Vehicles, Air Pollution, and Climate Forcing: A Business Perspective

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OUTLINE

Background

Vehicle emissions

Future outlook

Conclusions

Ford Motor Company

William Clay Ford Jr.

Society's assessment may change in the future as the science develops, but the present risk is clear. The climate appears to be changing, the changes appear to be outside natural variation, and the likely consequences will be serious.

From a business planning point of view, that issue is settled. Anyone who disagrees is, in my view, still in denial. We at Ford Motor Company have moved on.

Speech to Greenpeace Business Conference – October 2000

Manufacturing versus "in-use" emissions

Life cycle CO_2 Impact (tonnes) for mid-size car

	Tonnes	% of total
Raw material production (steel, aluminum, plastics, …)	3.5	5.7%
Ford manufacturing/assembly	2.5	4.0%
Manufacturing logistics (inbound/outbound)	0.1	0.2%
Fuel (120,000 miles at 22.9 mpg) WTW	55.1	88.9%
Maintenance and repair	0.6	1.0%
End of life/recycling	0.1	0.2%
Total Lifecycle	61.9	100%

"In-use" dominate manufacturing CO_2 emissions (and other air pollution/climate change related compounds)

[Emissions from facilities have been reduced substantially (see http://www.ford.com)]

Vehicle contribution to climate forcing: CO_2, HCs, CO, NO_x, PM, R-134a, N_2O, CH_4.

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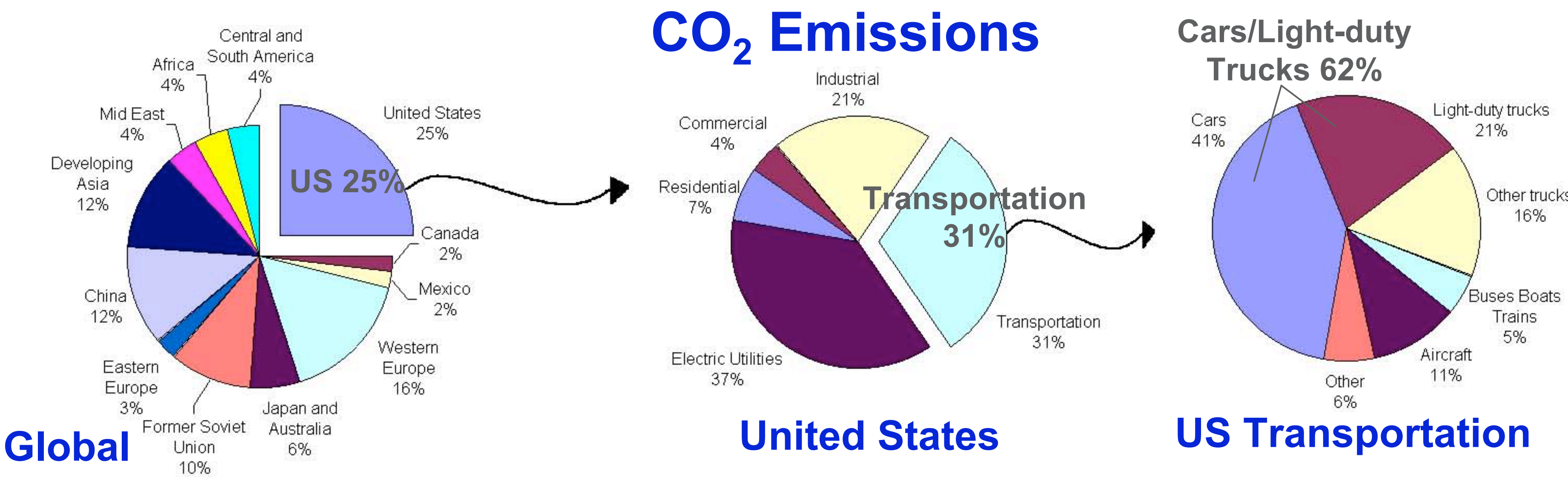


- **On-road light-duty car and trucks contribute about 19% of US and 12% of global CO_2 emissions.**
- **Vehicles CO_2 emissions approximately 1 GtC yr^{-1}**

Vehicle contribution to climate forcing: CO_2, HCs, CO, NO_x, PM, R-134a, N_2O, CH_4.

Year	HC (g/mile)	CO (g/mile)	NO_x (g/mile)
1911 Model T	8	120	2
1930 Model A	12.8	111	0.5
1957-1962 US Fleet	8.8	81.6	3.7
1963-1967 US Fleet	9.1	92.8	3.5
1963-1967 US Fleet	4.7	58.7	4.9
1975/1976 US Federal	1.5	15	3.1
1991 US Federal	0.41	3.4	1.0
1994 US Federal	0.41	3.4	0.4
2000 Europe Stage III [g, b]	0.32	3.8	0.24
2004 US Federal	0.125	1.7	0.2
2005 Europe Stage IV [g,c]	0.16	1.6	0.13
2007 US Federal [a, d]	0.075		0.05

a: Tier II bin 5 average requirement, b: 80 K km, c: 100 K km, d: 50 K mi, g: gasoline

Major, and continuing progress, in reducing criteria pollutant emissions.

Vehicle contribution to climate forcing: CO_2, HCs, CO, NO_x, PM, R-134a, N_2O, CH_4.

Diesel Particulate Filters (DPF) offer efficient control of soot. PSA Peugeot Citroen first to market (2000).

As of 2/7/2005, 1,000,000 DPF equipped vehicles sold by PSA Peugeot Citroën.

Ford to equip diesel vehicles with DPF starting 2007 (US), 2005-2010 (Europe).

DPFs have approx. 3% FE penalty - no free lunch.

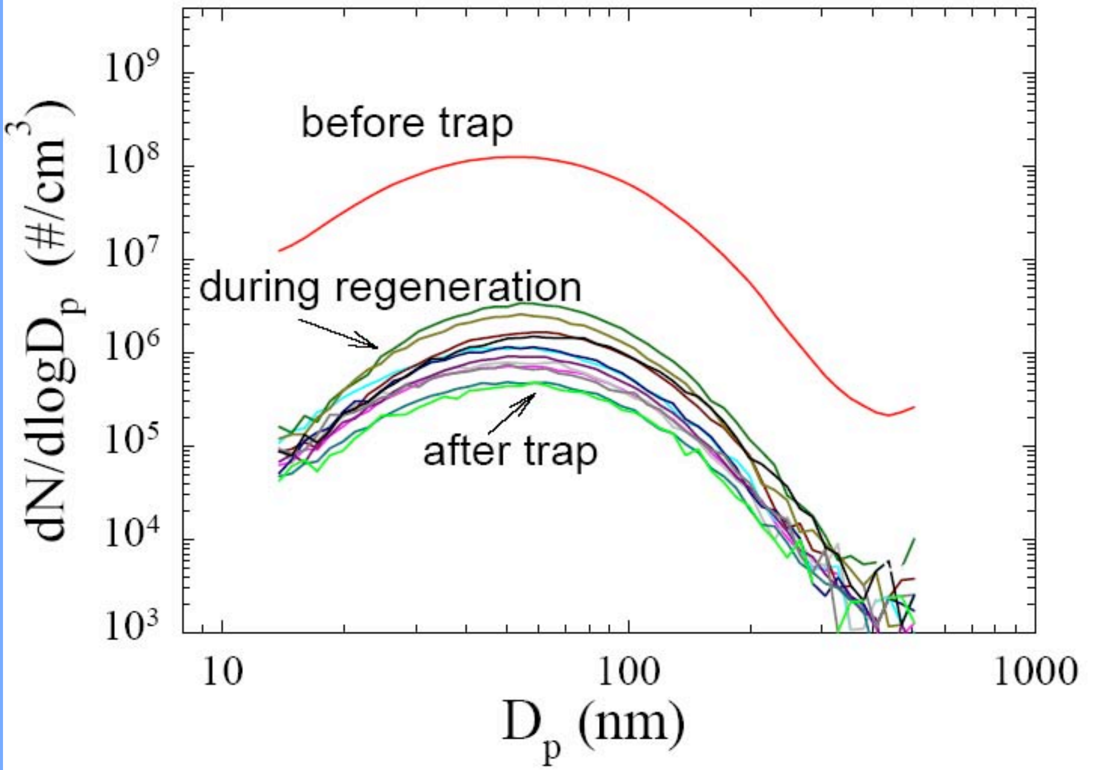


Figure 10. Particle Size Distribution: Regeneration with Low Sulfur Fuel

Source: Guo, G.; Xu, N.; Laing, P. M.; Hammerle, R. H.; Maricq, M. M., SAE Paper 2003-01-0047

Vehicle contribution to climate forcing: CO_2, HCs, CO, NO_x, PM, R-134a, N_2O, CH_4.

R-134a (CF_3CFH_2), replacement for CFC-12 (CF_2Cl_2) in vehicle AC units. Four emission modes: regular, irregular, servicing, disposal.

Schwarz (2001): overall average emission = **0.24±0.06 g/day**

Siegl et al. (2002): overall average emission = **0.41±0.27 g/day**.

Schwarz and Harnish (2003): regular plus irregular = 0.19 g/day

Stemmler et al. (2004): regular plus irregular = 0.336 g day^{-1}

Vincent et al. (2004): overall average emission **0.24 g/day.**

Assuming 0.3 ±0.1 g/day emission, 25 mpg, 10000 miles/year, GWP = 1300, then climate forcing impact of R-134a is approx. 3-5% that of tailpipe CO_2

Sources: Schwarz: http://www.oekorecherche.de/english/berichte/volltext/MAC-LOSS-2001.pdf; Siegl et al., Environ. Sci. Technol., 36, 561 (2002); Schwarz and Harnish, Final Report B4-3040/2002/337136/MAR/C1, for European Commission (2003); Stemmler et al., Environ. Sci. Technol., 38, 1998 (2004); Vincent et al., SAE paper 2004-01-2256.

Vehicle contribution to climate forcing: CO_2, HCs, CO, NO_x, PM, R-134a, N_2O, CH_4.

Several measurements of on-road emission factors including:

Berges et al. (1993): (g N_2O/ g CO_2) = $(6 \pm 3) \times 10^{-5}$.

Becker et al. (1999): (g N_2O/ g CO_2) = $(6 \pm 2) \times 10^{-5}$.

Becker et al. (2000): (g N_2O/ g CO_2) = $(4.1 \pm 1.2) \times 10^{-5}$.

Jimenez et al. (2000): (g N_2O/ g CO_2) = $(8.8 \pm 2.8) \times 10^{-5}$.

Using GWP for N_2O = 330 (100 year time horizon) estimate that N_2O emissions from vehicles have climate forcing impact which is approximately 1-3% of that of CO_2 emissions from vehicles.

Sources: Berges et al. J. Geophys. Res., 98, 18527 (1993); Becker et al. Environ. Sci. Technol., 33, 4134 (1999); Becker et al. Chemosphere Global Change Sci., 2, 387 (2000); Jimenez et al. Chemosphere Global Change Sci. 2, 397 (2000); Huai et al., Atmos. Environ., 38, 6621 (2004)

Vehicle contribution to climate forcing: CO_2, HCs, CO, NO_x, PM, R-134a, N_2O, **CH_4**.

Nam et al. (2004): average emission factor for the U.S. on-road vehicle fleet of (g CH_4/ g CO_2) = (15±4) x 10^{-5}.

Using GWP for CH_4 = 23 (100 year time horizon) calculate that CH_4 emissions from vehicles have global warming impact which is 0.3-0.4% of that of CO_2 emissions from vehicles.

Source: Nam et al. Environ. Sci. Technol., 38, 2005 (2004).

Future Outlook

HYDRO
DAIMLERCHRYSLER
VOLKSWAGEN AG
General Motors
Ford
bp
TOYOTA
HONDA
MICHELIN
RENAULT
NISSAN

World Business Council for Sustainable Development

Mobility 2030 Report

http://www.wbcsd.ch/plugins/DocSearch/details.asp?type=DocDet&ObjectId=NjA5NA

Model projects CO_2, CO, NOx, PM, HC, emissions in 11 geographical areas to year 2050. Excel spreadsheet available.

Lifecycle WTW analysis of costs and benefits of future automotive fuels and powertrains. Participants include JRC, BP, Total, Shell, ExxonMobil, Renault, Ford, VW, BMW, PSA, DaimlerChrysler

concawe
EUCAR
European Council for Automotive R&D

WELL-TO-WHEELS ANALYSIS OF FUTURE AUTOMOTIVE FUELS AND POWERTRAINS IN THE EUROPEAN CONTEXT

EUROPEAN COMMISSION
DIRECTORATE-GENERAL
Joint Research Centre

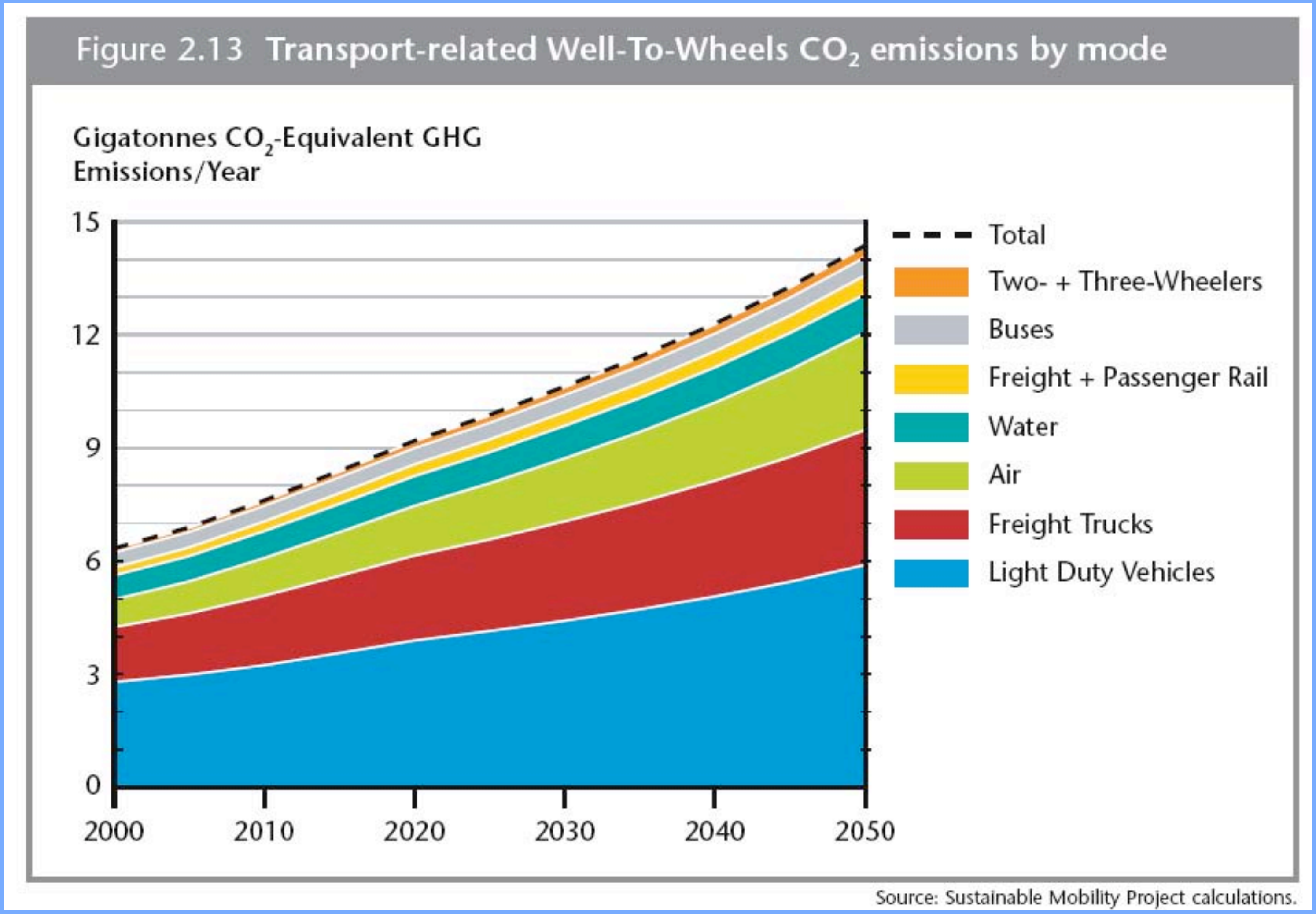
http://ies.jrc.cec.eu.int/Download/eh

General Motors
Ford
bp
Hydro
DaimlerChrysler
Volkswagen AG
Michelin
Renault
Toyota
Honda
Nissan

World Business Council for Sustainable Development: Mobility 2030 Report

Sectors, Fuels, Regions and Data Contained in the Spreadsheet Model

Sectors / Modes	Vehicle Technologies/ Fuels	Regions	Variables
• Light-duty vehicles (cars, minivans, SUVs) • Medium trucks • Heavy-duty (long-haul) trucks • Mini-buses ("paratransit") • Large buses • 2-3 wheelers • Aviation (Domestic + Int'l) • Rail freight • Rail passenger • National water-borne (Inland plus coastal) • Int'l shipping	• Internal combustion engine: ◊ Gasoline ◊ Diesel ◊ LPG-CNG ◊ Ethanol ◊ Biodiesel • Hybrid-Electric ICE (same fuels) • Fuel-cell vehicle ◊ Hydrogen (With feedstock differentiation for biofuels and hydrogen)	• OECD Europe • OECD North America • OECD Pacific (Japan, Korea, Australia, NZ) • Former Soviet Union (FSU) • Eastern Europe • Middle East • China • India • Other Asia • Latin America • Africa	• Passenger kilometres of travel • Vehicle sales (LDVs only) • Vehicle stocks • Average vehicle fuel-efficiency • Vehicle travel • Fuel use • CO_2 emissions • Pollutant emissions (PM, NOx, HC, CO, Pb) • Safety (road fatalities and injuries)



CO_2 ↑ x 2, but …

Source: Mobility 2030, WBCSD (2004)

Figure 2.16 OECD regions: Transport-related Carbon Monoxide (CO) emissions by mode

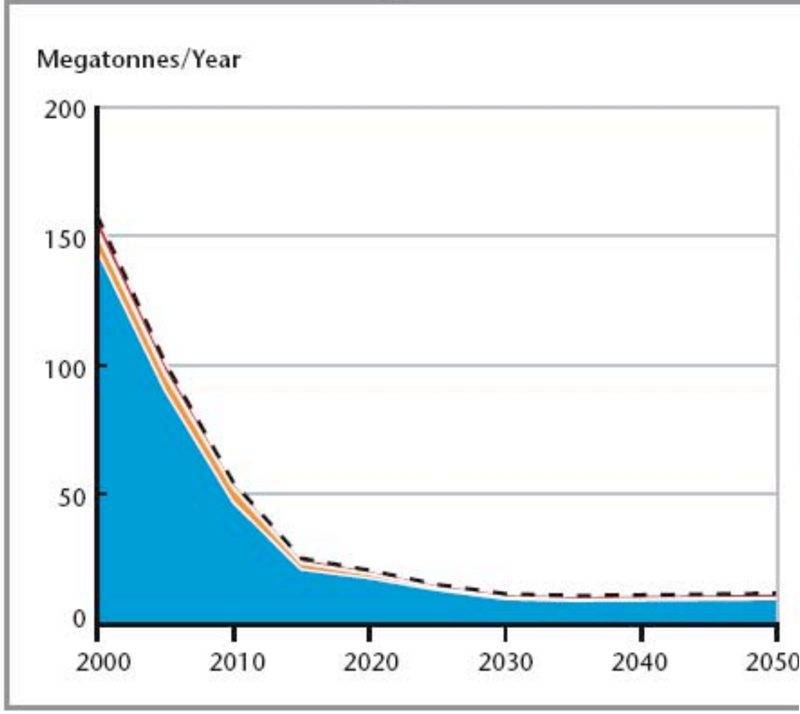
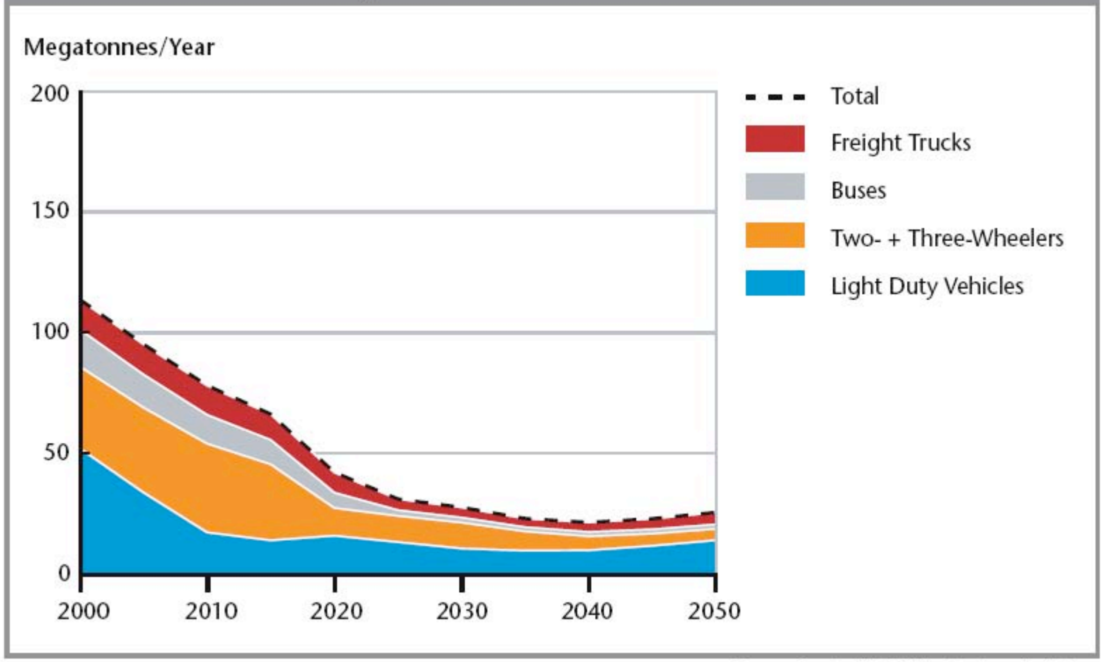


Figure 2.21 Non-OECD regions: Transport-related Carbon Monoxide (CO) emissions by mode



Source: Sustainable Mobility Project calculations.

CO ↓ x 4-10

Source: Mobility 2030, WBCSD (2004)

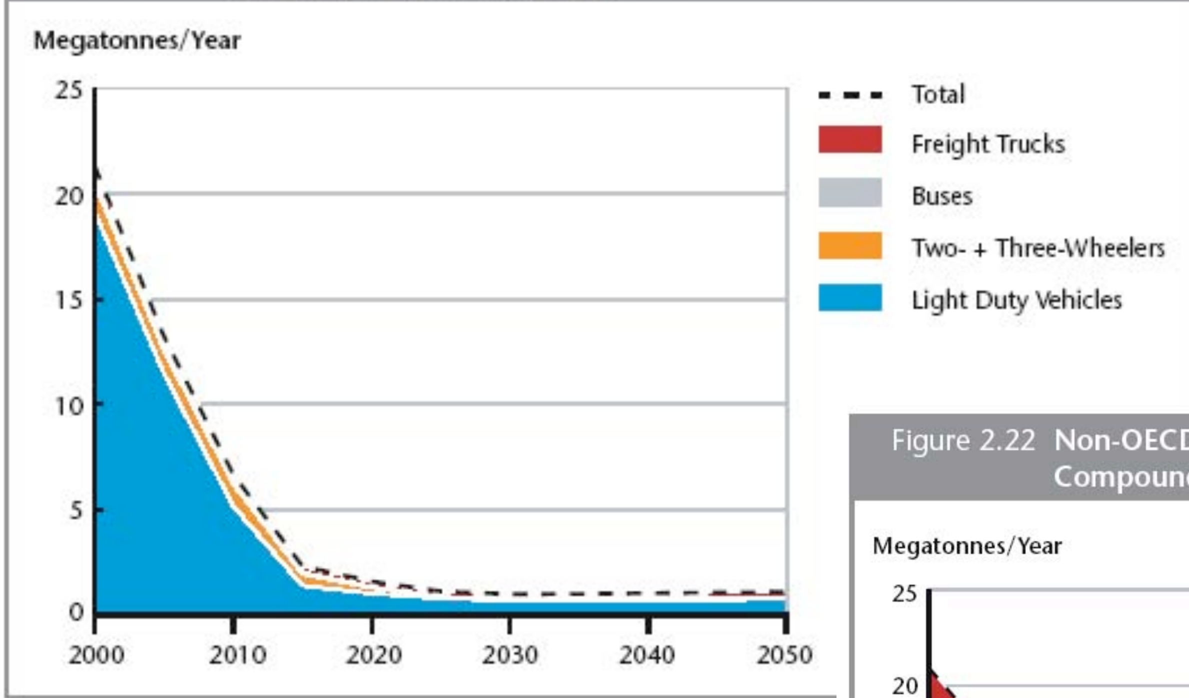


Figure 2.17 OECD regions: Transport-related Volatile Organic Compound (VOC) emissions by mode

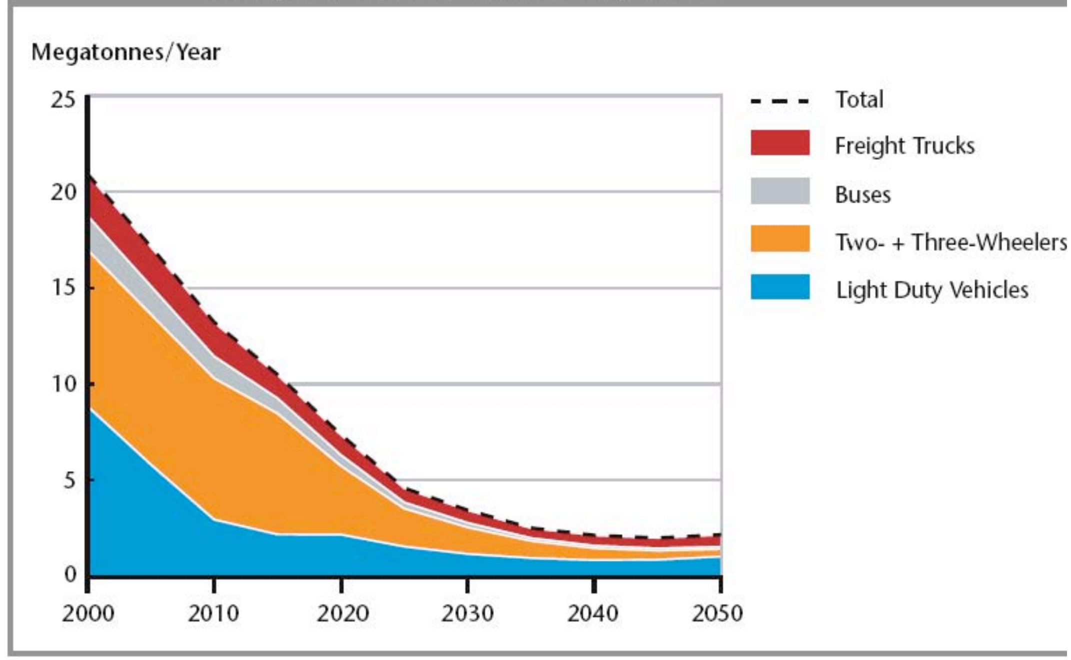


Figure 2.22 Non-OECD regions: Transport-related Volatile Organic Compound (VOC) emissions by mode

Source: Sustainable Mobility Project calculati

VOC ↓ x 10-20

Source: Mobility 2030, WBCSD (2004)

Figure 2.18 OECD regions: Transport-related Particulate Matter (PM-10) emissions by mode

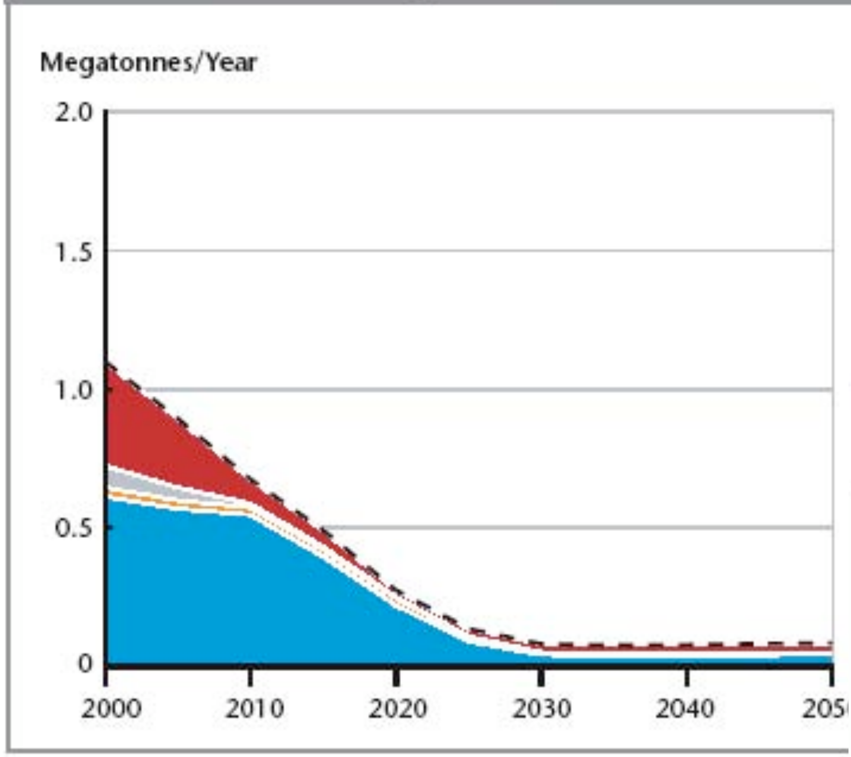
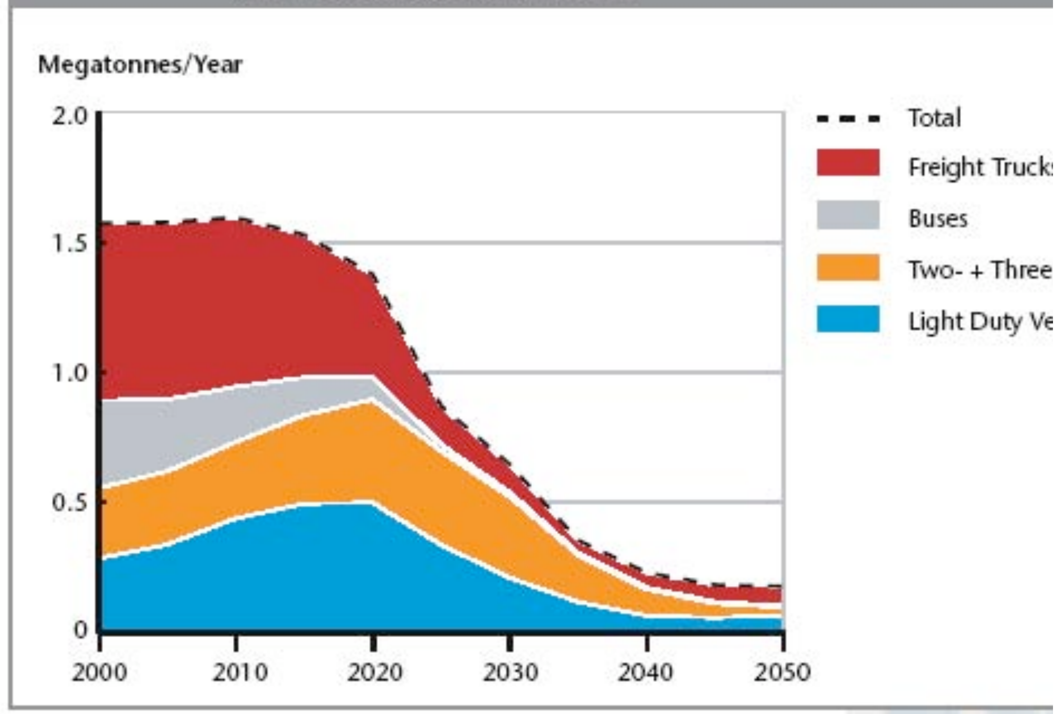


Figure 2.23 Non-OECD regions: Transport-related Particulate Matter (PM-10) emissions by mode

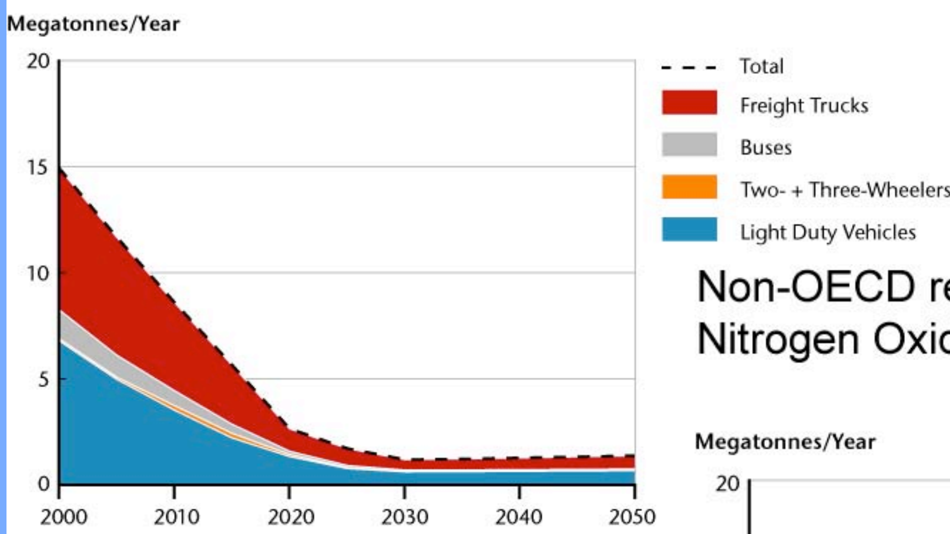


Source: Sustainable Mobility Project calculations.

PM ↓ x 5-10

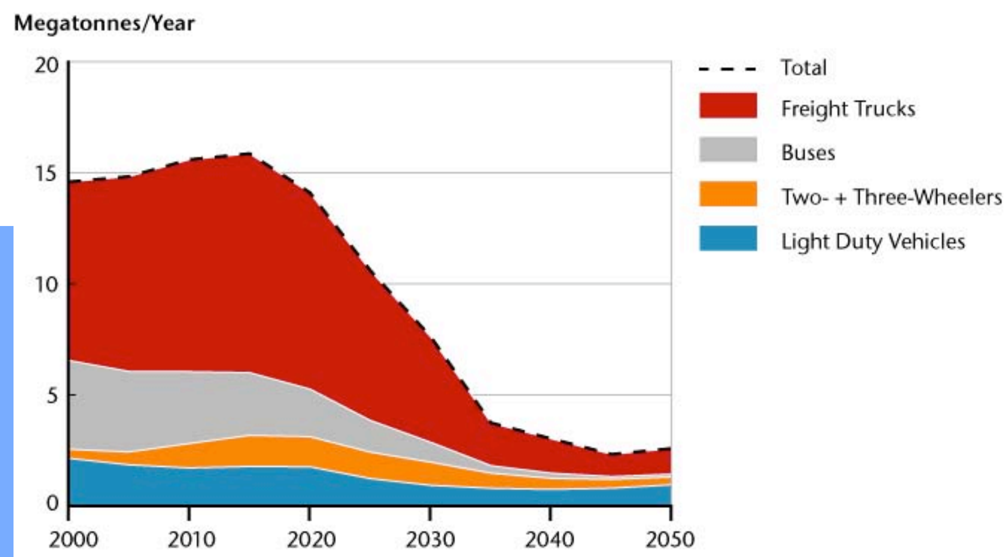
Source: Mobility 2030, WBCSD (2004)

OECD regions: Transport-related Nitrogen Oxide (NOx) emissions by mode



Source:
Sustainable Mobility Project calculations.

Non-OECD regions: Transport-related Nitrogen Oxide (NOx) emissions by mode



Source:
Sustainable Mobility Project calculations.

NO_x ↓ x 5-10

Source: Mobility 2030, WBCSD (2004)

Future Outlook

Road transport emissions (2000- 2050):

CO_2 up x 2

CO down x 4-10

VOC down x 10-20

NO_x down x 5-10

PM down x 5-10

Conclusions

HCs, CO, NO_x, PM, R-134a, N_2O, CH_4 are small and/or short term issues.

CO_2 is large and long term issue.

Some options to reduce life cycle CO_2 emissions

Eco driving

Reduce weight

Reduce power

Diesel versus gasoline

Hybrid technology

Biomass derived fuel

Electric vehicles

H_2 ICE (internal combustion engine)

H_2 fuel cell technology

[no "silver bullet" here, need to consider life cycle impacts, systems thinking approach]

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Concluding remarks:

Spectacular progress in reducing criteria pollutants

Climate change is the future challenge

Life cycle analysis, systems thinking approach, and business-academic-government collaboration is vital to address issue