996]

Emitrade me-50 11 Global CO

Global CO-Emissions Contribution of All Sources in 2000

Biogenic CO Emissions Total 450 x Mt/a

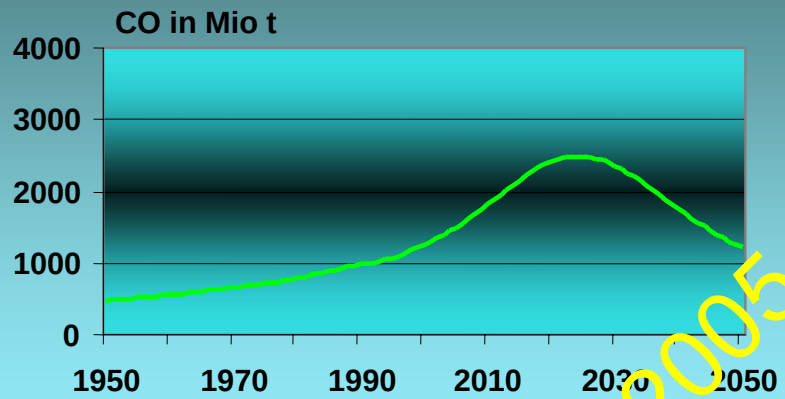
Anthropogenic CO Emissions Total 830 x Mt/a



[Ref: OECD 1993, 1995; Conrad, R. 1982; Crutzen, P.M. 1983; Streit, B. 1994; Walsh, P.M. 1990; Garnier, C. et al. 1996, Olivier, J.G.J. et al. 1996]

Emitrade me-50 12 Global CO C

Trend of Worldwide CO-Emissions
All Sources in All Countries

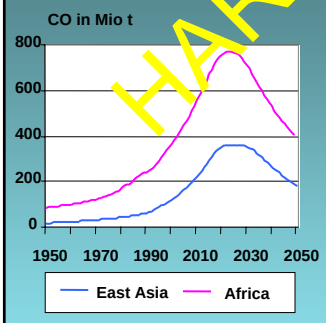


[Reference: World Road Statistics, Geneva, Welt in Zahlen.de

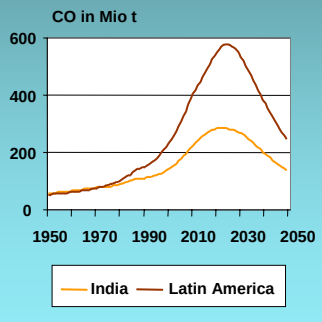
Emitrade
me-50 13
CO-E-To-W

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

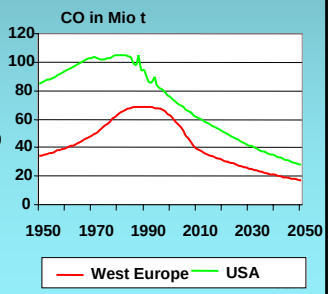
East Asia and Africa



Latin America and India



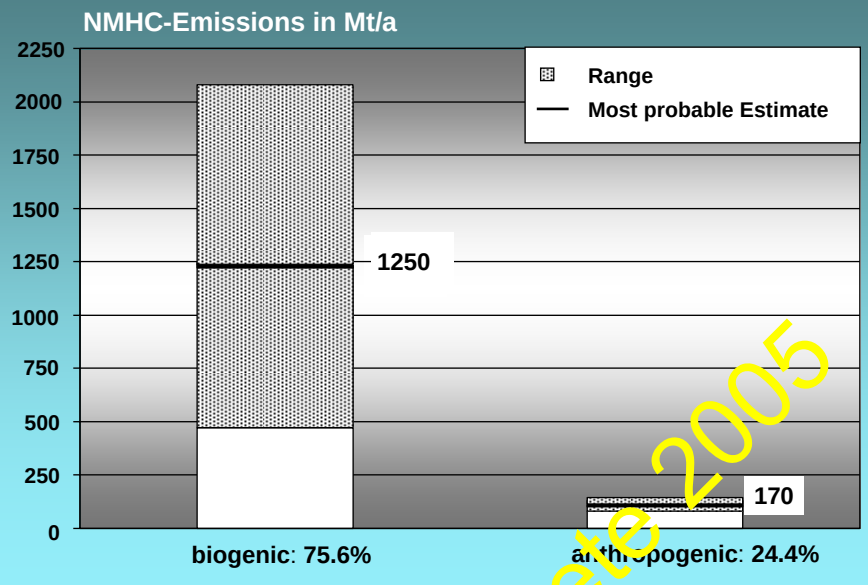
USA and West Europe



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

me-50 14
CO-E-T

Global Annual NMHC Emissions including Ranges

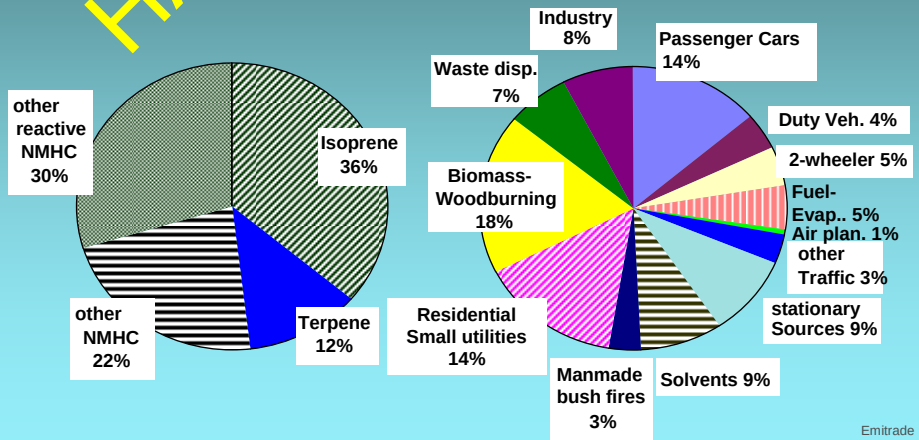


[Ref: OECD 1993, 1995; Conrad, R. 1982; Crutzen, P.M. 1983; Streit, B. 1994; Walsh, P.M. 1990; Ga[illegible] et [illegible]. 1996, Olivier, J.G.J. et al. 1996]

Emitrade me-50 15 Global NMHC

Global NMHC-Emissions Contribution of all Sources in 2000

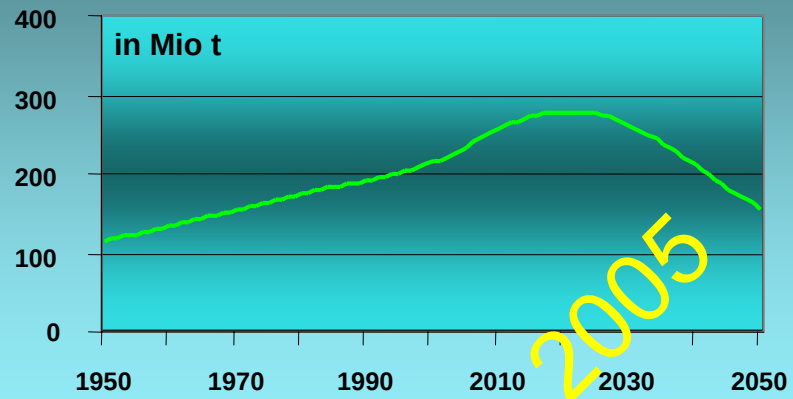
Biogenic NMHC-Emissions	Anthropogenic NMHC- Emissions
Total [illegible] x Mt/a	Total 120 x Mt/a



[Refe: Fehsenfeld et al. 1992, Hewitt et al. 1992; Piccot et al. 1992, Levine 1994, Walsh 1994, Guenther et al. 1995, Müller et al. 1995, Rudolph 1995, Strand et al. 1995]

Emitrade me-50 16 Global NMHC C

Trend of Worldwide HC Emissions
All Sources in All Countries

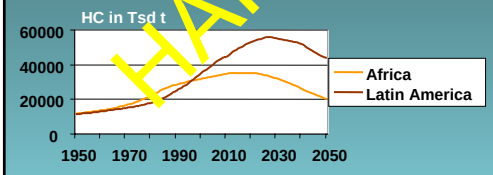


[Reference: World Road Statistics, Geneva, Welt in Zahlen.de

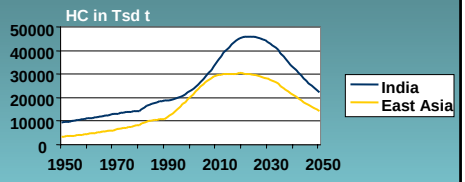
Emitrade
me-50 17
HC-E-To-W

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

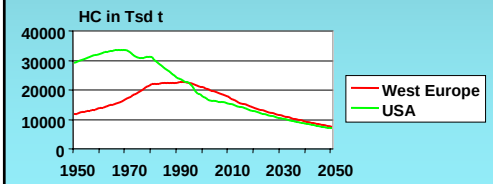
Latin America and Africa



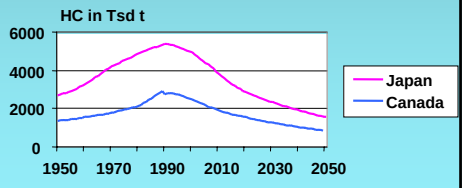
India and East Asia



USA and West Europe



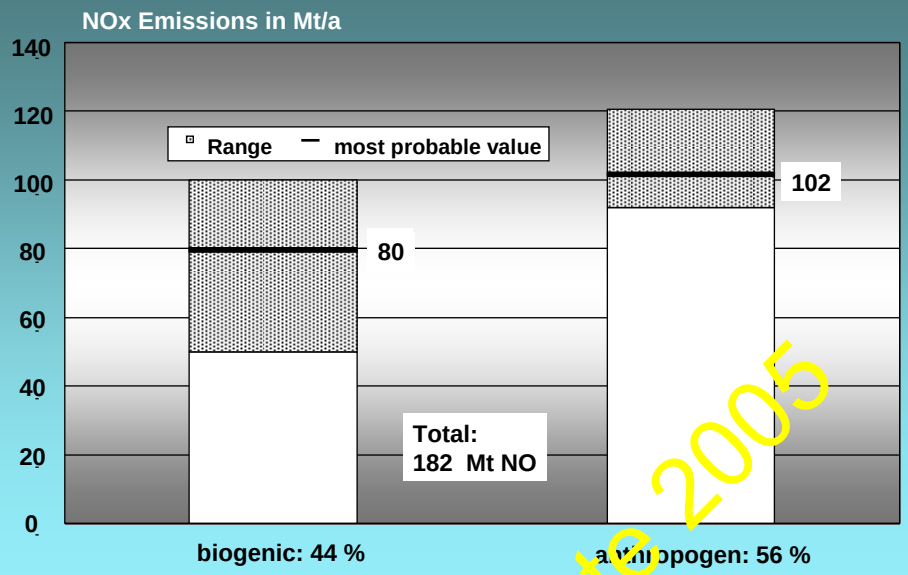
Japan and Canada



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

Emitrade
me-50 18
HC-E-T

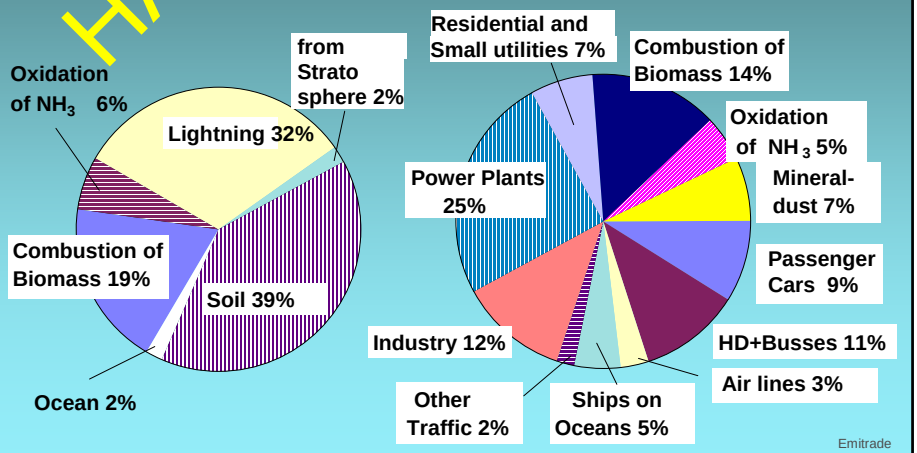
Global Annual NOx Emissions including Ranges



[Ref: OECD 1993, 1995; Conrad, R. 1982; Crutzen, P.M. 1983; Streit, B. 1994; Walsh, P.M. 1990; Ga[illegible] et [illegible]. 1996, Olivier, J.G.J. et al. 1996]

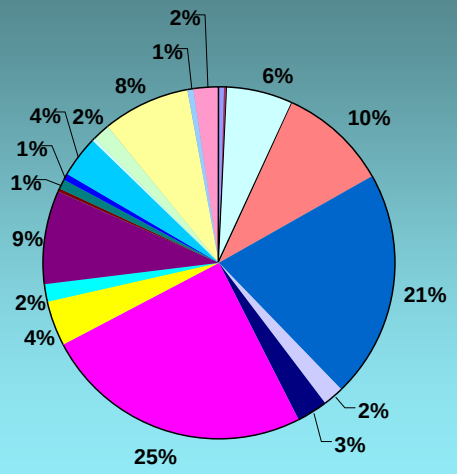
Global Annual NO_x-Emissions Share of Different Sources in 2000

Biogenic NO_x-Emissions Total 80 Mill. t/a	Anthropogenic NO_x-Emissions Total 110 Mt/a



[Quelle: Kolar, J. 1990; OECD 1993, 1995; Streit, B. 1994; Logan, J.A. 1983; Elkins, J.W. 1989; Penner et al. 1991; IPCC 1995; Lee et al. 1997; Köhler et al. 1997; Müller et al. 1995; Strand u. Hov 1995; Potter et a. 1996; Schumann 1997), WG EL, Vienna]

Worldwide NOx Emissions 1995
Contribution of Different Sources

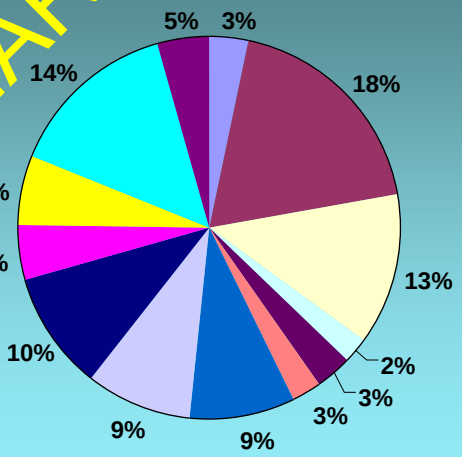


- B10-INDUSTRY V3
- B20-POWER GENERATION V3
- B30-CHARCOAL PRODUCTION V3
- B40-RCO: RESIDENTIAL V3
- B51-ROAD TRANSPORT (ETH.) V3
- F10-INDUSTRIAL SECTOR V3+
- F20-POWER GENERATION V3
- F30-OTS (ALL) V3
- F40-RCO SECTOR(RES+COM+OTH) V3
- F51-ROAD TRANSP.(INCL. EVA) V3
- F54-TRANS. LAND NON-ROAD V3
- F57-AIR (ALL) V3
- F58-INTERN. SHIPPING V3
- F80-OIL PROD/(TRANSM)/HANDL V3
- I10: IRO: IRON&STEEL
- I30: CHE: CHEMICALS V3
- I41-NME-CEMENT V3
- I50-PAP: PULP & PAPER V3
- L41-BB-DEFORESTATION(DIR.EFF.)
- L42-BB-SAVANNA BURNING
- L43-BB-AGRIC. WASTE BURNING
- L44-BB-VEGETATION FIRES(TEMP.)
- W40-WASTE INCINER.(NON-ENERGY)

Source: EDGAR 3.2, 2002

me-50 21
NOx-1995

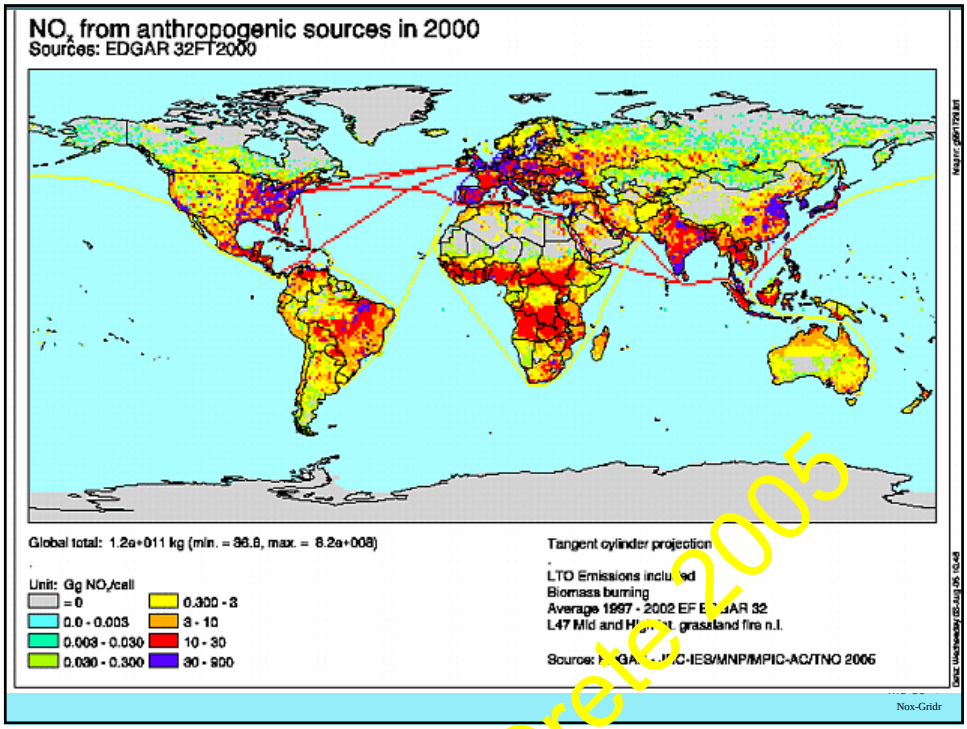
Worldwide NOx Emissions 1995
Contribution of Different Countries

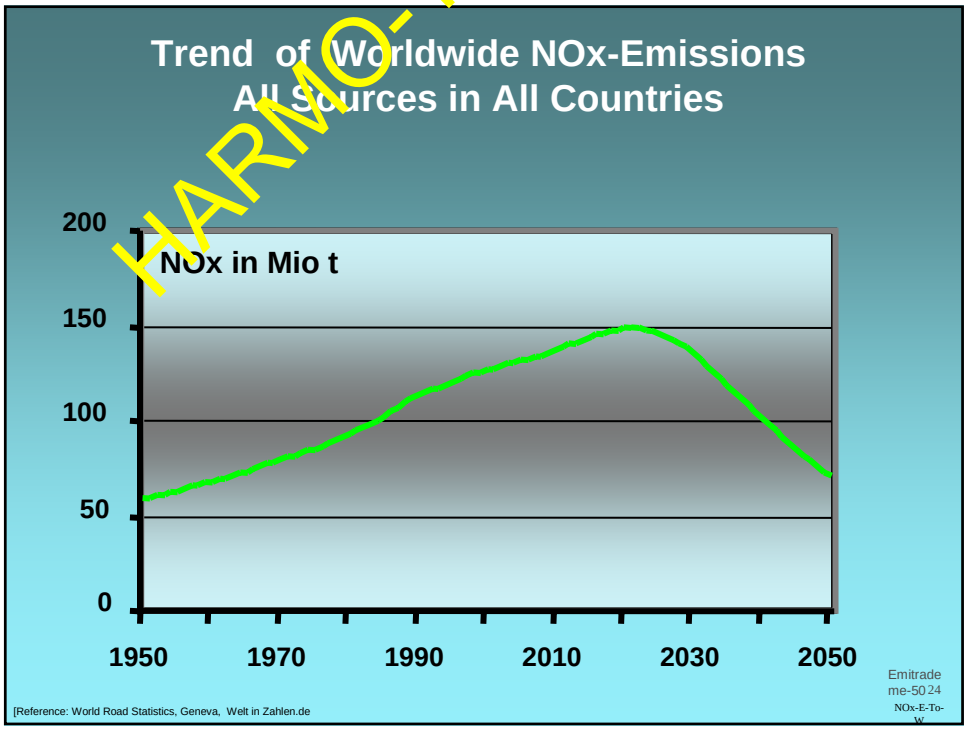


- 01: CANADA
- 02: USA
- 03: OECD EUROPE
- 04: OCEANIA
- 05: JAPAN
- 06: EASTERN EUROPE
- 07: FORMER USSR
- 08: LATIN AMERICA
- 09: AFRICA
- 10: MIDDLE EAST
- 11: SOUTH ASIA
- 12: EAST ASIA
- 13: SOUTH EAST ASIA

Source: EDGAR 3.2, 2002

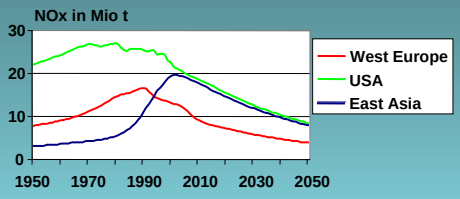
Emitrade
me-50 22
NOx-Countries



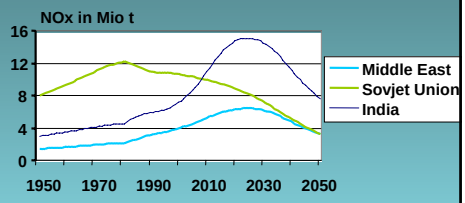


Trend of Worldwide NOx-Emissions
All Sources - Trend in Different Countries

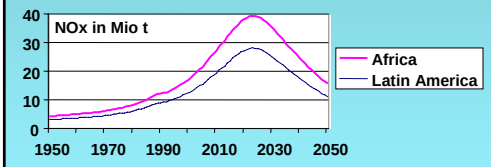
All Sources in USA, East Asia and West Europe



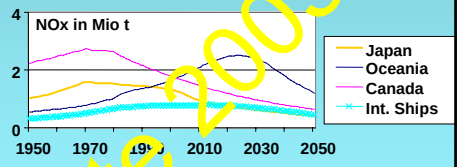
All Sources in Former Sovjet Union, India and Middle East



All Sources in Africa and Latin America



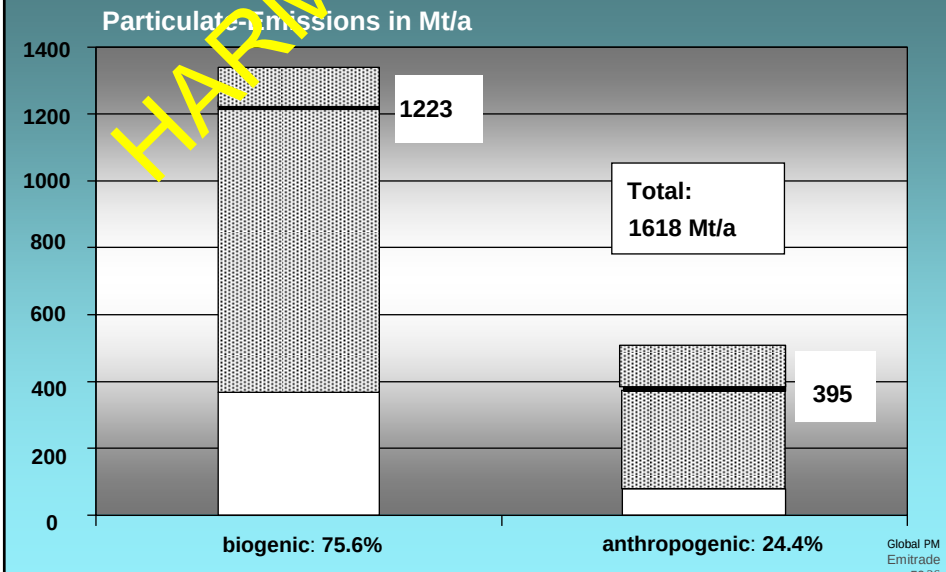
All Vehicles in Canada, Oceania, Japan and International Ships



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

Emitrade
me-50 25
NOx-E-T

Global Annual PM Emissions including Ranges



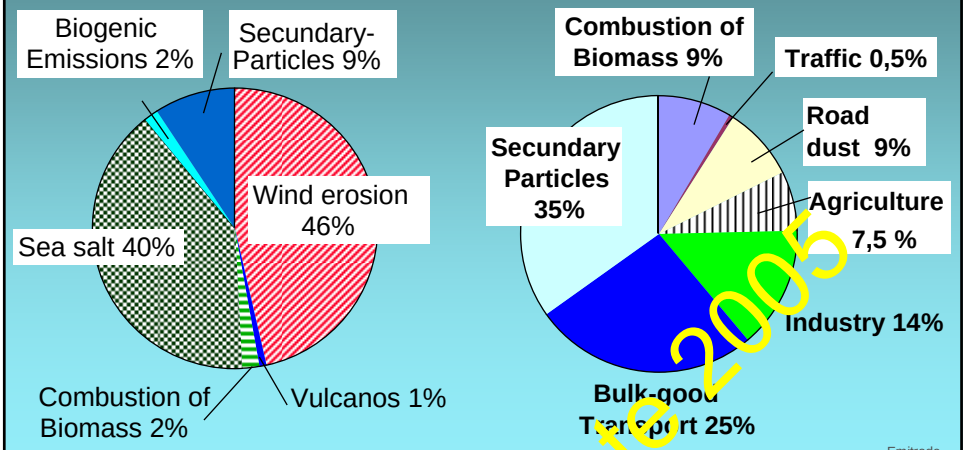
Global PM
Emitrade
me-50 26

[Ref: OECD 1993, 1995; Conrad, R. 1982; Crutzen, P.M. 1983; Streit, B. 1994; Walsh, P.M. 1990; Garnier, C. et al. 1996, Olivier, J.G.J. et al. 1996]

Global Annual PM-Emissions Share of Different Sources

Biogenic PM-Emissions Total 3250 Mt/a

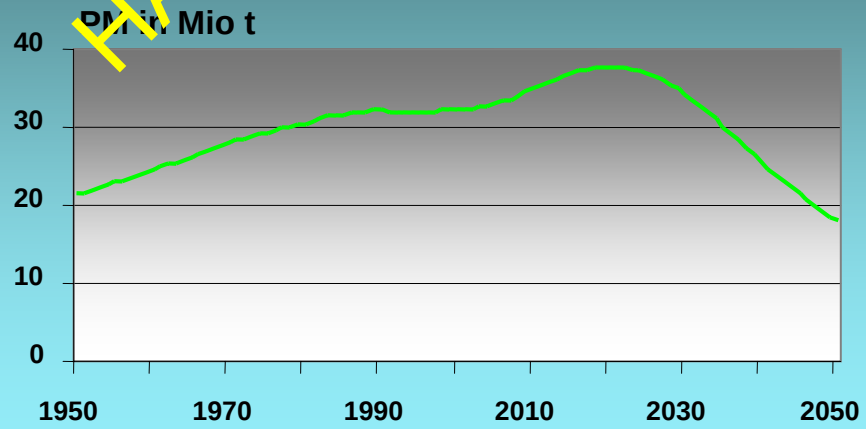
Anthropogenic PM-Emissionen Total 570 Mt/a



[Quellen: Parlar et al. 1995, Colbeck 1995, IPCC 1995, Lenz et al. 1993, Foxt[illegible]um 1993]

Emitrade me-50 27
PM Share 2000

Trend of Worldwide PM-Emissions All Sources in Million t

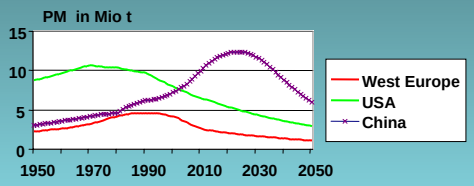


[Reference: World Road Statistics, Geneva, Welt in Zahlen.de

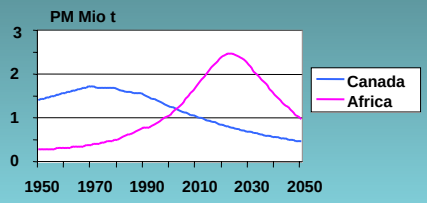
Emitrade me-50 28
PM-E-To-W

Trend of Worldwide PM-Emissions
All Sources in Different Countries

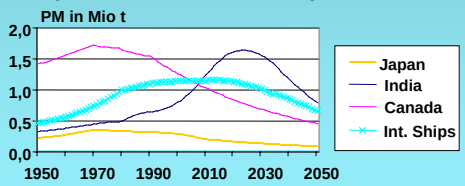
All Sources in China, USA and West Europe



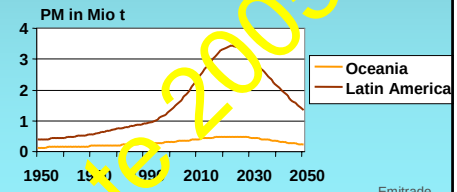
All Sources in Africa and Canada



All Vehicles in Canada, India, Japan and International Ships



All Sources in Latin America and Oceania



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

Emitrade me-50 29
PM-E-T

Methodology for the Estimation of Worldwide Road Transport Emissions

Methodology approach (Example for Passenger Cars)

$$E_{Veh.} = \Sigma\ (E_{Canada}+E_{USA}+E_{Latinamer.}+E_{Africa}+E_{West\ Europe}+ ...+ E_{Int.Ship.})$$

$$E_{PC:USA} = (Reg.\ Cars_{USA} * Av.Annual\ Mileage_{USA} * relat.\ E\text{-}Factor_{USA})$$

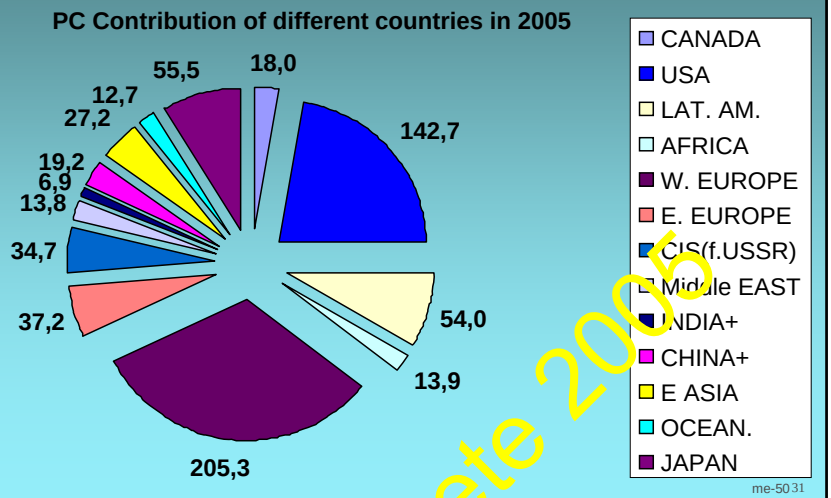
Registered Passenger Car and goods vehicle numbers and average annual mileage from World Road statistics 1980 to 2004 of International Road Federation.

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.

Emitrade me-50 30
Methodo RT

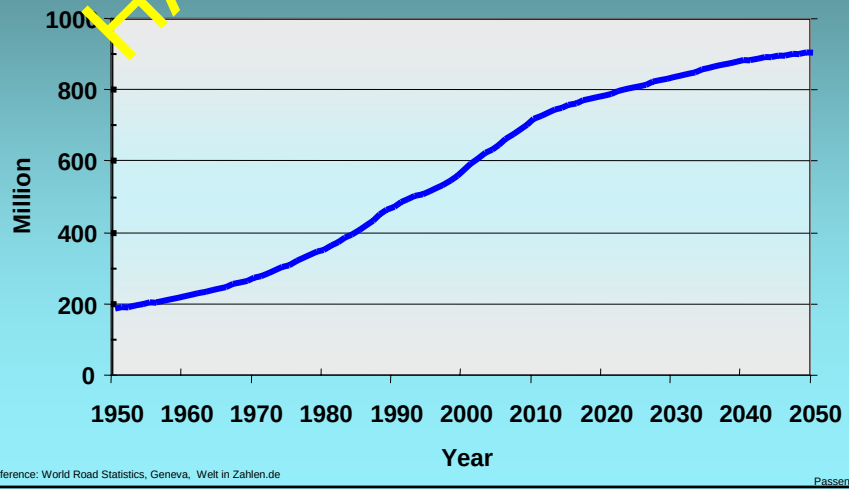
Worldwide Vehicle Trend
Passenger Cars 2005



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

me-50 31
PC per Countr

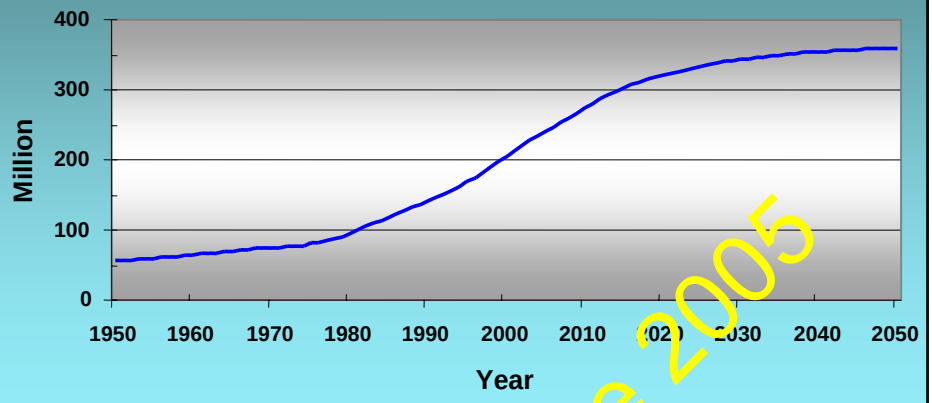
Trend of Worldwide Passenger Cars
All Countries



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

Emitrade
me-50 32
Passenger Car Trend

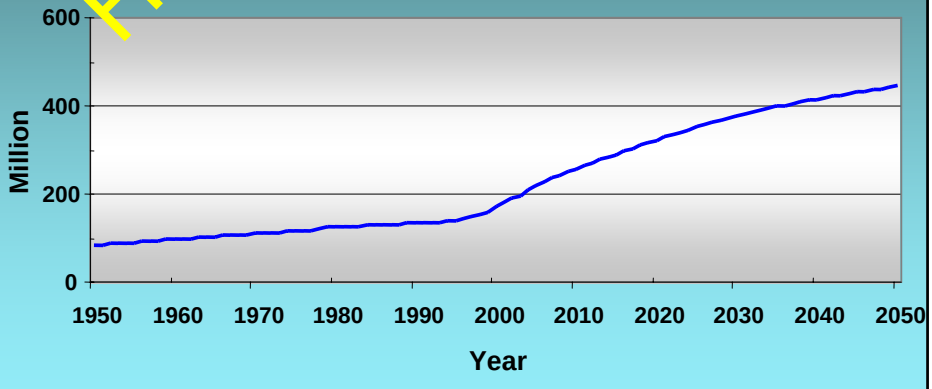
Worldwide Vehicle Trend
Duty Vehicles



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

Emitrade
me-50 33
Duty Veh.

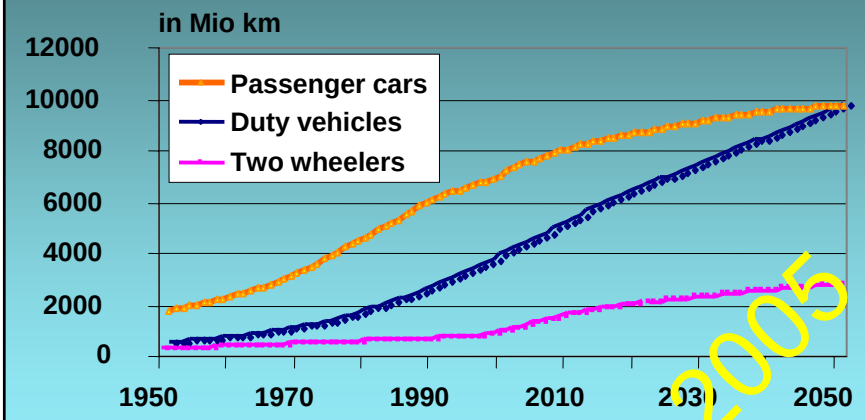
Worldwide Vehicle Trend
Two Wheeler



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

Emitrade
me-50 34
2W

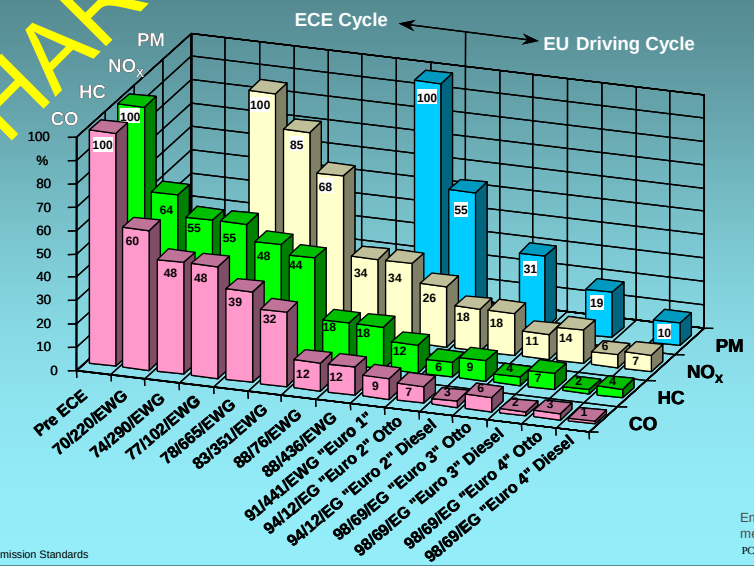
Total Mileage Trend Road Transport Worldwide



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

Emitrade
me-50 35
Mileage

Trend of Worldwide Emission Standards
Example EU Passenger Cars

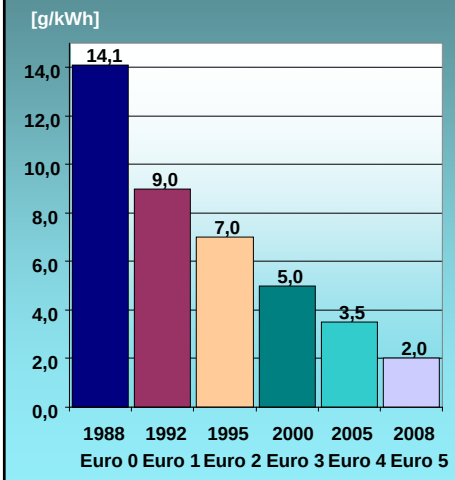


[Reference: Schweinle G., Emission Standards

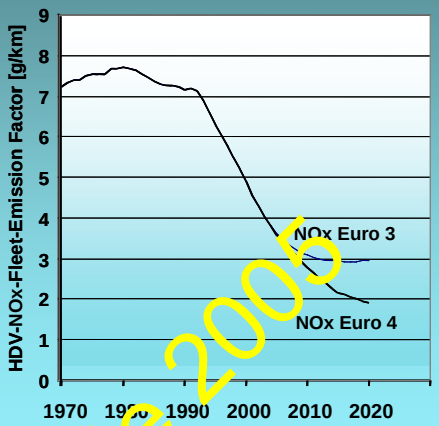
Emitrade
me-50 36
PC-Standards

Trend of Worldwide NOx Emission Standards And Fleet Emission Factor Example EU Duty Vehicles

NOx Emission Standard



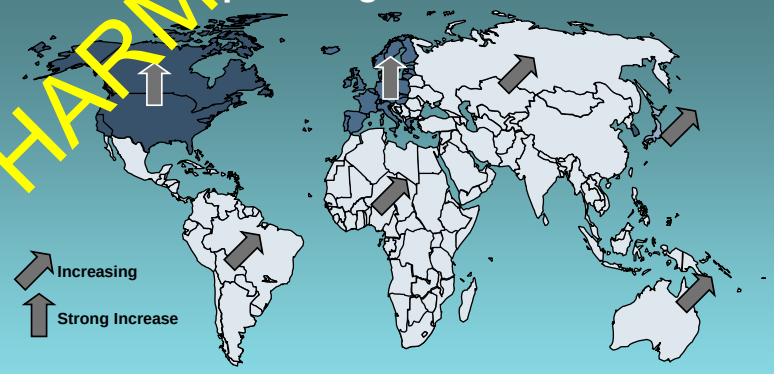
NOx Fleet Emission Factor in g/km



[Reference: Schweinle G., Emission Standards

Emitrade me-50 37
HD NOx - Standards

Emission Requirements starting from EU and US spreading out worldwide



Increasing Requirements

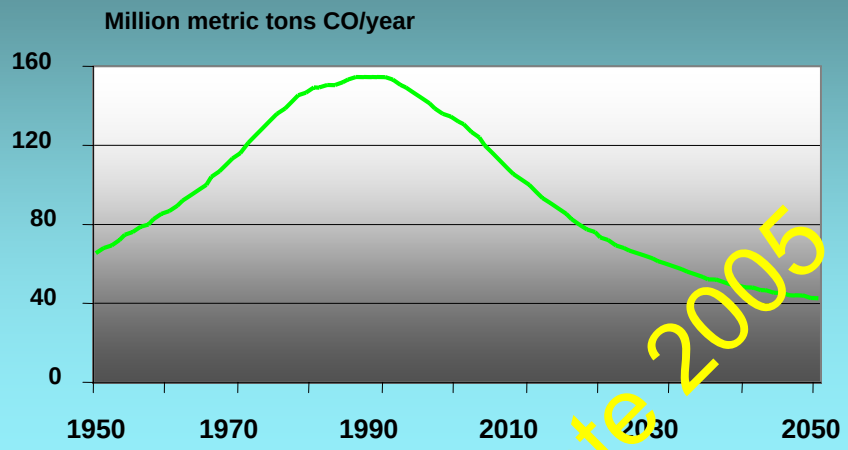
- Many asiatic Markets and Rest of the World
  - follow max. to EU- or US/California-Niveau
- Japan:
  - Further Stringency (max. to EU-Niveau)

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 Staates
- valid similar for South Korea

Emitrade me-50 38

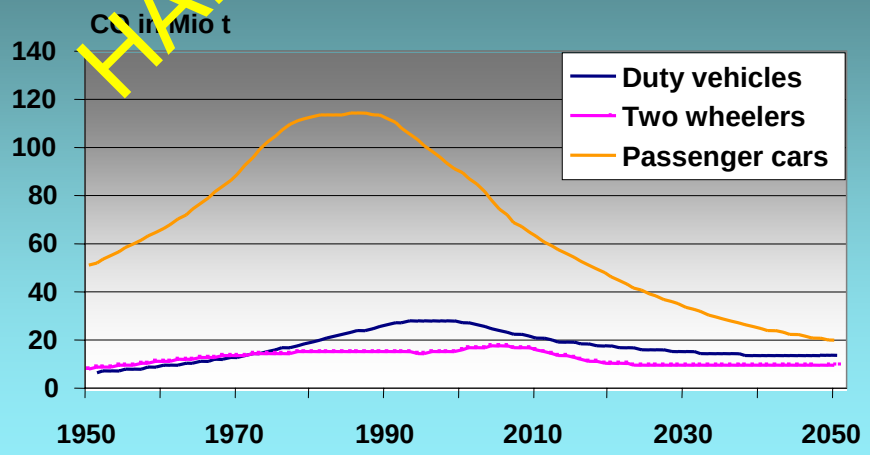
Trend of Worldwide CO Emissions
All Vehicles Together



[Reference: OECD 1993, 1995; Conrad, R. 1982; Crutzen, P.M. 1983; Streit, B. 1994; Walsh, P.M. 1990; Garnier, ... e... 199..., Olivier, J.G.J. et al. 1996]

Emitrade me-50 39
Emi-CO-RT-W

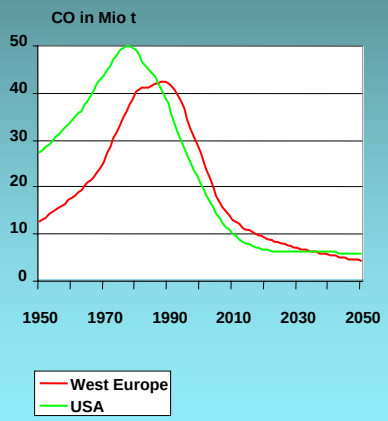
Trend of Worldwide CO Emissions in Mio t
Passenger Cars, Duty Vehicles and Two Wheeler



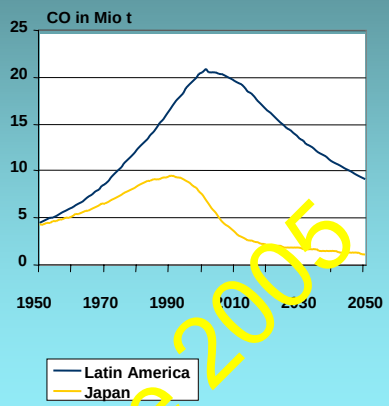
Emitrade me-50 40
CO PC HD

Trend of Worldwide CO-Emissions All Vehicles Together

All Vehicles in USA and West Europe



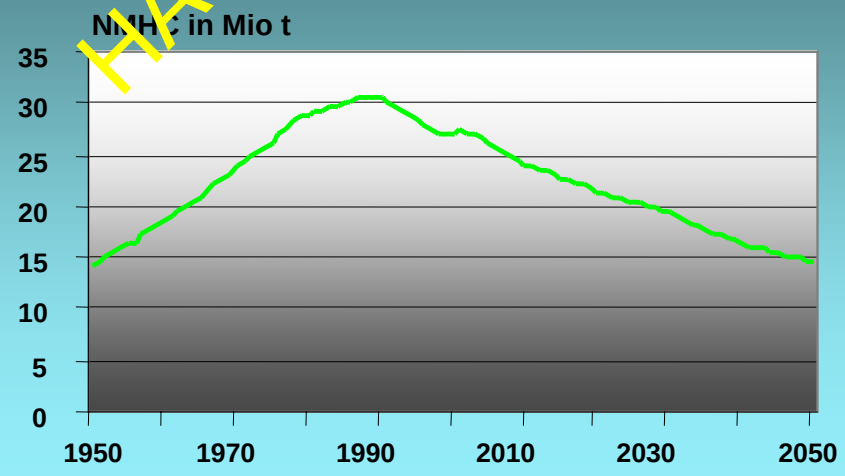
All Vehicles in Latin America and Japan



[Reference: OECD 1993, 1995; Conrad, R. 1982; Crutzen, P.M. 1983; Streit, B. 1994; Walsh, P.M. 1990; Garnier, ... et al. 199..., Olivier, J.G.J. et al. 1996]

Emitrade me-50 41
CO-Emi-RT-...

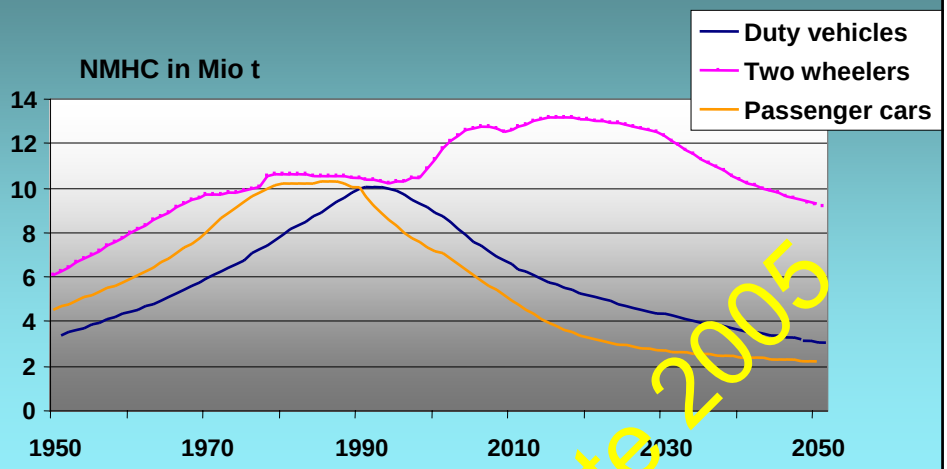
Trend of Worldwide HC Emissions All Vehicles Together



[Reference: OECD 1993, 1995; Conrad, R. 1982; Crutzen, P.M. 1983; Streit, B. 1994; Walsh, P.M. 1990; Garnier, C. et al. 1996, Olivier, J.G.J. et al. 1996]

Emitrade me-50 42
Emi-HC-RT-...

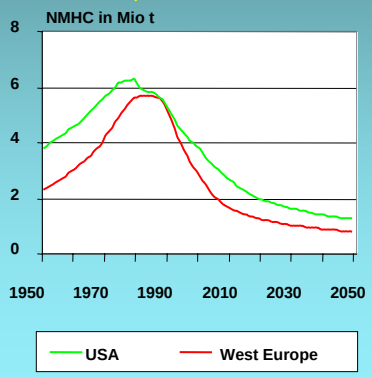
Trend of Worldwide NMHC-Emissions
Passenger Cars, Duty Vehicles and Two Wheeler



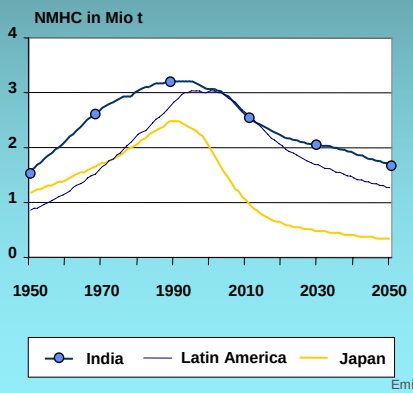
Emitrade me-50 43
HC PC HD

Trend of Worldwide HC-Emissions
All Vehicles Together

All Vehicles in USA and West Europe



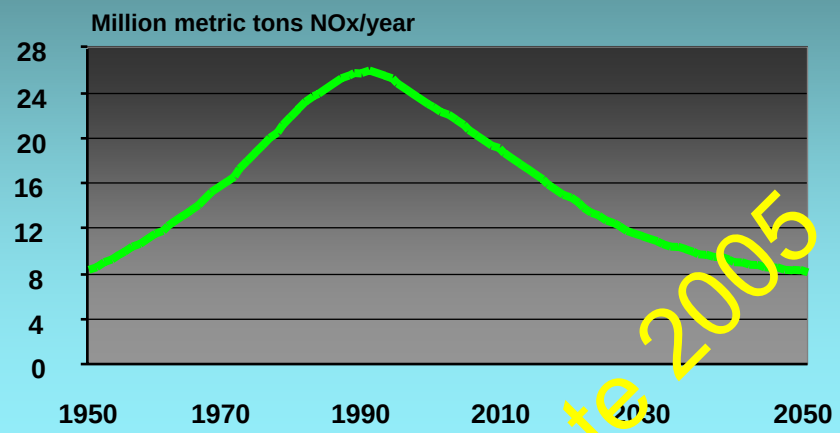
All Vehicles in Latin America, India and Japan



[Reference: OECD 1993, 1995; Conrad, R. 1982; Crutzen, P.M. 1983; Streit, B. 1994; Walsh, P.M. 1990; Garnier, C. et al. 1996, Olivier, J.G.J. et al. 1996]

Emitrade me-50 44
HC-Emi-

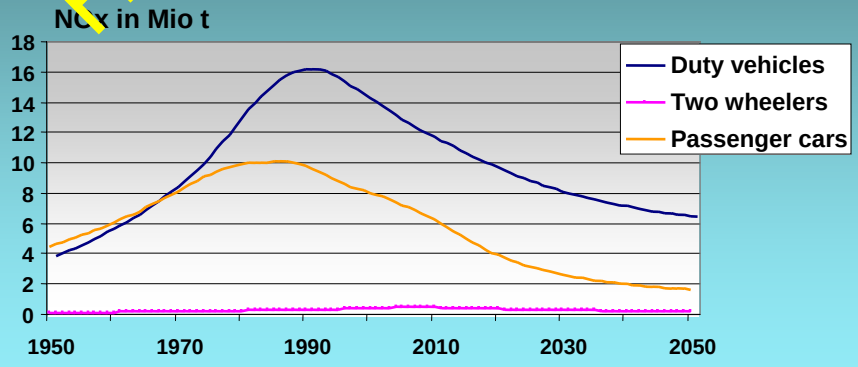
Trend of Worldwide NOx-Emissions
All Vehicles Together



[Reference: OECD 1993, 1995; Conrad, R. 1982; Crutzen, P.M. 1983; Streit, B. 1994; Walsh, P.M. 1990; Garnier, ... e... 199..., Olivier, J.G.J. et al. 1996]

Emitrade
me-50 45
Emi-Nox-RT-W

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

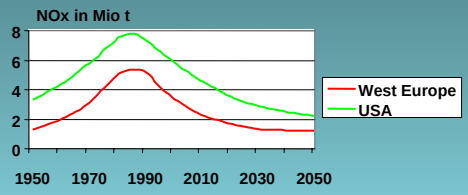


[Reference: World Road Statistics, Geneva, Welt in Zahlen.de

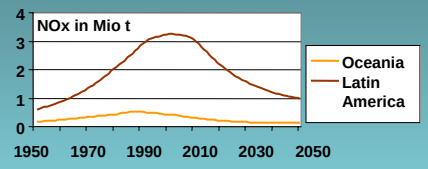
Emitrade
me-50 46
NOx PC-HD

Trend of Worldwide NOx-Emissions
All Vehicles Together

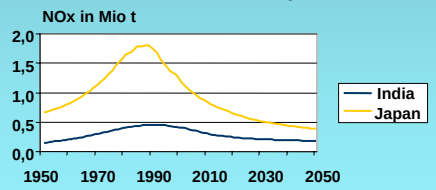
All Vehicles in USA and West Europe



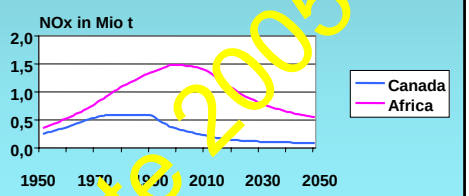
All Vehicles in Latin America and Oceania



All Vehicles in India and Japan



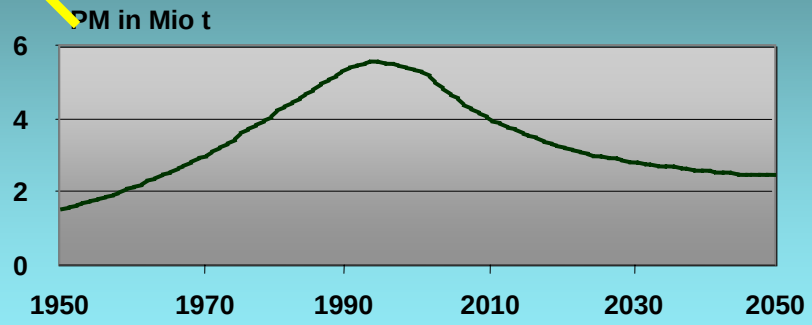
All Vehicles in Africa and Canada



[Reference: OECD 1993, 1995; Conrad, R. 1982; Crutzen, P.M. 1983; Streit, B. 1994; Walsh, P.M. 1990; Garnier, C. et al. 199 , Olivier, J.G.J. et al. 1996]

Emitrade me-50 47
NOx-Emi-PT

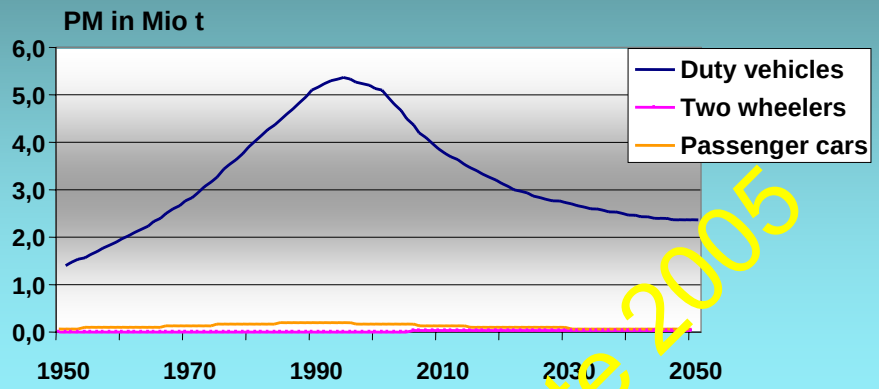
Trend of Worldwide PM-Emissions in Mio t
All Vehicles Worldwide



[Reference: OECD 1993, 1995; Conrad, R. 1982; Crutzen, P.M. 1983; Streit, B. 1994; Walsh, P.M. 1990; Garnier, C. et al. 1996, Olivier, J.G.J. et al. 1996]

Emitrade me-50 48
Emi-PM-PT

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

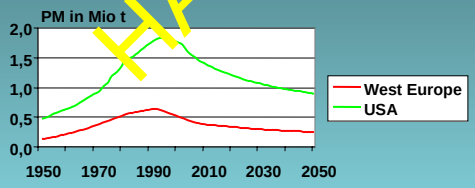


[Reference: World Road Statistics, Geneva, Welt in Zahlen.de

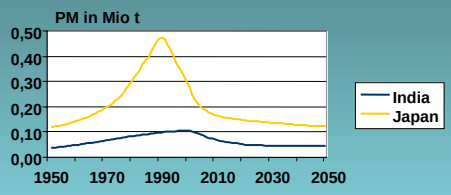
Emitrade
me-50 49
PM PC-HD

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

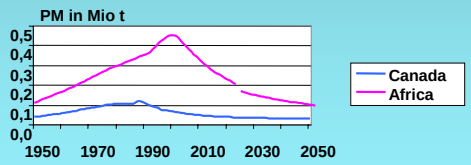
All Vehicles in [illegible] West Europe



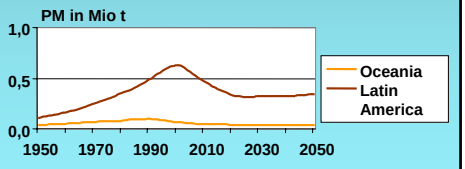
All Vehicles in India and Japan



All Vehicles in Africa and Canada



All Vehicles in Latin America and Oceania

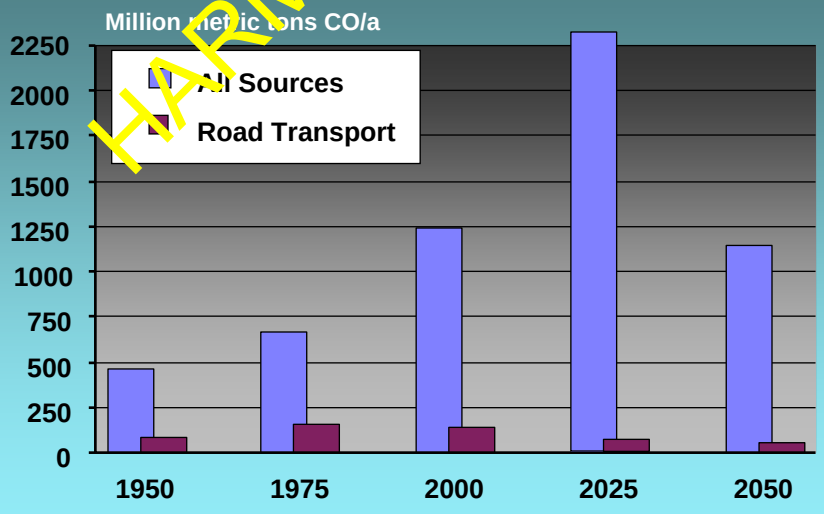


[Reference: World Road Statistics, Geneva, Welt in Zahlen.de

Emitrade
me-50 50
PM-Emi-RT-Countries

Comparison of Road Transport Emissions With Emissions of all Sources

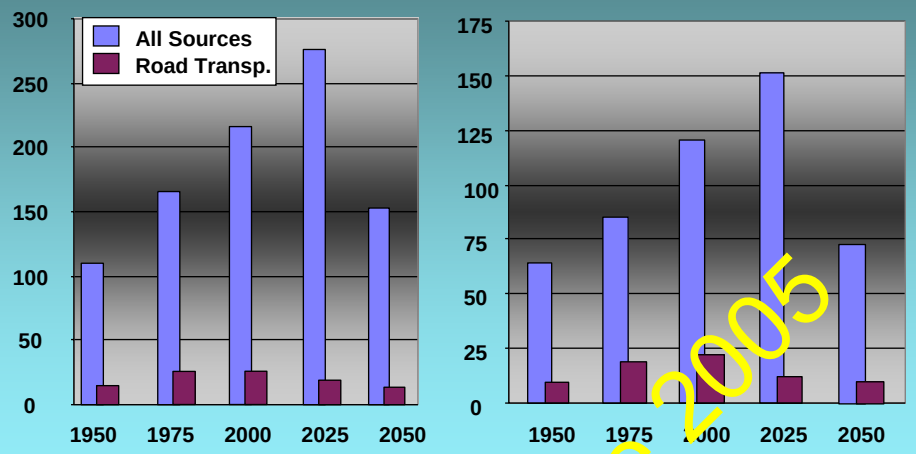
Trend of Worldwide CO Emissions Total and Road Transport



[Reference: OECD 1993, 1995; Conrad, R. 1982; Crutzen, P.M. 1983; Streit, B. 1994; Walsh, P.M. 1990; Garnier, C. et al. 1996, Olivier, J.G.J. et al. 1996]

BMW AG
Energie und Umwelt
Dr. Norbert Metz
me-8705

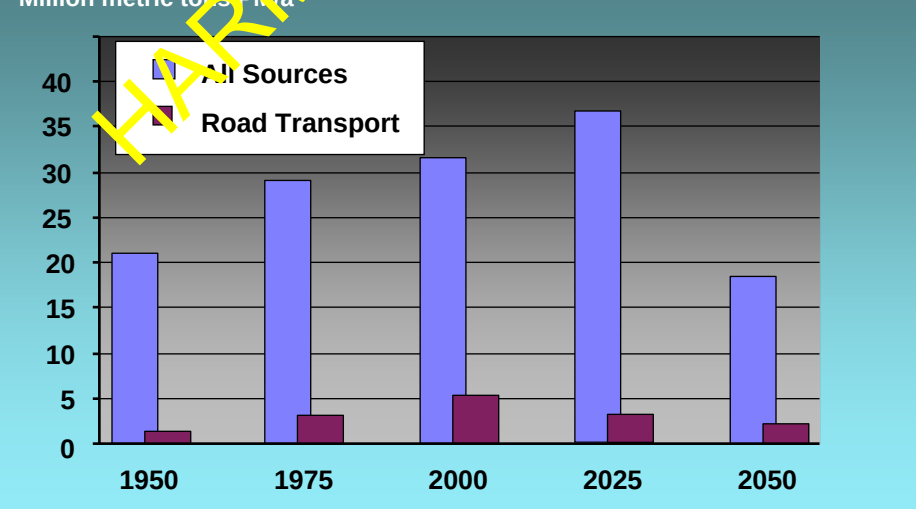
Trend of Worldwide VOC and NO_X-Emissions Total and Road Transport



Emitrade
me-50 53

[Ref: OECD 1993, 1995, 1997; Walsh, P.M. 1990; Garnier, C. et al. 1996, Olivier, J.G.J. et al. 1996, 2004], EPA-454/R-96-007, EPA-454/R-97-013, Air Quality Rep. VOC+NOx-Comparison

Trend of Worldwide PM Emissions Total and Road Transport



Emitrade
me-50 54

Ref: OECD 1993, 1995; Conrad, R. 1982; Crutzen, P.M. 1983; Streit, B. 1994; Walsh, P.M. 1990; Garnier, C. et al. 1996, Olivier, J.G.J. et al. 1996]

PM Comp-W

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 in China, followed by USA, Europe, Japan and Latin America.

Emitrade me-50 55
Summary 1

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
-

Emitrade me-50 56
Summary 2

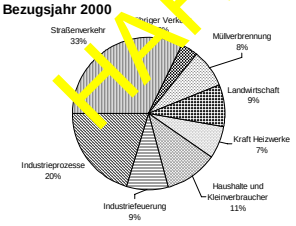
Summary 3 and Conclusion

- 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.

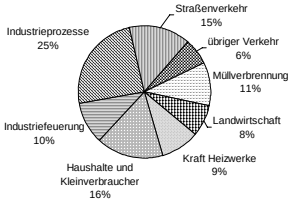
Emitrade
me-50 57
Summary 3

Anthropogene Partikel-Emissionen in der Europäischen Union

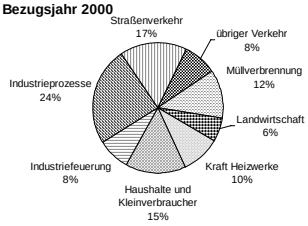
PM-Emissionen 3530 [kt/a]
Bezugsjahr 2000



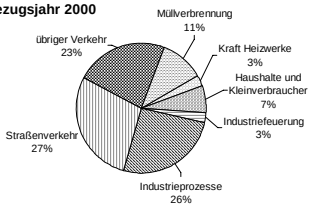
PM_{10}-Emissionen 1820 [kt/a]
Bezugsjahr 2000



$PM_{2,5}$-Emissionen 1120 [kt/a]
Bezugsjahr 2000



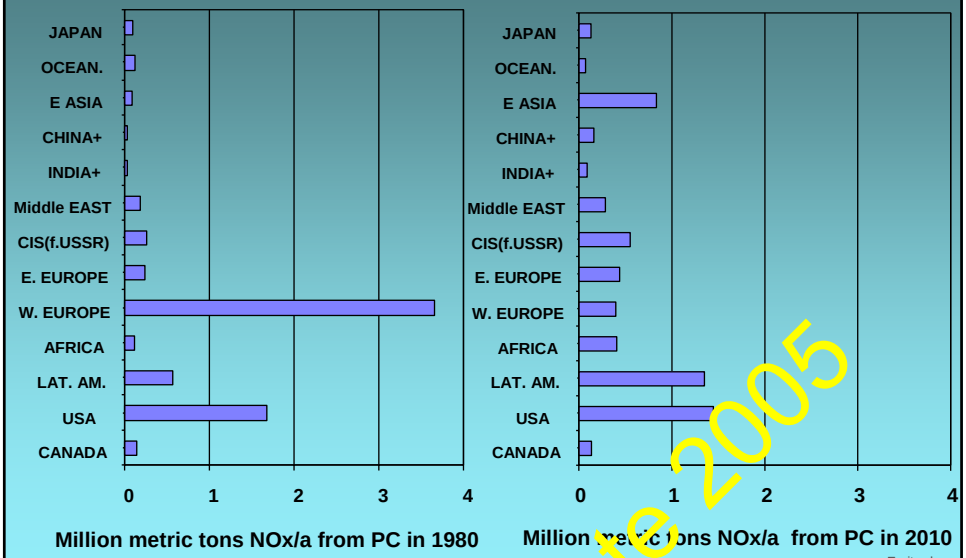
$PM_{0,1}$-Emissionen 270 [kt/a]
Bezugsjahr 2000



[Quelle: UBA 1998, 2000; IER 1999; TNO 1997, 2000; AOPII 1999; eigene Berechnungen]

me-50 58
EU-PM

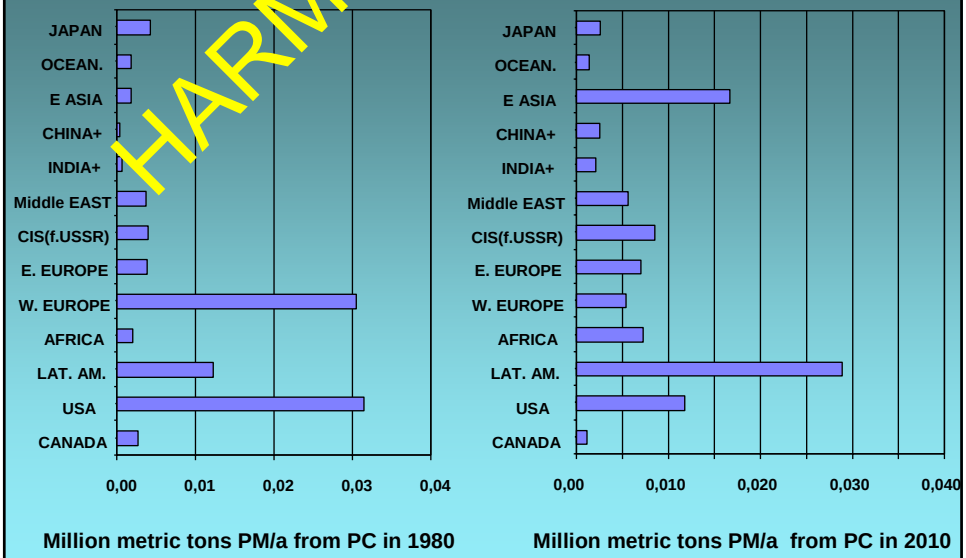
Worldwide NO_x- Emissions
Passenger Cars statewise in 1980 and 2010



Emitrade
me-50 59

[Reference: OECD 1993, 1995, 1997, 2000; Walsh, P.M. 1990; Garnier, C. et al. 1996, Olivier, J.G.J. et al. 1996, EPA-454/R-96-007, EPA-454/R-97-013

Worldwide PM- Emissions
Passenger Cars statewise in 1980 and 2010



Emitrade
me-50 60

[Reference: OECD 1993, 1995, 1997; Walsh, P.M. 1990; Garnier, C. et al. 1996, Olivier, J.G.J. et al. 1996], EPA-454/R-96-007, EPA-454/R-97-013

Entwicklung der Emissionen
aller Quellen in Europa (EU15)

[Quelle: AOP II 1999]

Carbon monoxide	Emissions in kt						
EU15 sector totals	1990	1995	2000	2005	2010	2015	2020
Agriculture	579	573	567	561	555	550	544
Combustion: energy	651	690	728	787	808	866	923
Combustion: industry	3398	3086	3138	3108	3013	2941	2919
Combustion: non-industry	6775	5892	5901	5919	5962	5970	5953
Fuel extraction	61	60	59	59	58	58	57
Other mobile	1924	1905	1886	1866	1847	1828	1809
Process	2622	2596	2569	2543	2517	2491	2465
Road transport	31362	26372	19280	12662	8407	5973	5048
Solvent	1	1	1	1	1	1	1
Waste	2755	2728	2700	2672	2645	2617	2590
EU15	**50126**	**43903**	**36829**	**30180**	**25815**	**23294**	**22308**
Change from 1995	-14%	0%	16%	31%	41%	47%	49%

Non methane volatile organic compounds	Emissions in kt						
EU15 sector totals	1990	1995	2000	2005	2010	2015	2020
Agriculture	101	101	101	101	101	101	101
Combustion: energy	252	244	236	228	220	220	220
Combustion: industry	51	54	57	61	64	64	64
Combustion: non-industry	655	654	652	650	649	649	649
Fuel extraction	1018	910	803	695	588	588	588
Other mobile	752	710	668	626	584	584	584
Process	776	824	872	920	968	968	968
Road transport	5415	4378	2828	1522	804	600	566
Solvent	4157	3861	3565	3269	2973	2973	2973
Waste	84	85	86	87	88	88	88
EU15	**13261**	**11821**	**9869**	**8160**	**7040**	**6835**	**6802**
Change from 1995	-12%	0%	17%	31%	40%	42%	42%

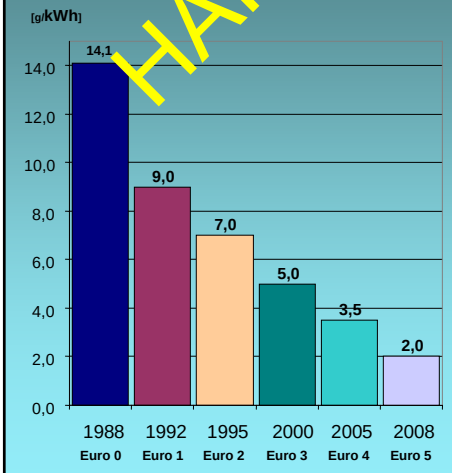
Nitrogen oxides	Emissions in kt						
EU15 sector totals	1990	1995	2000	2005	2010	2015	2020
Agriculture	341	315	289	263	237	237	237
Combustion: energy	2757	2396	2035	1673	1312	1312	1312
Combustion: industry	811	795	779	764	748	748	748
Combustion: non-industry	571	584	596	608	620	620	620
Fuel extraction	0	0	0	0	0	0	0
Other mobile	1771	1695	1619	1544	1468	1468	1468
Process	708	692	676	661	645	645	645
Road transport	5865	5131	3925	2678	1631	1157	985
Solvent	0	0	0	0	0	0	0
Waste	0	0	0	0	0	0	0
EU15	**12824**	**11608**	**9920**	**8190**	**6661**	**6188**	**6015**
Change from 1995	-10%	0%	15%	29%	43%	47%	48%

Particulate matter < 10 microns	Emissions in kt						
EU15 sector totals	1990	1995	2000	2005	2010	2015	2020
Agriculture	23	23	24	24	25	25	25
Combustion: energy	461	437	413	390	366	366	366
Combustion: industry	414	373	333	293	252	252	252
Combustion: non-industry	481	436	391	346	301	301	301
Fuel extraction	0	0	0	0	0	0	0
Other mobile	25	24	24	23	23	23	23
Process	467	456	446	428	415	415	415
Road transport: Diesel exhaust	227	245	227	115	67	47	43
Road transport: Gasoline exhau	80	68	36	34	35	37	40
Road transport: Non exhaust	33	41	47	53	58	63	68
Solvent	0	0	0	0	0	0	0
Waste	90	77	53	29	6	6	6
EU15	**2332**	**2179**	**1939**	**1736**	**1548**	**1535**	**1538**
Change from 1995	7%	0%	11%	20%	29%	30%	29%

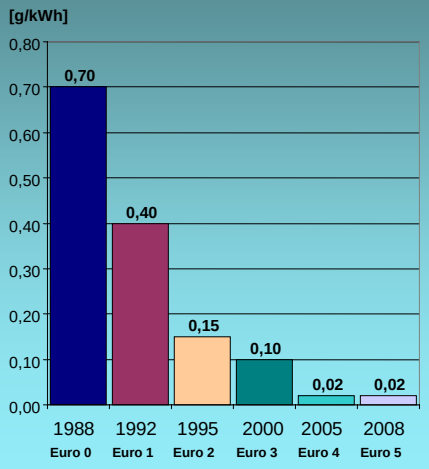
Emitrade me-50 61

Trend of Worldwide Emission Standards
Example EU Duty Vehicles

NOx Emission Standard



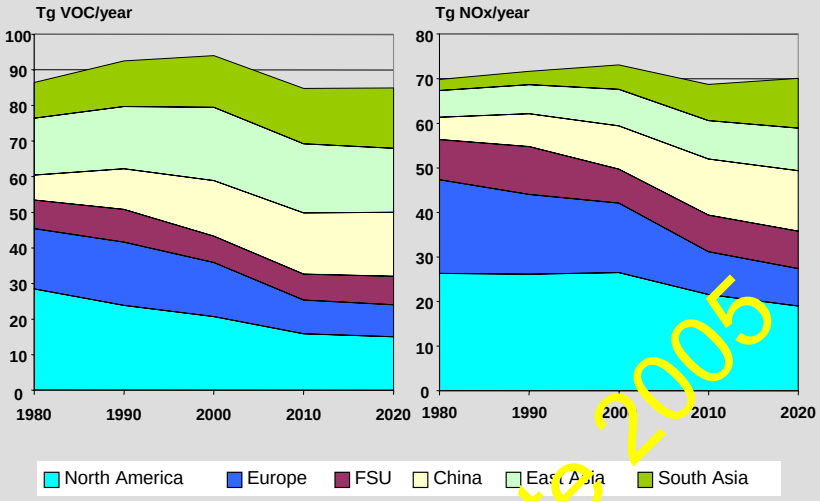
Particle Emission Standard



[Reference: Schweinle G., Emission Standards

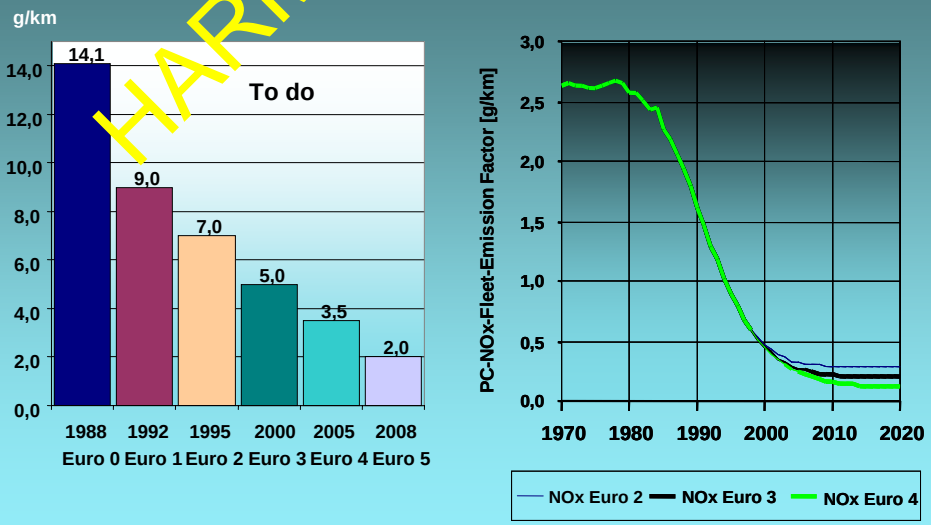
Emitrade me-50 62
HD-Standards

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



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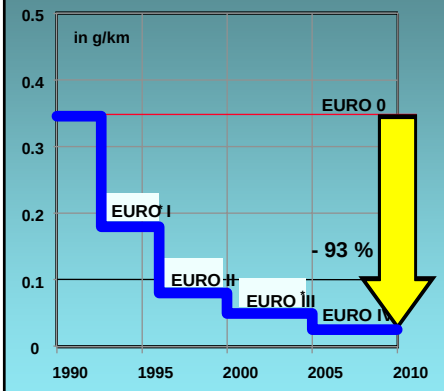
me-5064

Ref: Lenz H.P. AK-EL, 98, Wien

Emission Factors for Passenger Cars for PM



*) Change of Driving Cycle

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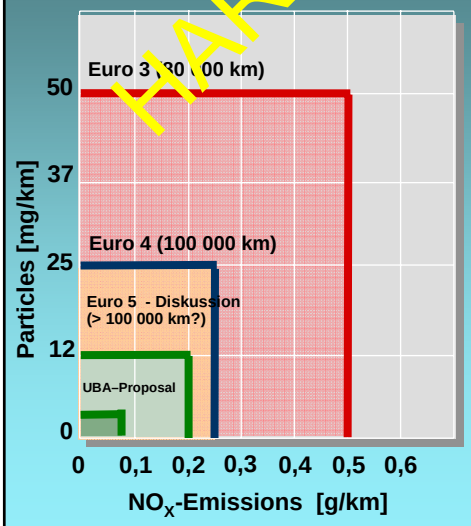
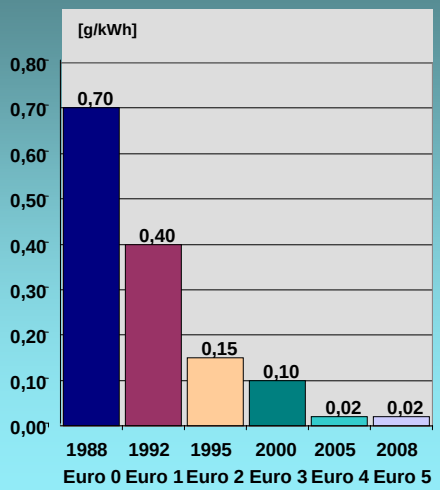
me-50 65

Ref: Lenz H.P. AK-EL, 98, Wien

PM Emission Standards and Emission Factors for Heavy Duty Vehicles





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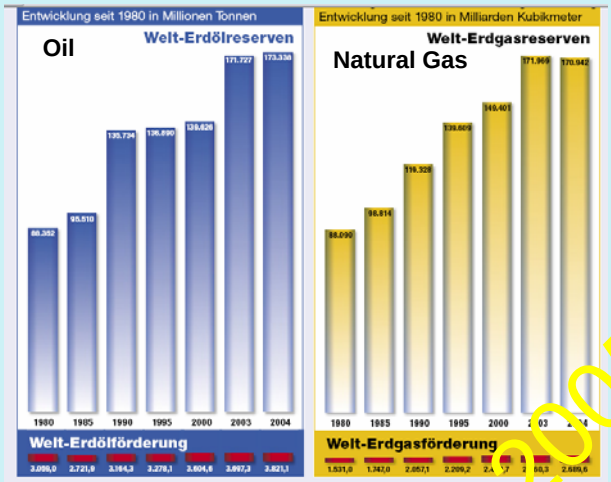
me-50 66

Ref: Lenz H.P. AK-EL, 98, Wien

Reserves of Oil and Gas - Trend since 1980



[Reference: Öldorado 2005

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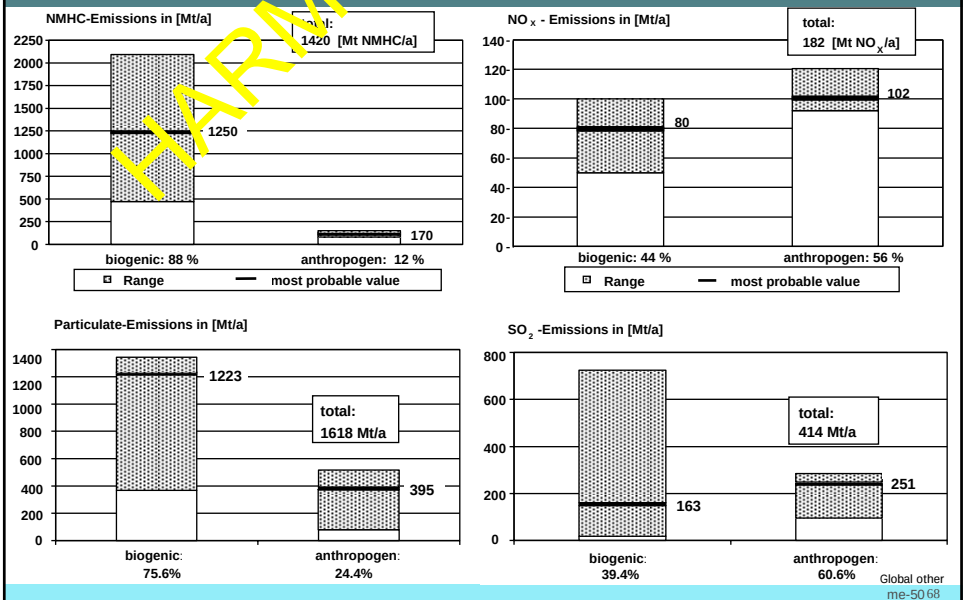
me-50 67
Oil-Gas-Res.

Global Annual VOC-, NOx-, PM- and SO_2 - Emissions including Ranges

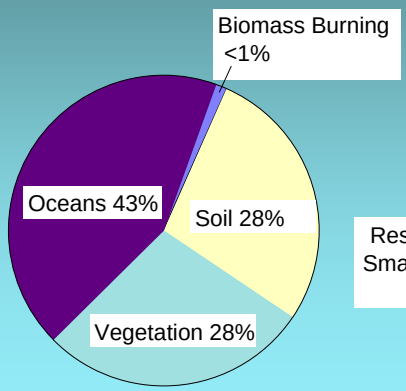


Global other
me-50 68

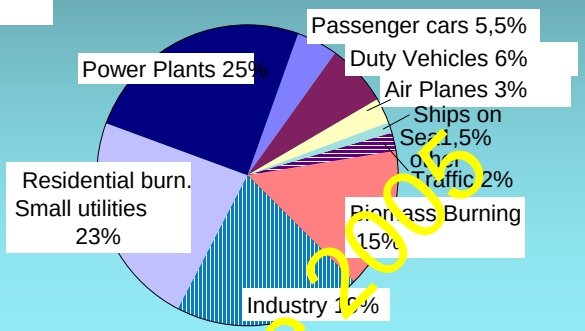
[Reference: OECD 1993, 1995; Conrad, R. 1982; Crutzen, P.M. 1983; Streit, B. 1994; Walsh, P.M. 1990; Garnier, C. et al. 1996, Olivier, J.G.J. et al. 1996]

Globale jährliche CO_2-Emissionen
Anteil verschiedener Quellen

Biogenic CO_2 Emissions
Total 770 Billion t/a



Anthropogenic CO_2 Emissions
Total 28 Billlion t/a



CO2 Global

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me-50 69

[Quelle: OECD\IEA 1993, 1995; IPCC 1995; Bolle, H.J. 1991; Walsh, P.M. 1990; K[illegible]bauer 1995; Faber et al. 1993; Woodwell 1996; Korte 1987; Heinmann 1997]