

Motor Vehicle Pollution Control: Emissions Vs. Efficiency Getting the Principles Right

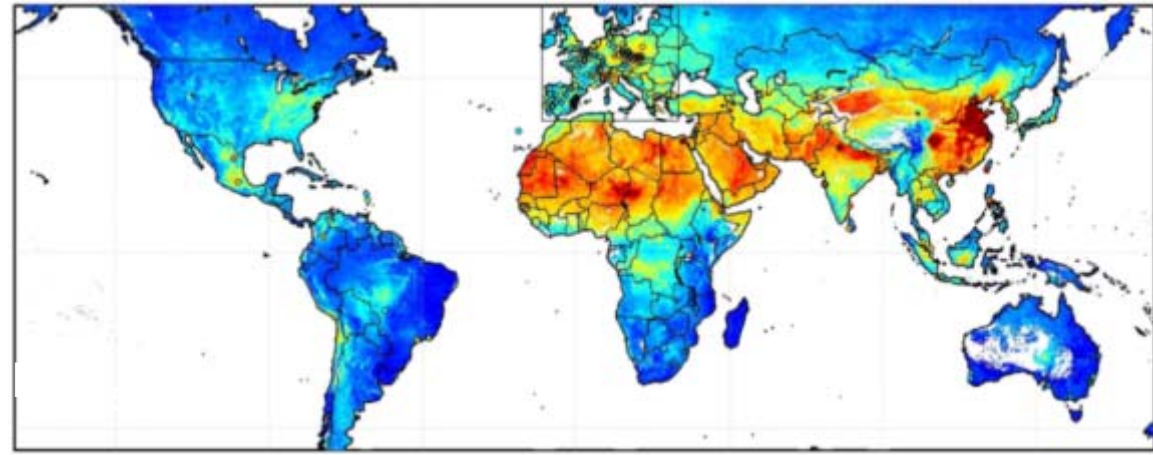
July 24, 2013

Michael P. Walsh
International Consultant

Founding Chairman
Board of Directors,
International Council on Clean
Transportation



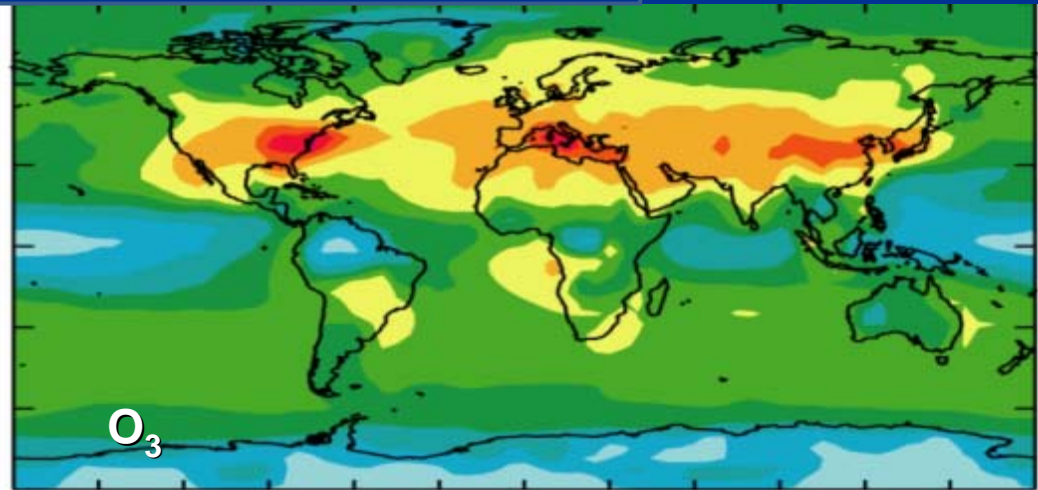
Air Pollution Remains Very Serious in Many Countries Especially $\text{PM}_{2.5}$ And O_3



$\text{PM}_{2.5}$

Van Donkelaar et al. (2010)

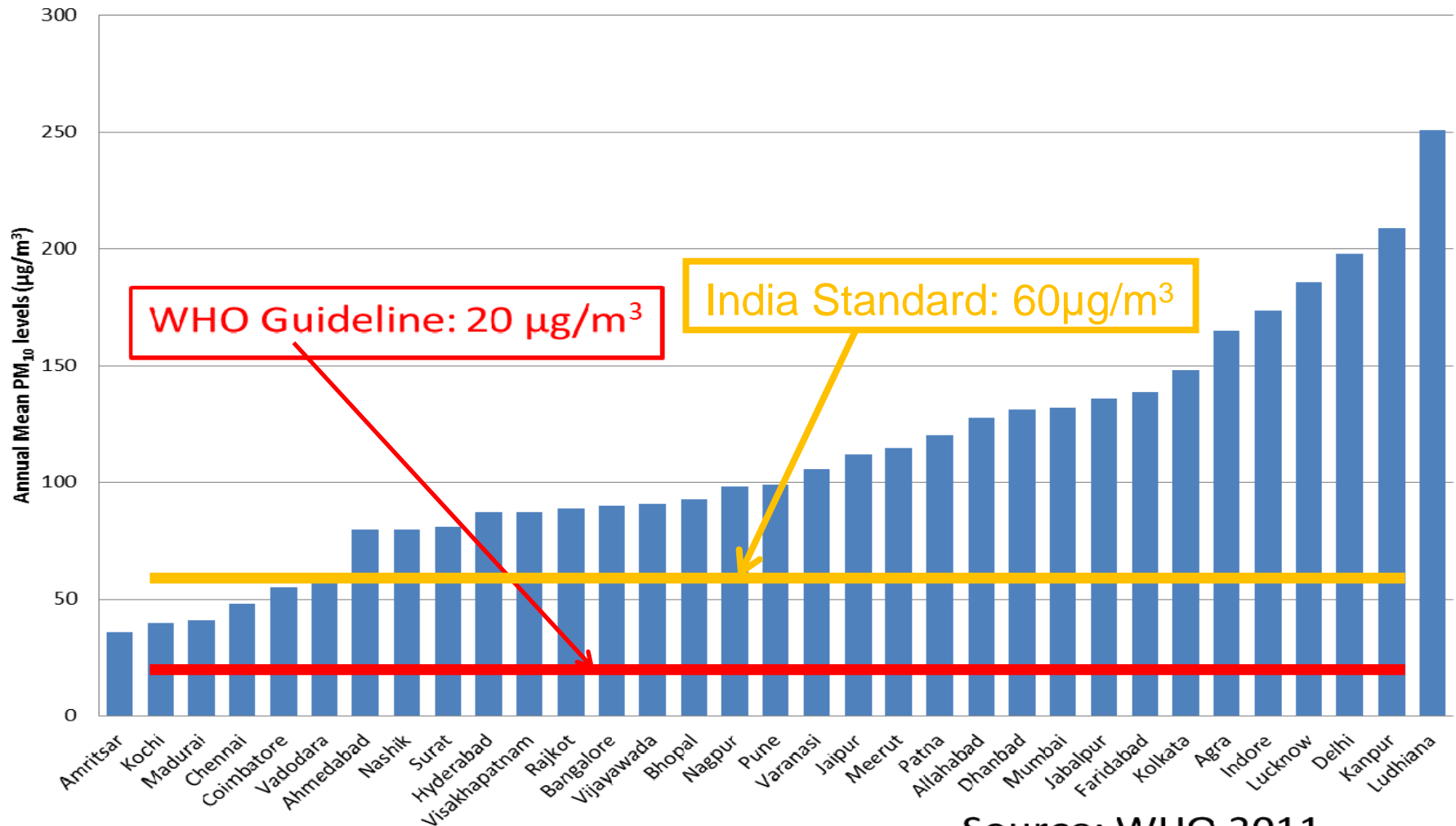
O_3



Lelieveld, J., and F. J. Dentener (2000)

India: Many Cities Substantially Exceed WHO and Indian Air Quality Guidelines

2008 Annual Mean PM₁₀ Levels In Indian Cities*

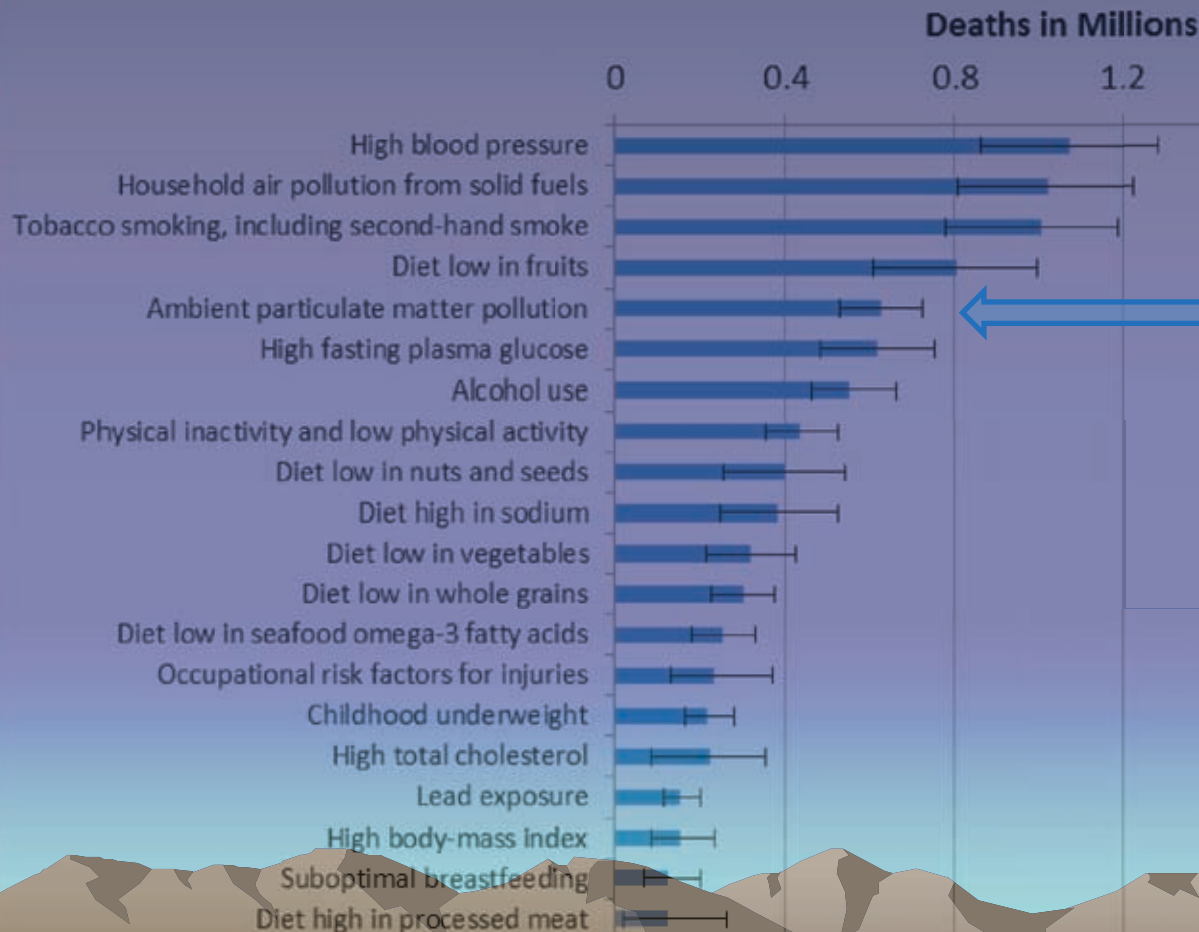


Source: WHO 2011

Top 20 Mortality Risk Factors in India for 2010

Ambient PM_{2.5} is 5th leading mortality risk factor

Leading Risk Factors for Deaths in 2010 in India

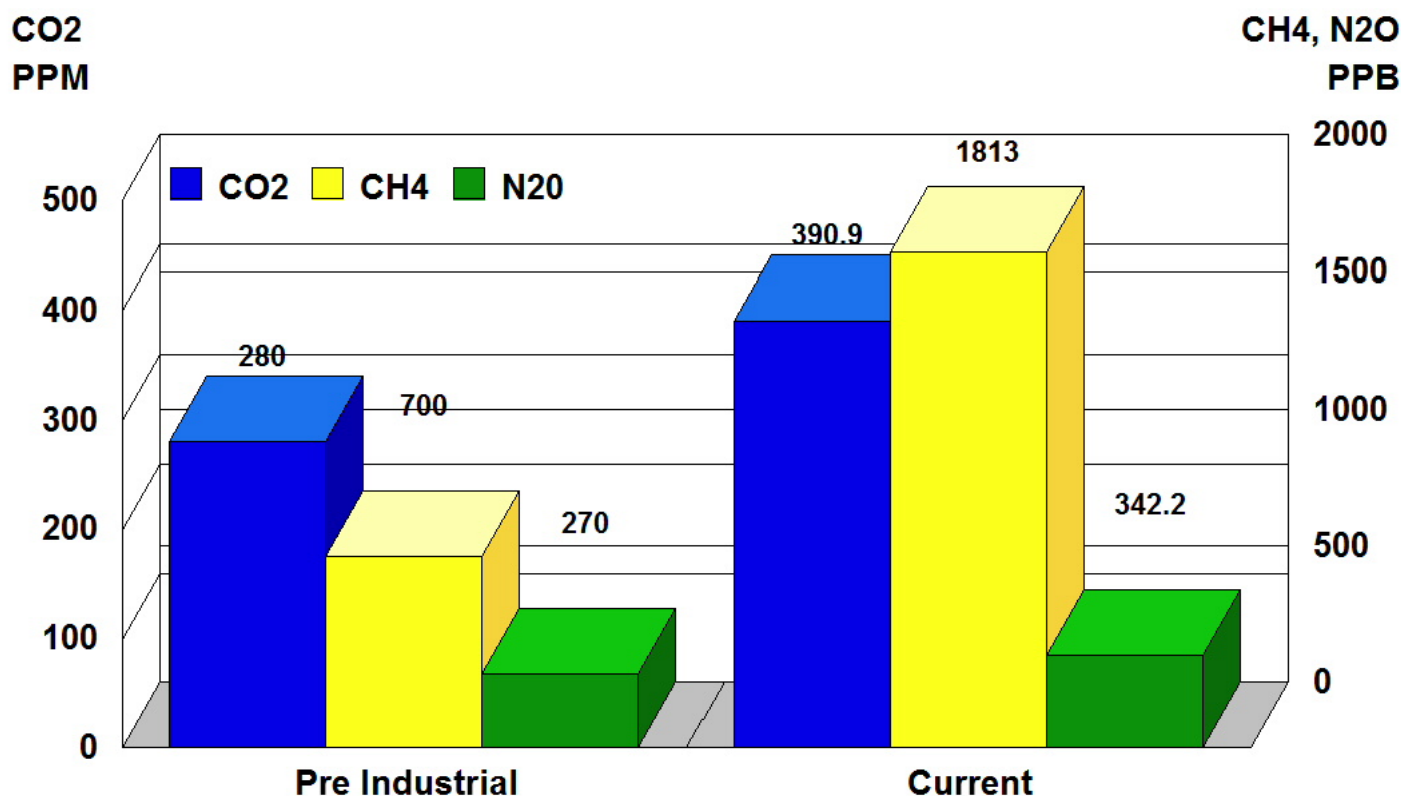


Ambient PM_{2.5} caused an estimated 627,000 deaths ~6% of all deaths in 2010

We Now Face A New Global Challenge: Climate Change

GHG Concentrations Are Reaching New Peaks

CO₂ Reached 400 PPM in the Last Few Weeks!



Arctic Ice Melt



Increasing Droughts



Subtropics expected to expand with global warming.

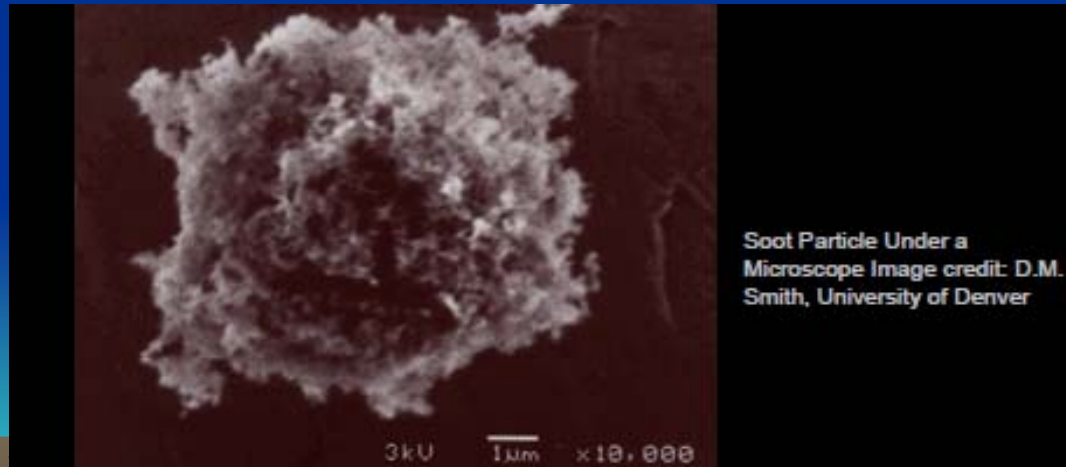
Observations show 4 degrees of latitude expansion.

Fires Are Increasing World-Wide

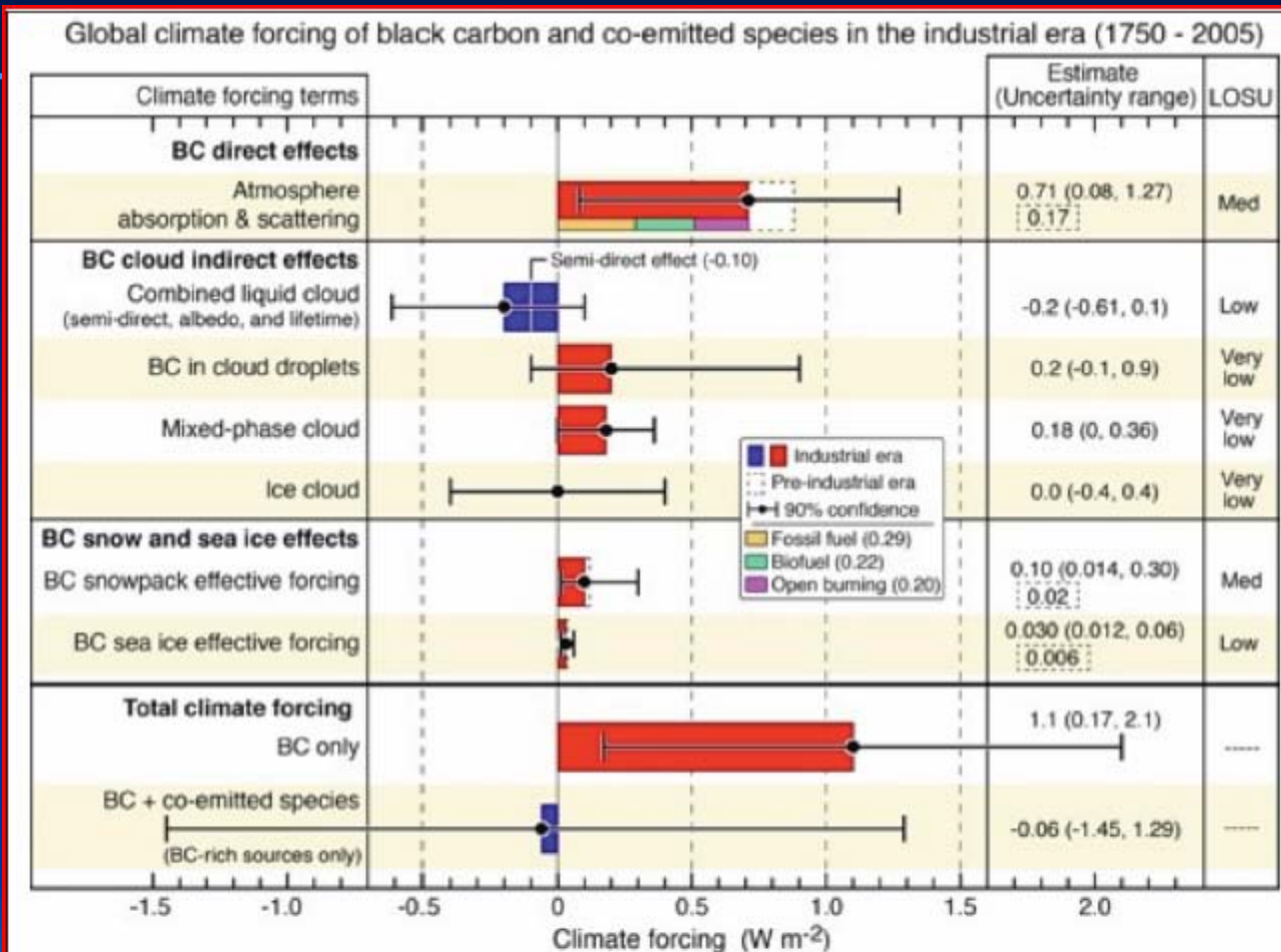


BC: Linking Climate and Air Pollution

- Black Carbon (BC) is part of the air pollution mixture known as **particulate matter** (PM)
 - Most strongly light-absorbing component of PM
 - Formed by incomplete combustion of fossil fuels, biofuels, and biomass, and is a major component of “soot”
 - Mainly found in the fine particle ($PM_{2.5}$) fraction, which is most strongly linked to adverse health effects

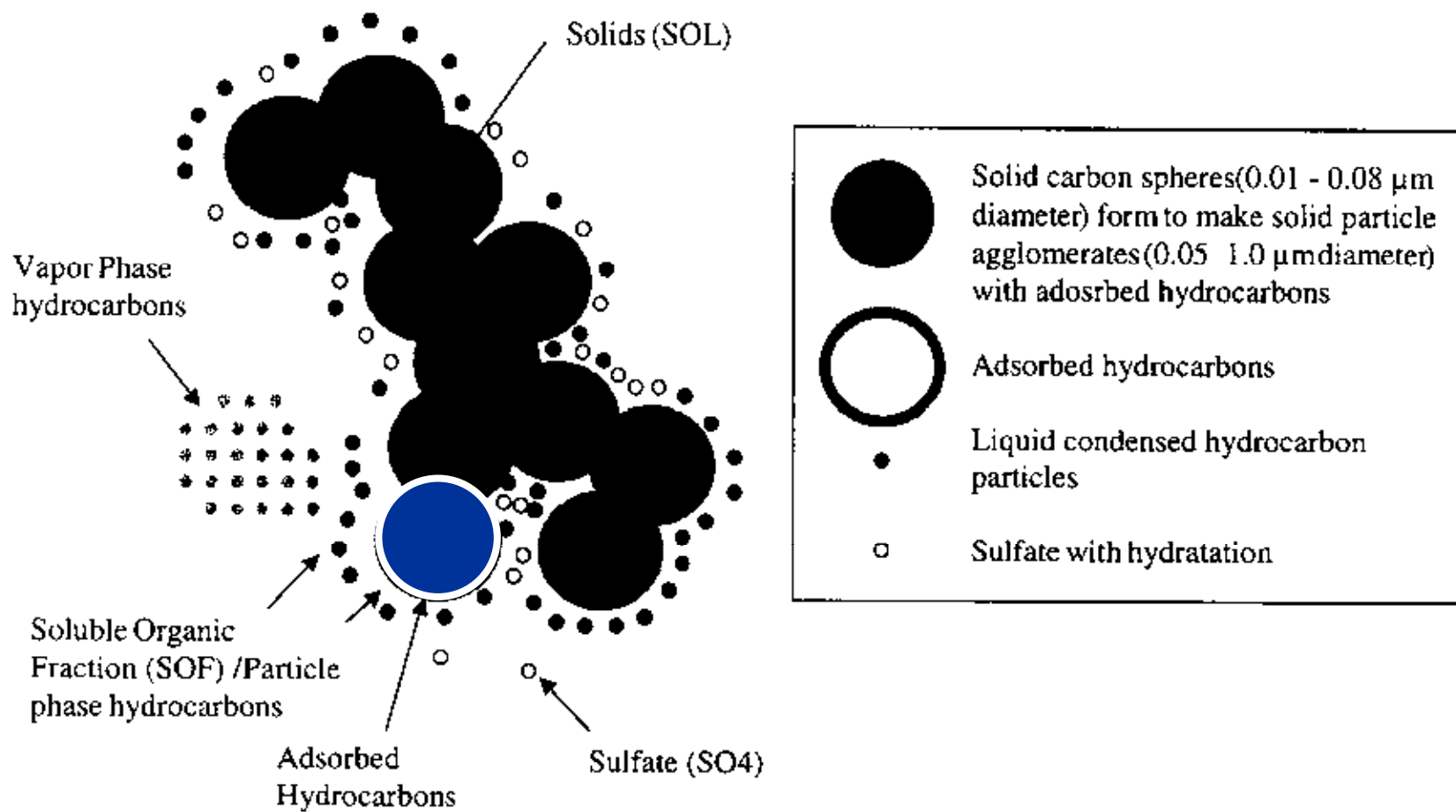


Most Recent Study Says Black Carbon is Second Only To CO2



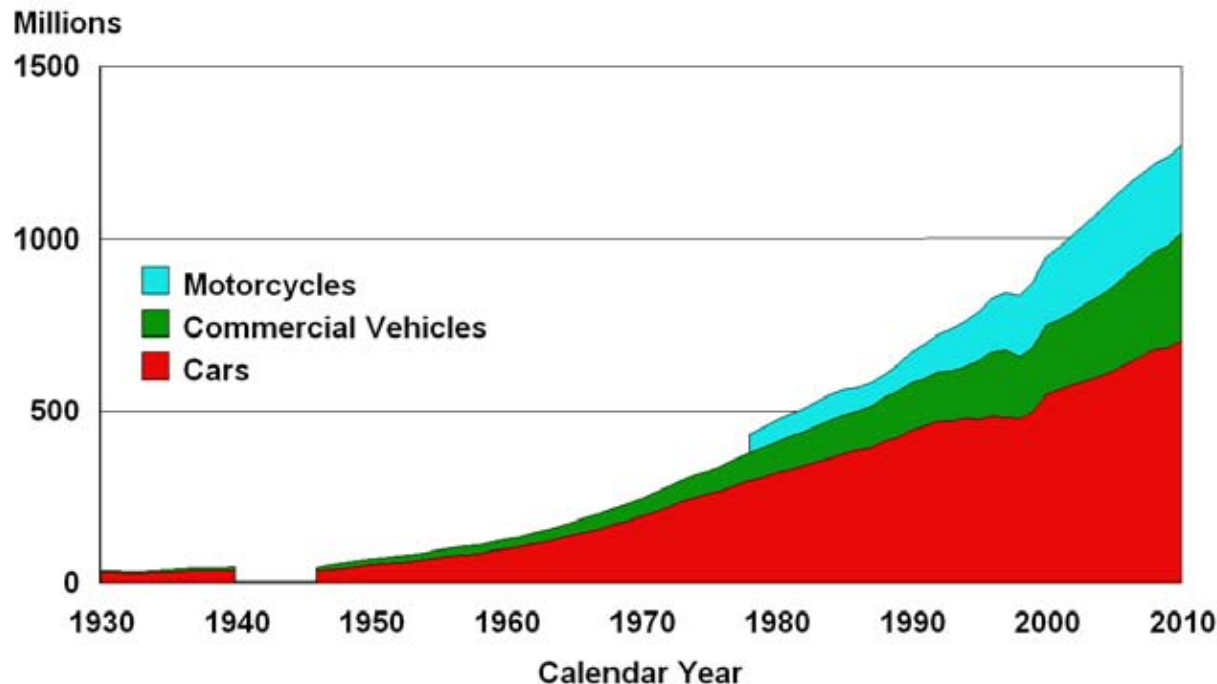
Quantitative estimates of black carbon influence, expressed as "climate forcing," or perturbation to Earth's energy balance. The upper red bar can be compared to the direct forcing of $+0.34 W m^{-2}$ from the IPCC Fourth Assessment report. The addition of forcing components to give net forcing (lowest red bar) was one contribution of this work. For comparison, carbon dioxide forcing in the year 2005 was $+1.66 W m^{-2}$.

Black Carbon is the Core of Diesel PM



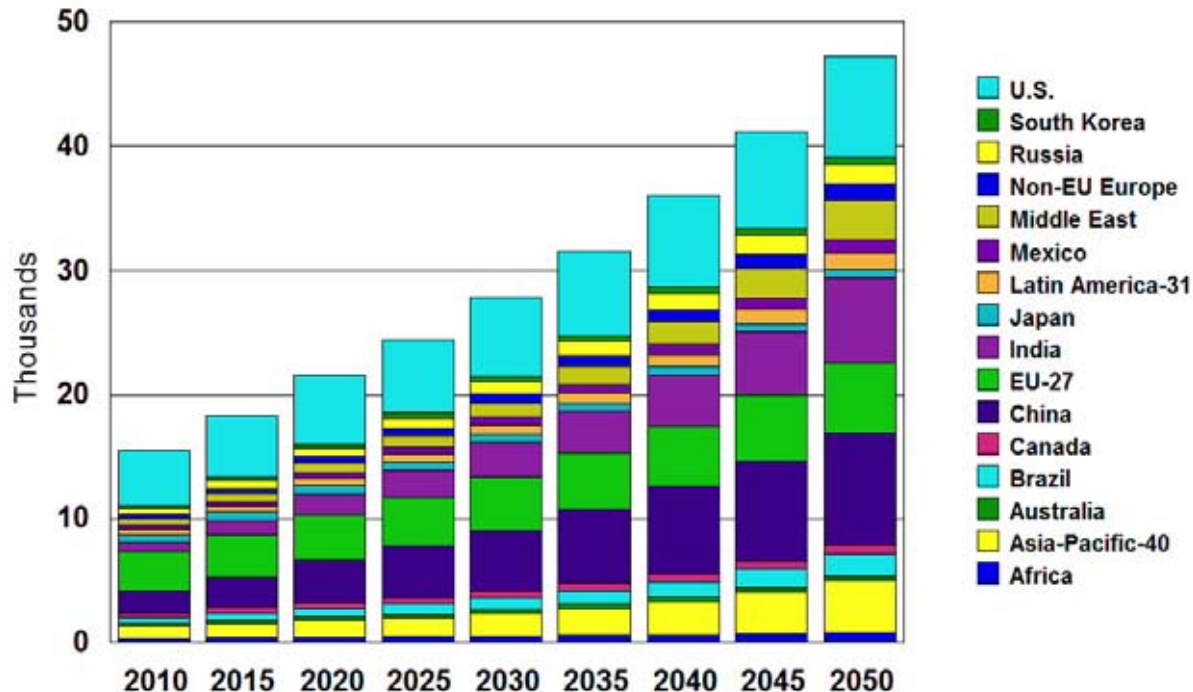
Historical High Growth Has Resulted In Vehicles Being Important Contributor To Local, Regional and Global Pollution

World Motor Vehicle Population



Looking Ahead, High Growth Is Anticipated, Placing Continued Pressure On The Environment

Global Forecast of VKT by Region (billions)



**Note
Especially
China
and
India**

Other Special Concerns With Vehicles

June 2012 - WHO Classifies Diesel Engine Exhaust As Group 1 Known Carcinogen




Diesel engine exhaust carcinogenic



WHO/PAHO

12 June 2012 -- After a week-long meeting of international experts, the International Agency for Research on Cancer (IARC), which is part of the World Health Organization, today classified diesel engine exhaust as carcinogenic to humans (Group 1), based on sufficient evidence that exposure is associated with an increased risk for lung cancer.

[Read the press release from IARC on diesel engine exhaust](#) 

Other Special Concern: Widespread Exposure to Vehicle Emissions in Urban Areas



Transport Pollution
is Ubiquitous

What Can We Do About It? Elements of a Comprehensive Vehicle Pollution Control Strategy

Better Air Quality

**Clean
Vehicle
Technologies**

**Clean
Fuels**

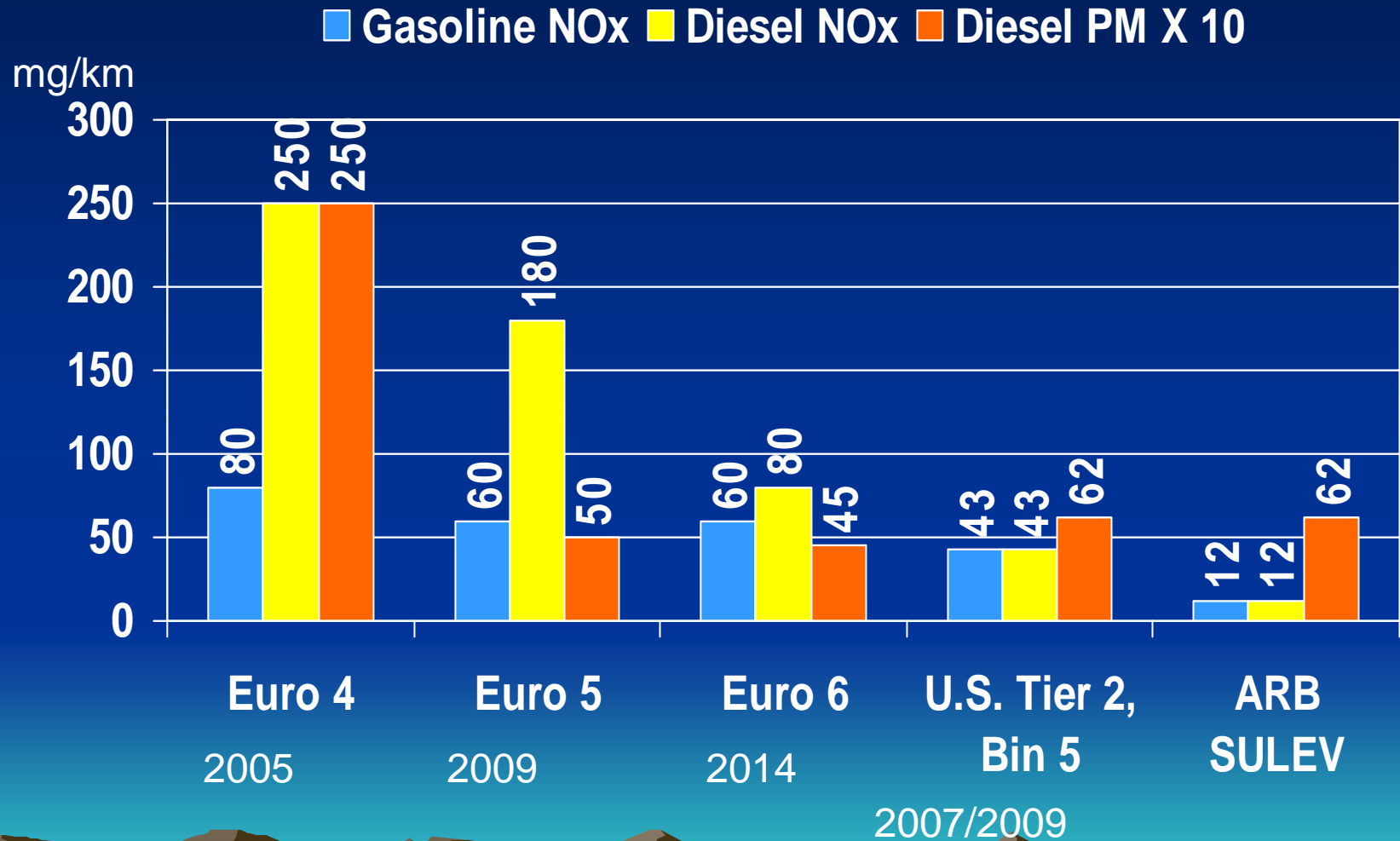


**Transportation &
Land use
Planning**

**Appropriate
Maintenance**

Technology Now Exists To Clean Vehicles

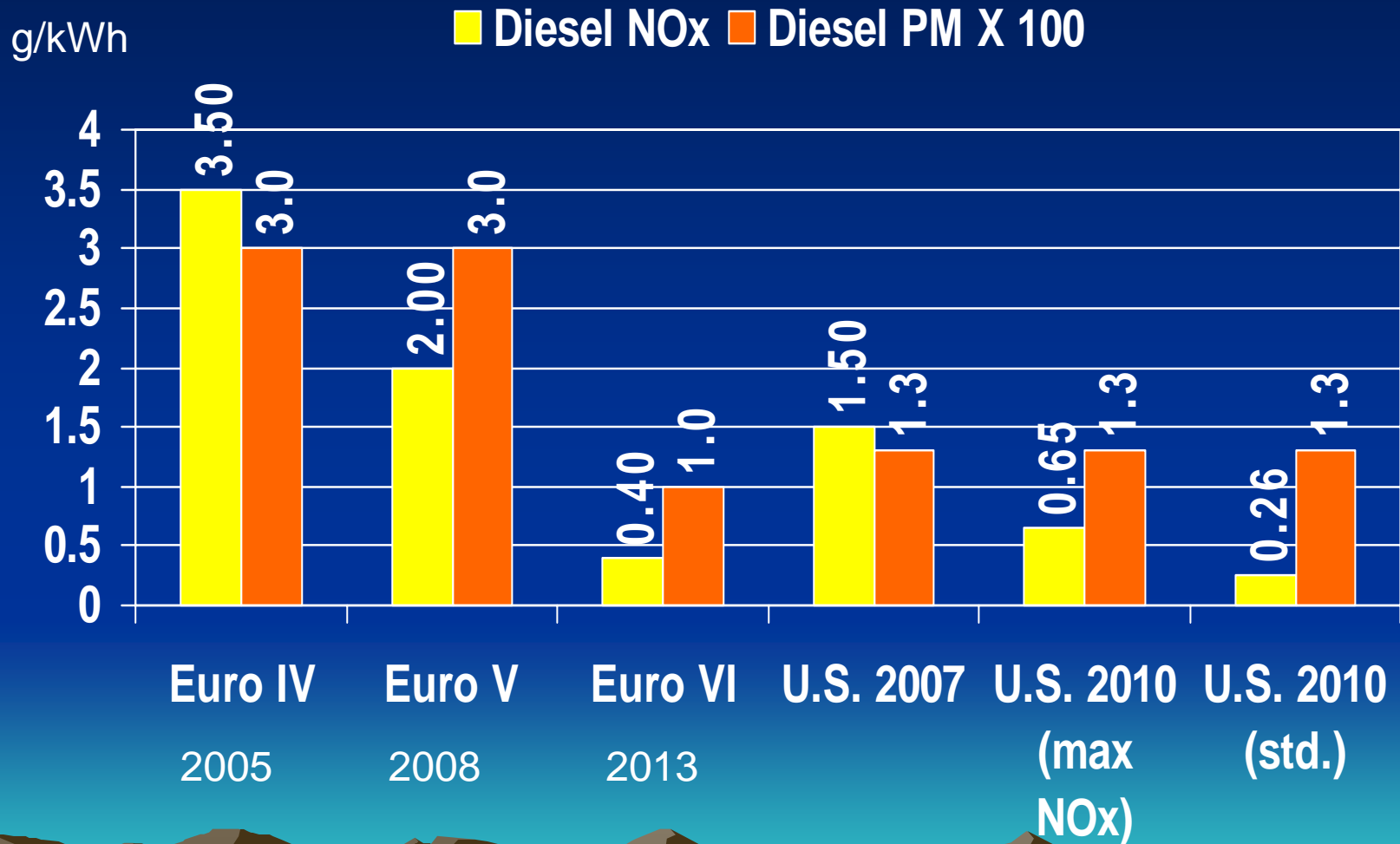
U.S. and Europe Light-Duty Vehicle Emission Standards



Euro 5+ (2011) and 6 include $6 \times 10^{11}/\text{km}$ **particle number** limit
Euro 6 PM mass limit uses revised PMP mass protocol

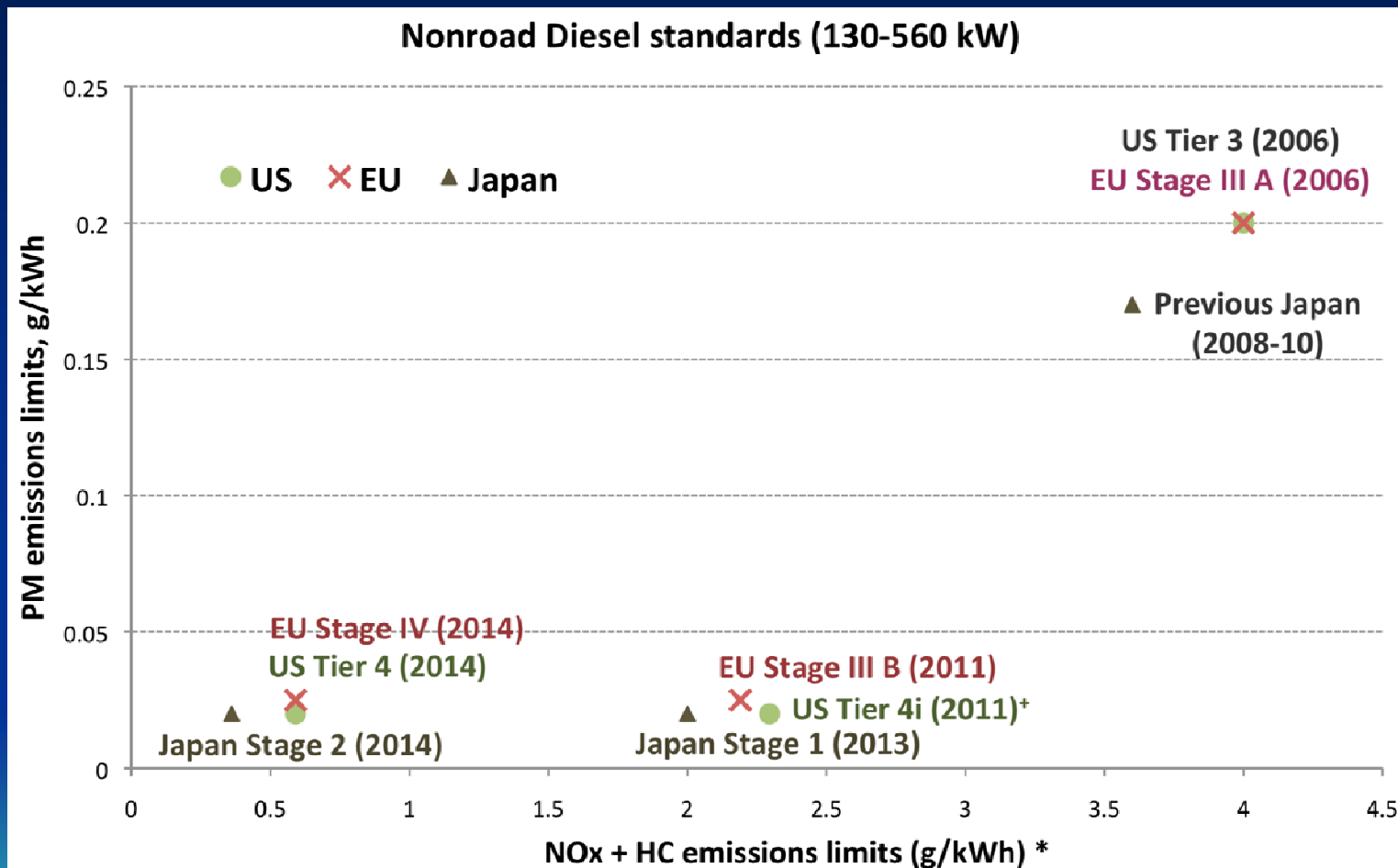
Technology Now Exists To Clean Vehicles

U.S. and Europe Heavy-Duty Engine Transient Cycle Emission Standards



Euro VI includes **particle number** limit

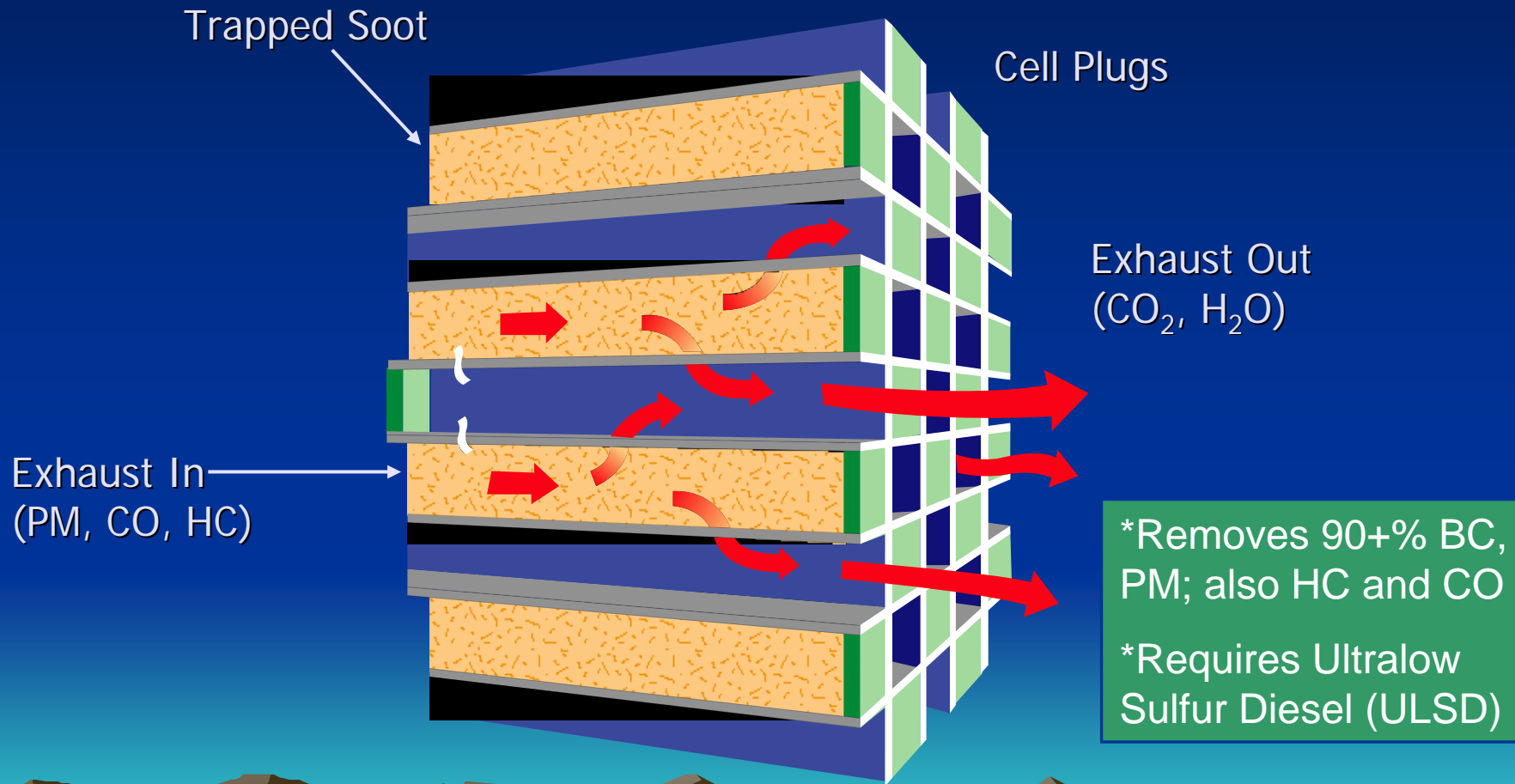
Even Starting To Be Phased in For Off Road Vehicles



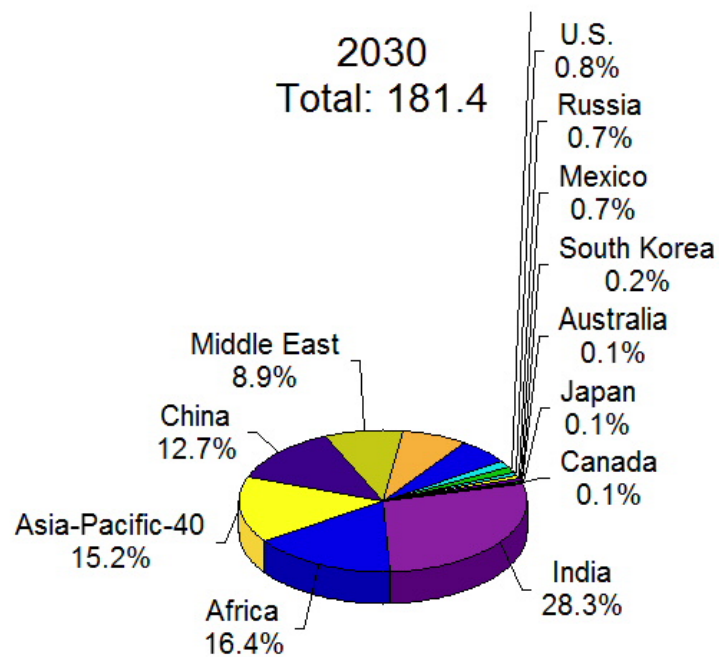
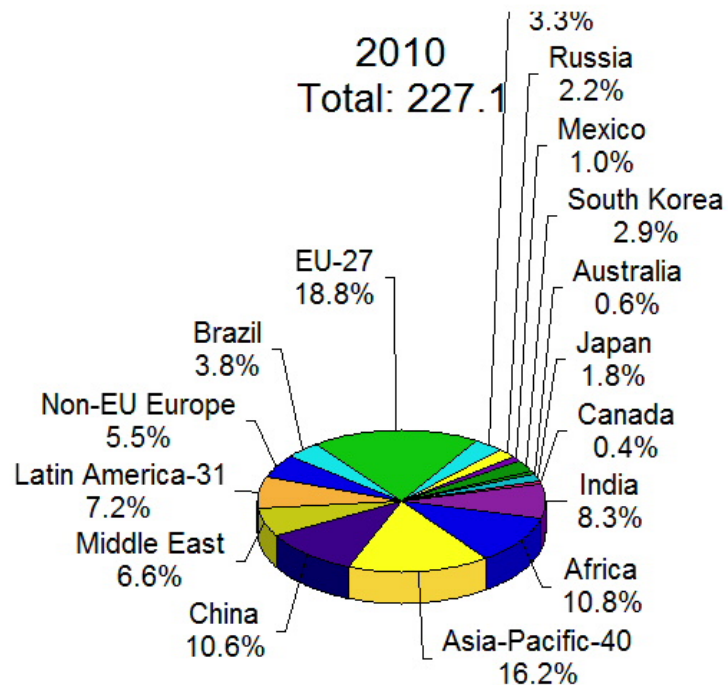
* NMHC + NOx for US and current Japan standards, HC + NOx for EU and previous Japan standards.

+ Tier 4i (interim) standard require full compliance of PM limit (0.02g/kWh) by 2011, and 50% of engines comply between 2011-13.

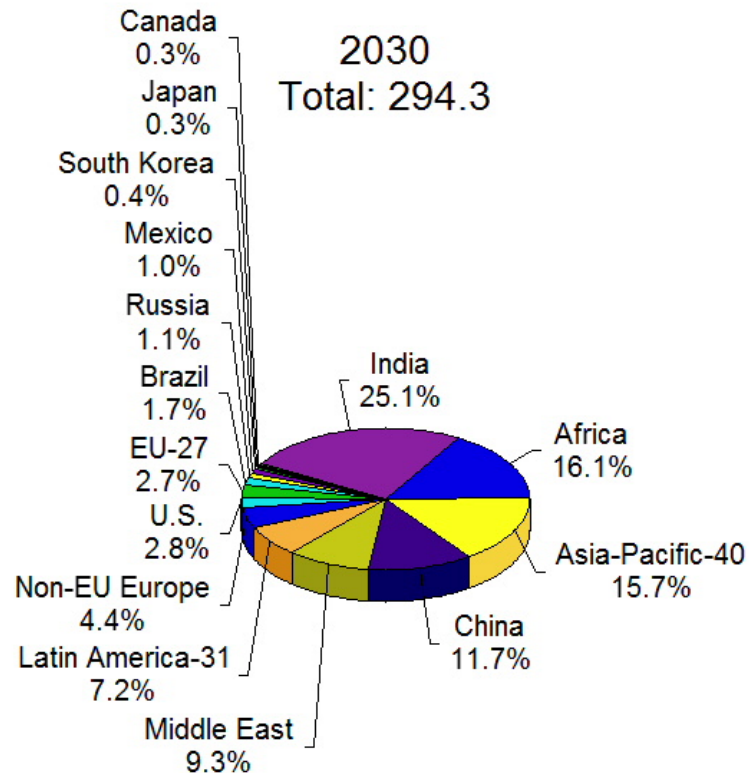
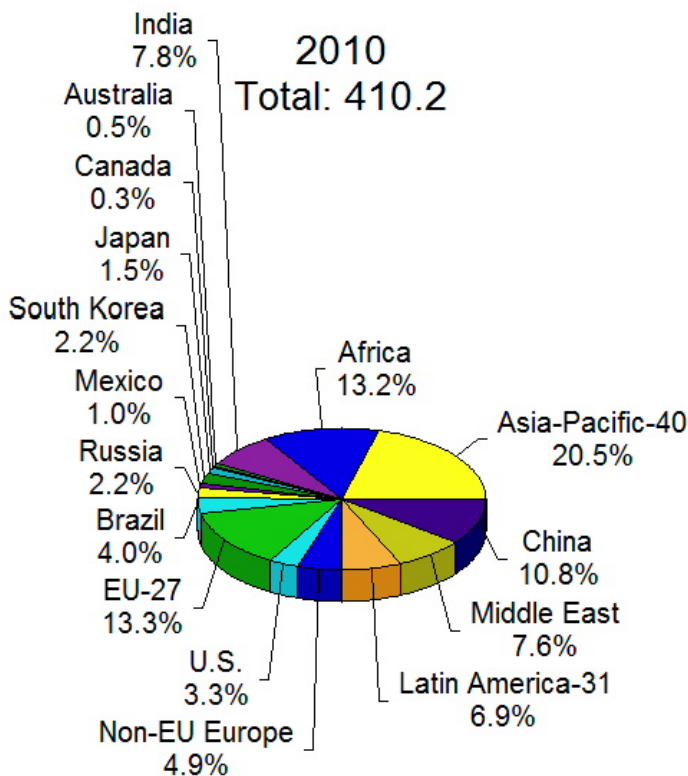
A Critical Technology: Diesel Particulate Filters (DPFs)



Black Carbon Emissions From Road Vehicles by Region



PM Emissions from Road Vehicles by Region



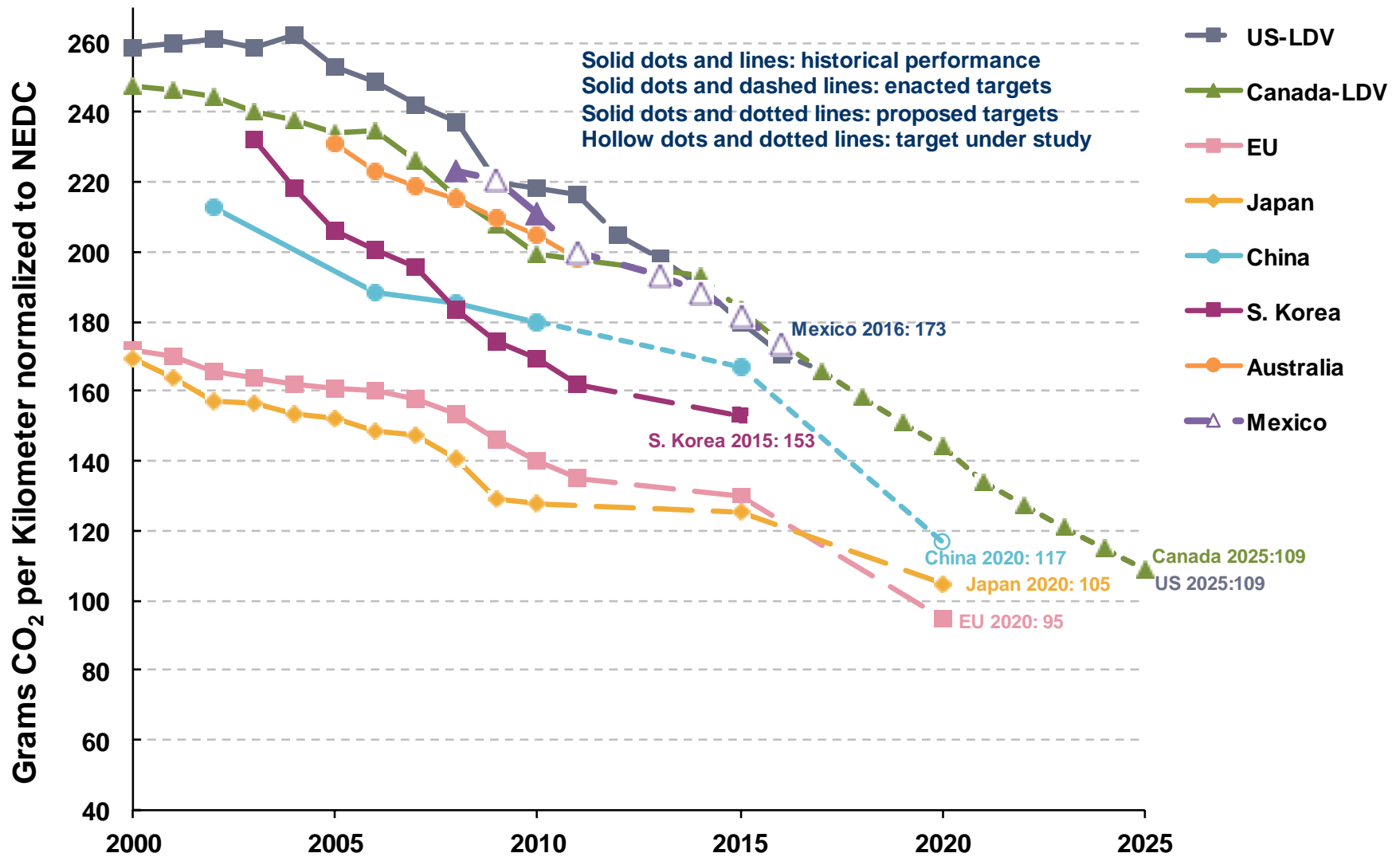
Benefits of Reducing Vehicle Emissions

- Shindell et al. (2011) estimate adopting European vehicle standards in India, China, and other industrializing and developing countries could lead to:
 - 120,000-280,000 avoided premature deaths in 2030 (valued at \$0.6-2.4 trillion in 2006 USD)
 - Mitigation of 0.2°C (+0.14°C/-0.17°C) Northern Hemisphere extra-tropical warming during 2040-2070
 - 6.1 – 19.7 million metric tons of avoided ozone related yield losses of major food crops



Shindell, D., G. Faluvegi, M. Walsh, S.C. Anenberg, R. Van Dingenen, N.Z. Muller, J. Austin, D. Koch, G. Milly. 2011. Climate, health, agricultural and economic impacts of tighter vehicle emissions standards, *Nature Climate Change*, 1:59-66.

Starting To Make Policy Progress on CO₂.



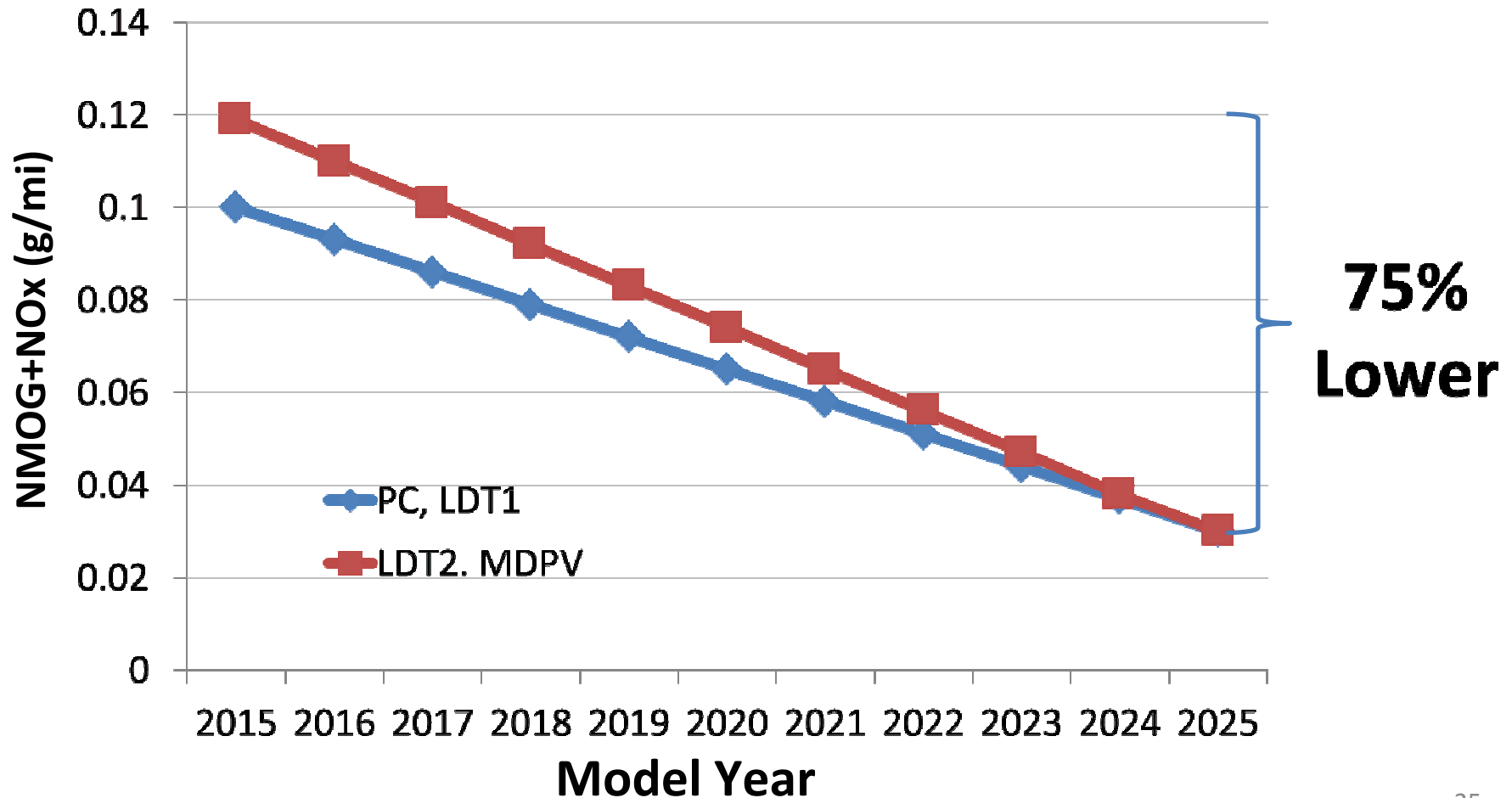
[1] China's target reflects gasoline vehicles only. The target may be lower after new energy vehicles are considered.

[2] US, Canada, and Mexico light-duty vehicles include light-commercial vehicles.

California Continues Technology Leadership

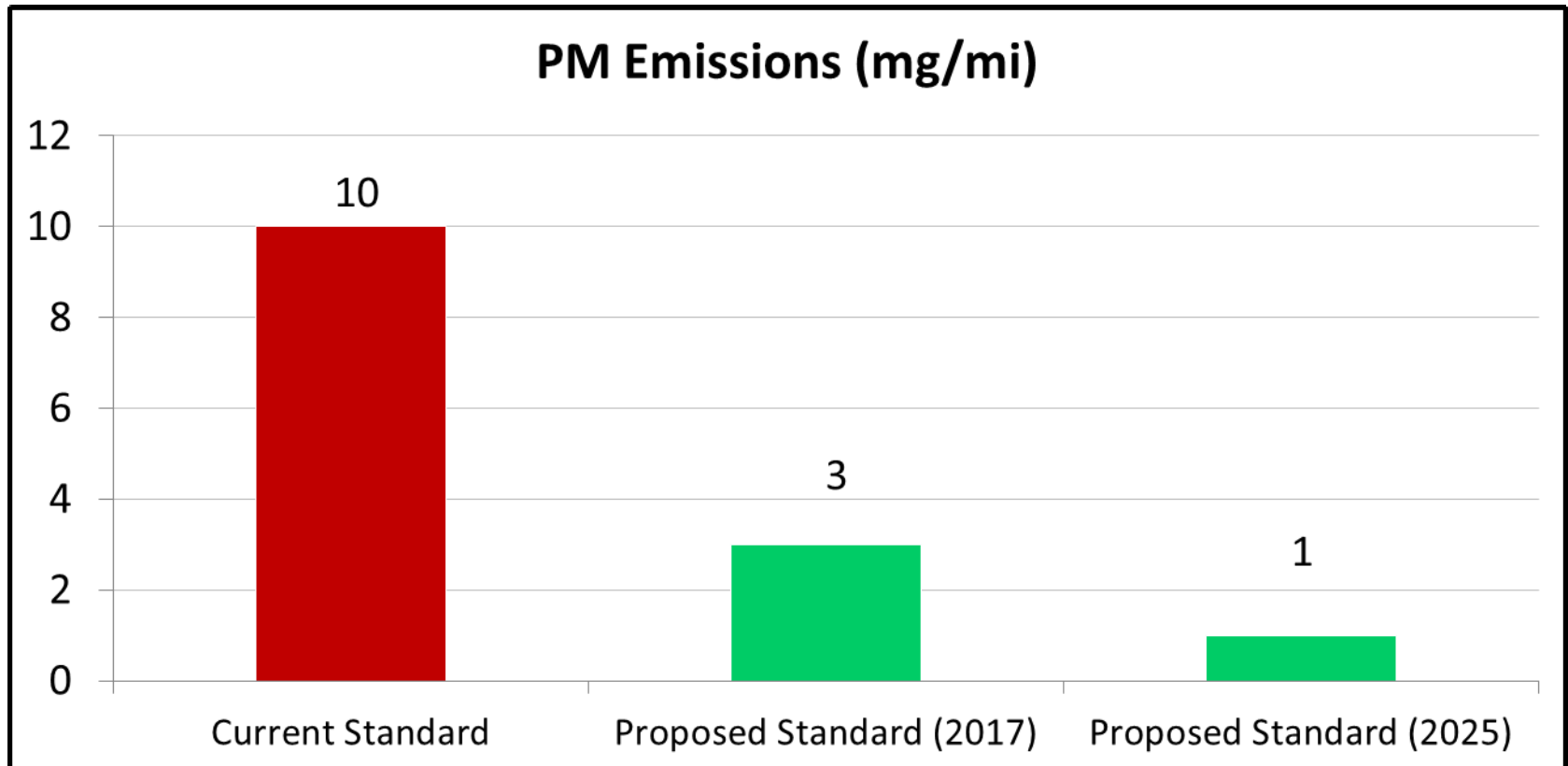


150,000-mile New Vehicle Fleet Average Emissions



LEV III Particulate Matter Standards

Advanced Clean Cars



Evaporative Emissions



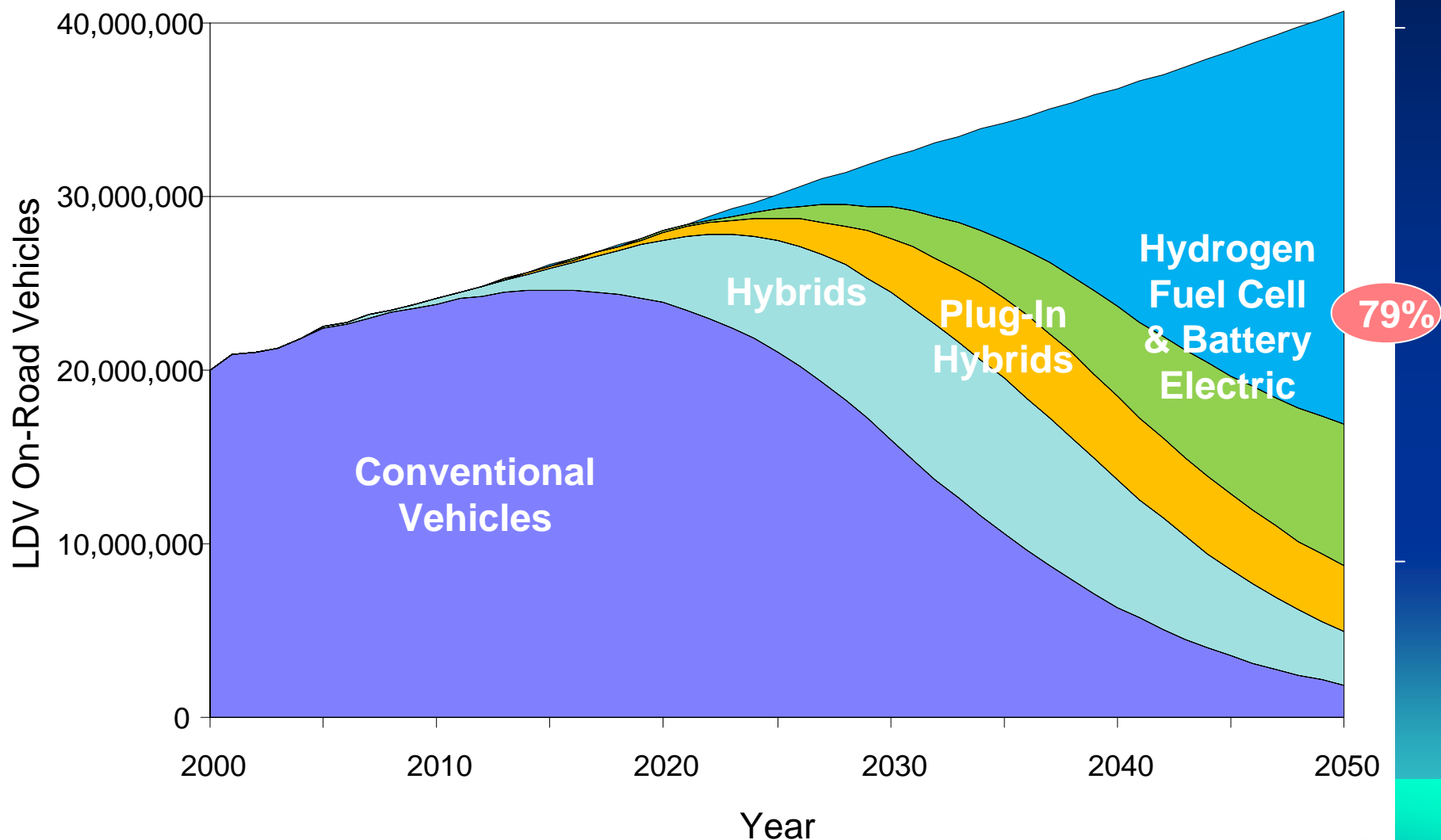
Advanced Clean Cars

- Extend **zero-evaporative emission** requirements currently in place for PZEVs to the entire light-duty vehicle fleet by MY 2022
- Extend **Onboard Refueling Vapor Recovery** (ORVR) requirements to all complete vehicles less than 14,000 pounds GVWR

Climate Action Program California

Major Source of GHG	Actions Taken
Passenger vehicles (LDV)	GHG emission standards: 50% reduction by 2025
Electric vehicles (LDV)	ZEV mandate; 15% of new sales by 2025
Heavy trucks (new)	National standards for engines/tractors: 9-23% reduction by 2017
Heavy truck (in-use, California)	Trailer aerodynamic devices: 5% reduction by 2016
Electricity	33% renewable by 2020
Combustion, fuels	Cap and trade program, 2 auctions, \$13/ton

Path to 2050: California's On-Road Vehicle Fleet



Countries Must Be Decisive!

China Announces A Clean Fuels Roadmap

State Council Says:

50 PPM Sulfur Nationwide by End of 2014

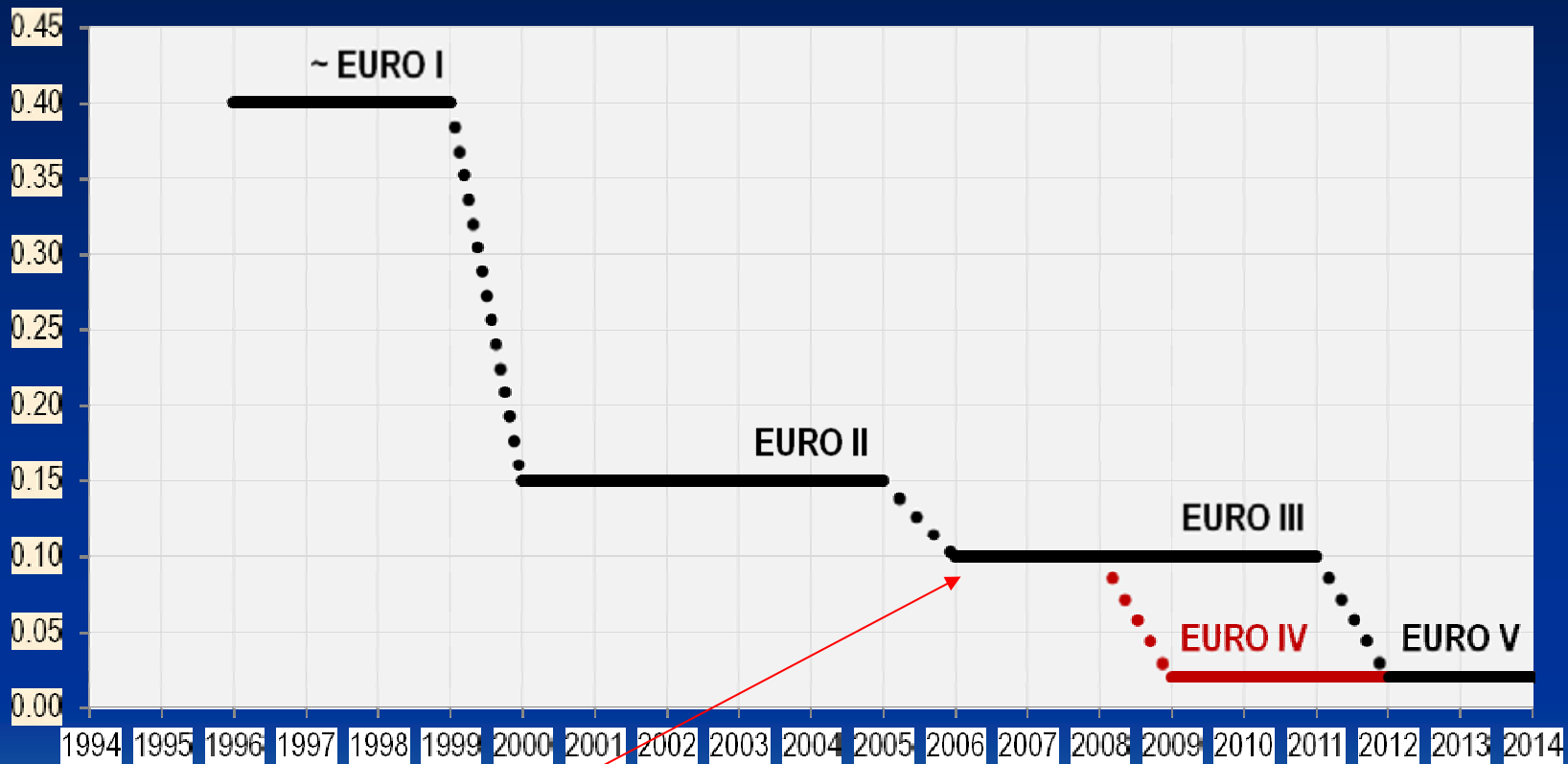
10 PPM by End of 2017

Even Quicker in Key Regions



Brazil Leapfrogs While Chile Innovates: PROCONVE

Evolution of Brazilian PM Emission Standards for Diesel Engines, g/kWh



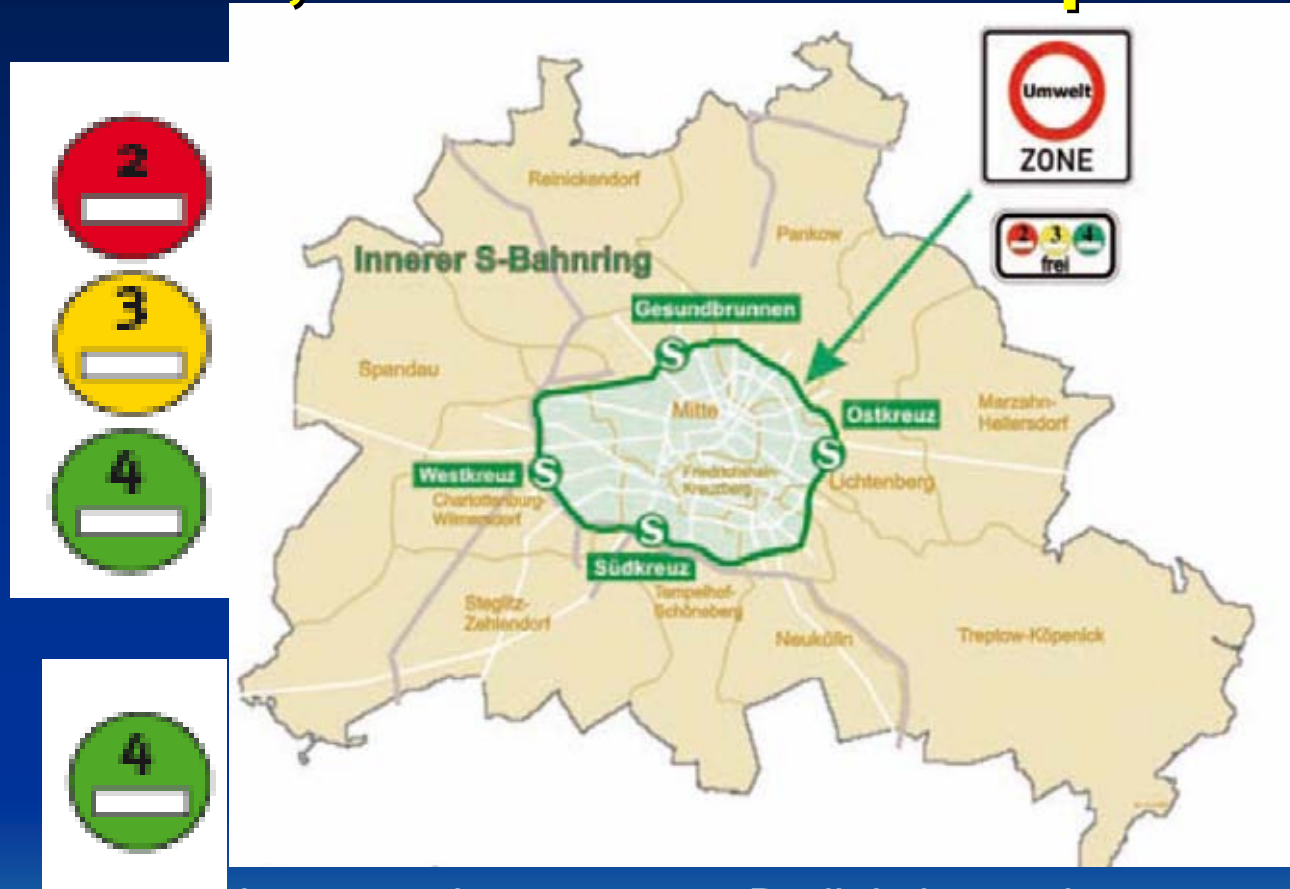
Santiago Adopts EURO III Bus Standards PLUS Particulate Filters

Berlin Leads On Environmental Zones Restrict Vehicles; Stimulate Clean Up

Stage 1 from 1.1. 2008:
Vehicles (lorries and
passenger cars) must at
least meet the
requirements of
Pollutant Class 2 of the
national vehicle label
scheme

Therefore, vehicles with
red, yellow and green
stickers are allowed.

Stage 2 from 1.1.2010:
Only vehicles in
Pollutant Class 4—thus,
only vehicles with green
stickers—can drive in
the zone.



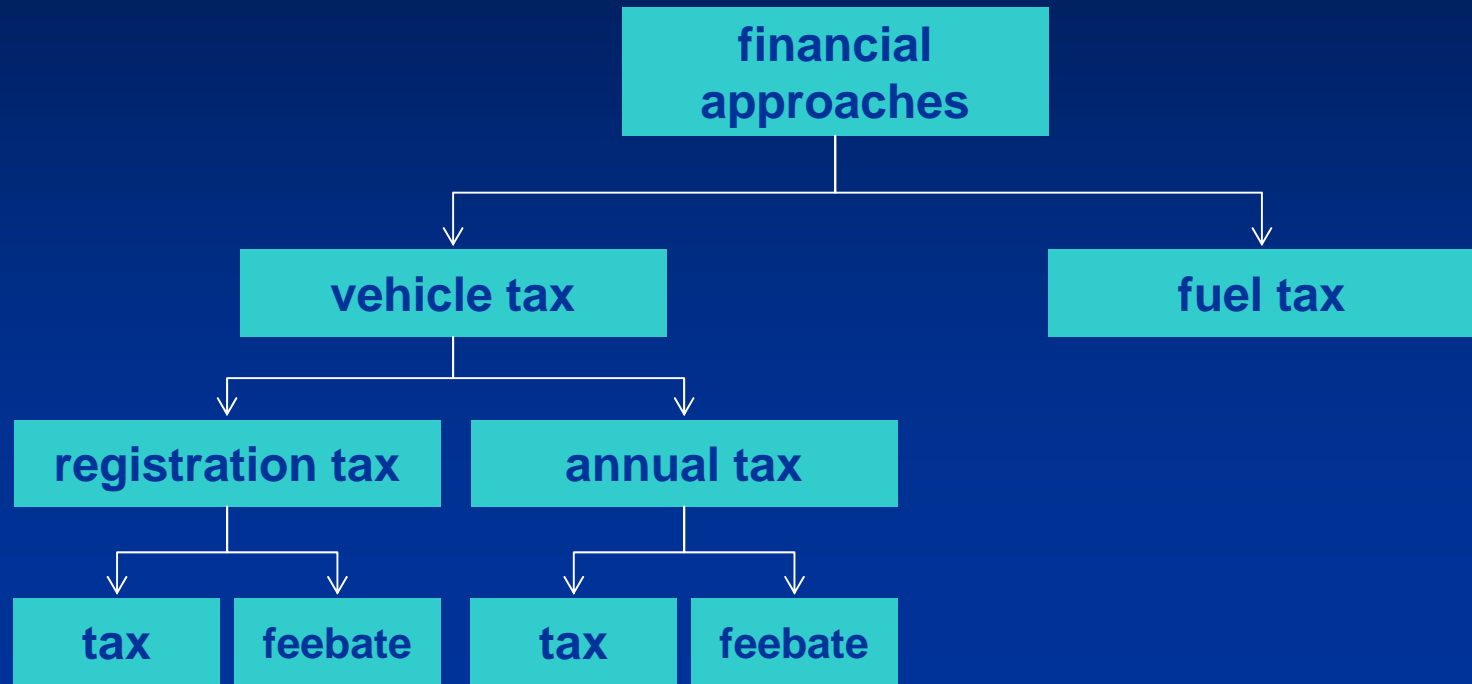
The environmental zone covers Berlin's inner city within the urban railway ring. It is an area of approximately 88 km², which is especially densely developed. Approximately one million of Berlin's 3.4 million inhabitants live here.

New Ideas Must Be Tried

Heavy Duty Diesel I/M Concept



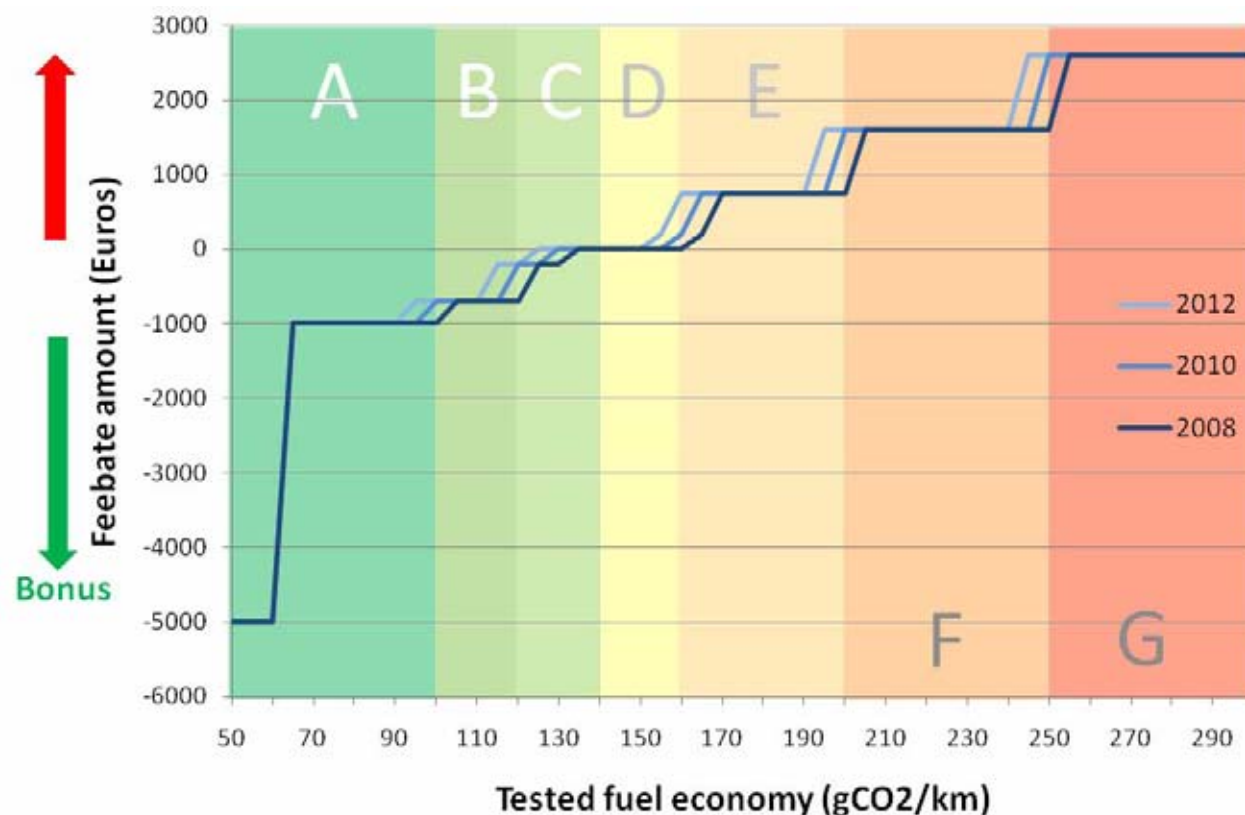
Complementary Measures: Key Types Of Financial Approaches To Reduce Emission Levels From Road Vehicles



The original Bonus/Malus

- It was announced in Sept 2007, to start in January 2008, designed to be €€€ neutral
- -5gCO₂/km every 2 years
- Special Bonus for hybrids and LPG : 2000 €

(If under 110 gCO₂/km)



	CO ₂ , g/km	Barème, €
Malus	>250	2600
	De 201 à 250	1600
	De 166 à 200	750
	De 161 à 165	200
	De 131 à 160	0
Bonus	De 121 à 130	200
	De 101 à 120	700
	De 61 à 100	1000
	<60	5000

Source : Code Général des Impôts

French Feebate System Led To Significant Drop In CO₂ Emissions

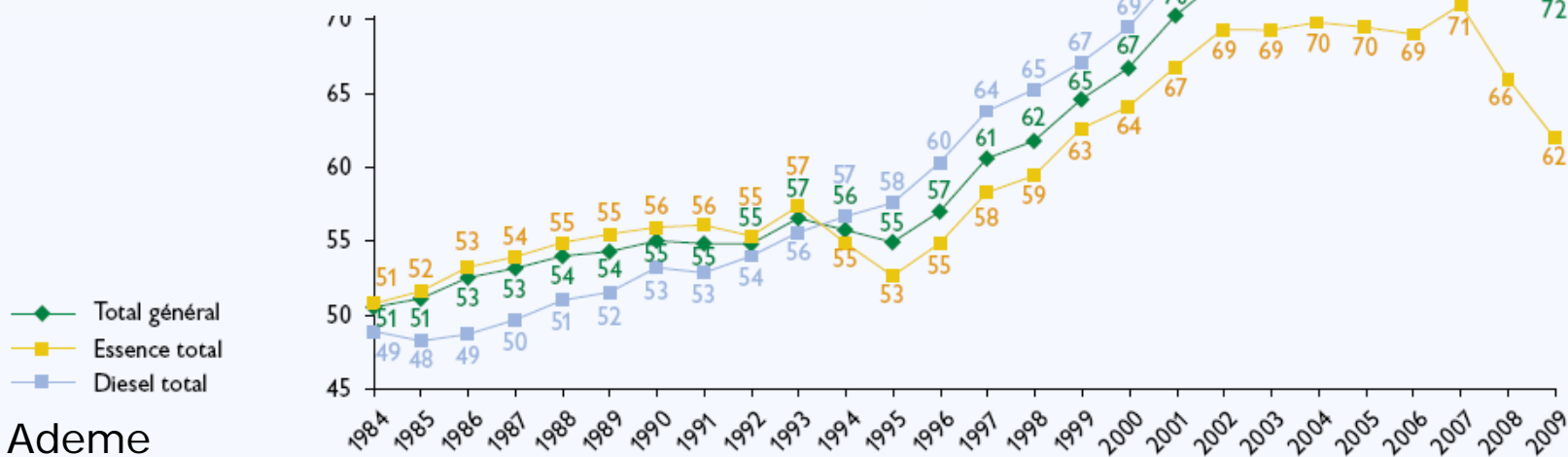
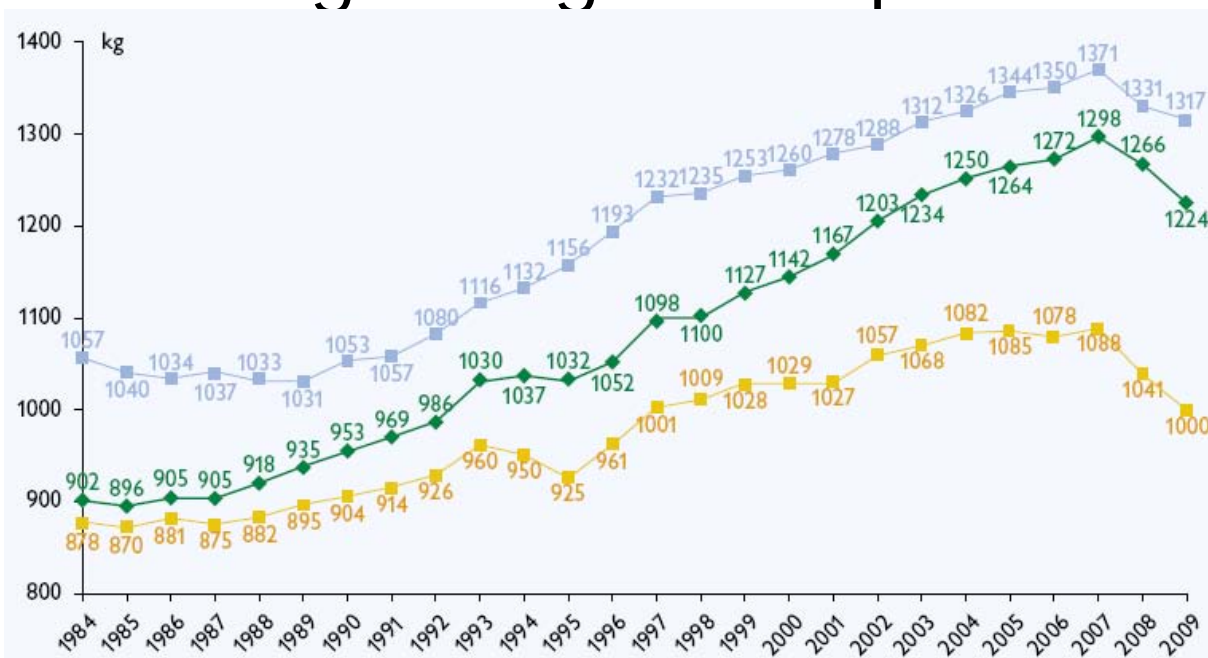
- 2001–2007 avg. reduction new vehicle CO₂ = 1 g/km per year
- 2008: emissions drop 9 g/km and 2009 by 7 g/km, Ministry of Transport attributes to introduction of bonus/malus system



Source: Les véhicules particuliers en France (Ademe), March 2011

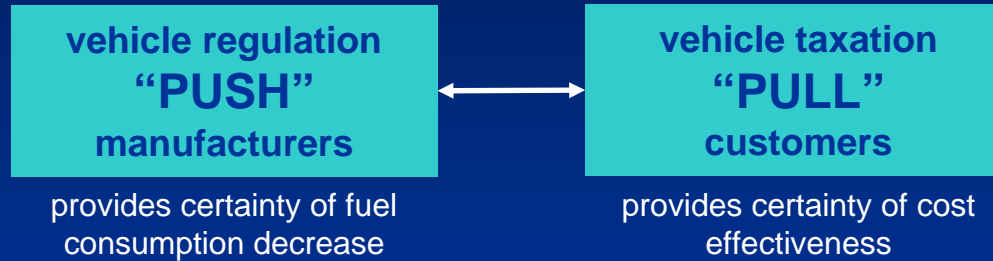
Impact on other characteristics

■ Average weight and power decreased fast



Source: Ademe

Feebate Vs. Fuel Economy Regulation?



Important Role of Complementary Policies

Today, At Least 16 Countries Have Some Form Of CO₂ Or Fuel Efficiency Tax On Light-duty Vehicles.

- New vehicle purchase or registration:
 - Austria, Canada, Finland, France, Ireland, Netherlands, Norway, Portugal, Spain, U.S.A.
- Annual or recurring registration fee:
 - Denmark, Germany, Ireland, Luxembourg, Portugal, Sweden, UK
- Sources: N.A. Braathen, 2010. “Incentives for CO₂ Emission Reductions in Current Motor Vehicle Taxes”, ENV/EPOC/WPNEP/T(2009)2/FINAL, Environment Directorate, OECD, Paris.
- H. He and A. Bandivadekar, 2011. “A Review and Comparative Analysis of Fiscal Policies Associated with New Passenger Vehicle CO₂ Emissions”, ICCT, February.



CO₂ Labeling In Combination With CO₂ Tax

Thirteen VED bands

The figures on the coloured arrows (A-M) indicate the 13 ranges of emissions by g/km that correspond to levels of annual Vehicle Excise Duty (VED or Road Tax). Low carbon-emitting cars pay less tax. The lowest – Band A – pay no tax.

Make, model and engine details

The vehicle make, model, fuel type, engine capacity and transmission type are all listed. Together they determine the CO₂ emissions and running costs.

<h1>Fuel Economy</h1>		Low Carbon Car																											
<p>CO₂ emission figure (g/km)</p> <table><tr><td><=100</td><td>A</td></tr><tr><td>101-110</td><td>B</td></tr><tr><td>111-120</td><td>C</td></tr><tr><td>121-130</td><td>D</td></tr><tr><td>131-140</td><td>E</td></tr><tr><td>141-150</td><td>F</td></tr><tr><td>151-165</td><td>G</td></tr><tr><td>166-175</td><td>H</td></tr><tr><td>176-185</td><td>I</td></tr><tr><td>186-200</td><td>J</td></tr><tr><td>201-225</td><td>K</td></tr><tr><td>226-255</td><td>L</td></tr><tr><td>256+</td><td>M</td></tr></table>		<=100	A	101-110	B	111-120	C	121-130	D	131-140	E	141-150	F	151-165	G	166-175	H	176-185	I	186-200	J	201-225	K	226-255	L	256+	M	B 117 g/km	
<=100	A																												
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<p>Fuel cost (estimated) for 12,000 miles</p> <p><small>A fuel cost figure indicates to the consumer a guide fuel price for comparison purposes. This figure is calculated by using the combined drive cycle (urban and motorway) and average fuel price. Re-calculated annually, the current cost per litre is as follows – petrol 115p, diesel 131p and LPG 55p.</small></p>		£1,104																											
<p>VED for 12 months</p> <p><small>Vehicle excise duty (VED) or road tax varies according to the CO₂ emissions and fuel type of the vehicle.</small></p>		£35																											
<h2>Environmental Information</h2>																													
<p>A guide on fuel economy and CO₂ emissions which contains data for all new passenger car models is available at any point of sale free of charge. In addition to the fuel efficiency of a car, driving behaviour as well as other non-technical factors play a role in determining a car's fuel consumption and CO₂ emissions. CO₂ is the main greenhouse gas responsible for global warming.</p>																													
Make/Model: Low Carbon Car		Engine Capacity (cc): 1399																											
Fuel Type: Diesel		Transmission: 5 speed manual																											
<p>Fuel Consumption:</p> <table><tr><th>Drive cycle</th><th>Litres/100km</th><th>Mpg</th></tr><tr><td>Urban</td><td>5.4</td><td>52.3</td></tr><tr><td>Extra-urban</td><td>3.8</td><td>74.2</td></tr><tr><td>Combined</td><td>4.4</td><td>64.2</td></tr></table>				Drive cycle	Litres/100km	Mpg	Urban	5.4	52.3	Extra-urban	3.8	74.2	Combined	4.4	64.2														
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<p>Carbon dioxide emissions (g/km): 117 g/km</p> <p>Important note: Some specifications of this make/model may have lower CO₂ emissions than this. Check with your dealer.</p>																													
ACT ON CO₂		Department for Transport																											
		VCA																											

CO₂ emissions figure

The black arrow points to the vehicle's relevant band of CO₂ emissions on which Vehicle Excise Duty (VED or Road Tax) is based.

Running costs

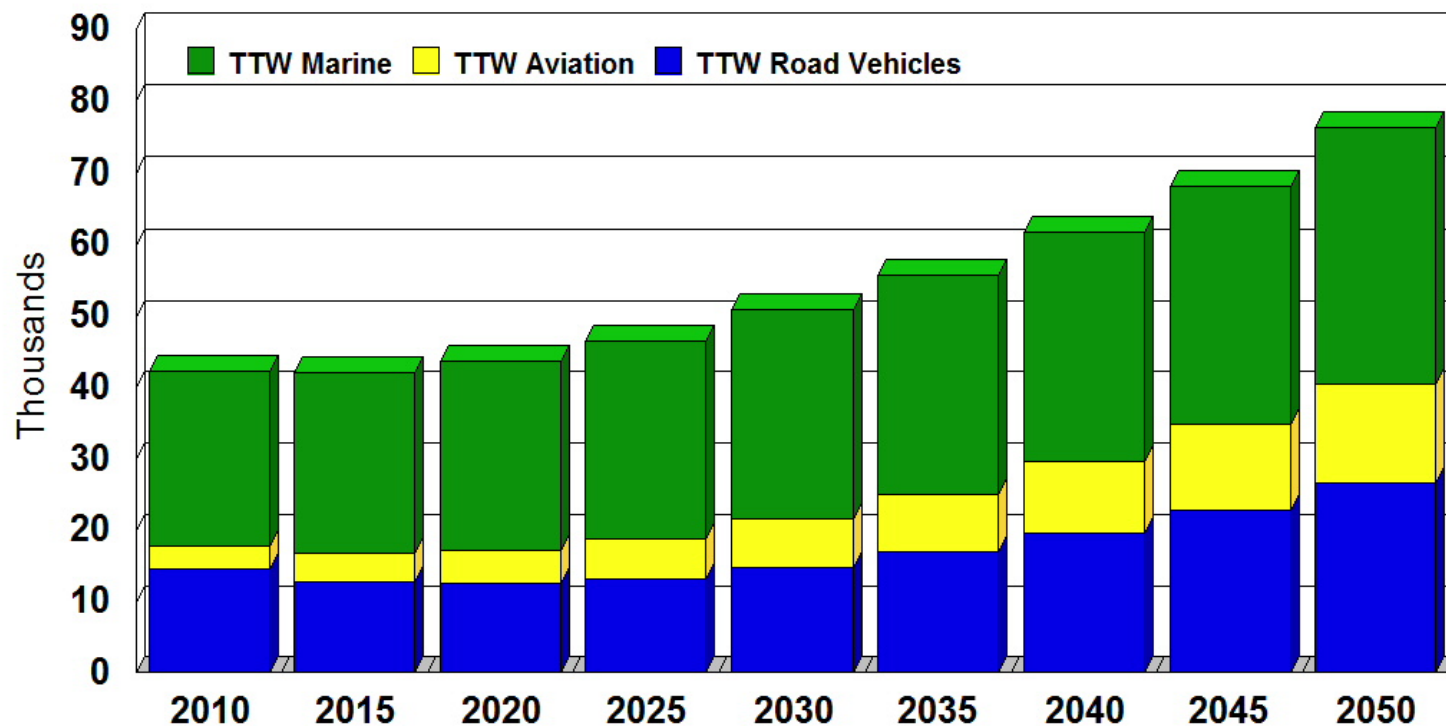
Average yearly fuel costs are calculated and displayed together with the relevant level of Road Tax. Figures updated with recent prices.

Fuel consumption

Shows how efficient the car is in miles per gallon and litres per 100km in town, country and combined driving situations.

Global Emissions Forecast for the Transportation Sector (kT)

Nitrogen Oxides



Bellagio Principles Should Guide Policymakers

- Design Programs & Policies That Reduce Conventional, Toxic, Noise and Greenhouse Emissions in Parallel
- Treat Vehicles and Fuels As A System
- Expect & Require Best Technologies and Fuels Worldwide – in Both Industrialized and Developing Countries



Thank You

