Reconciling the Diesel Engine With the Environment:
A Comprehensive Approach

Highway

Tier 2
Light-duty
(1999)

2007/2010
Heavy-duty
(2001)

Common Aspects--

- Systems approach– fuel change enables clean technologies
- Large environmental benefits
- Responsive to needs of States to meet air quality goals
- Collaborative process

Nonroad

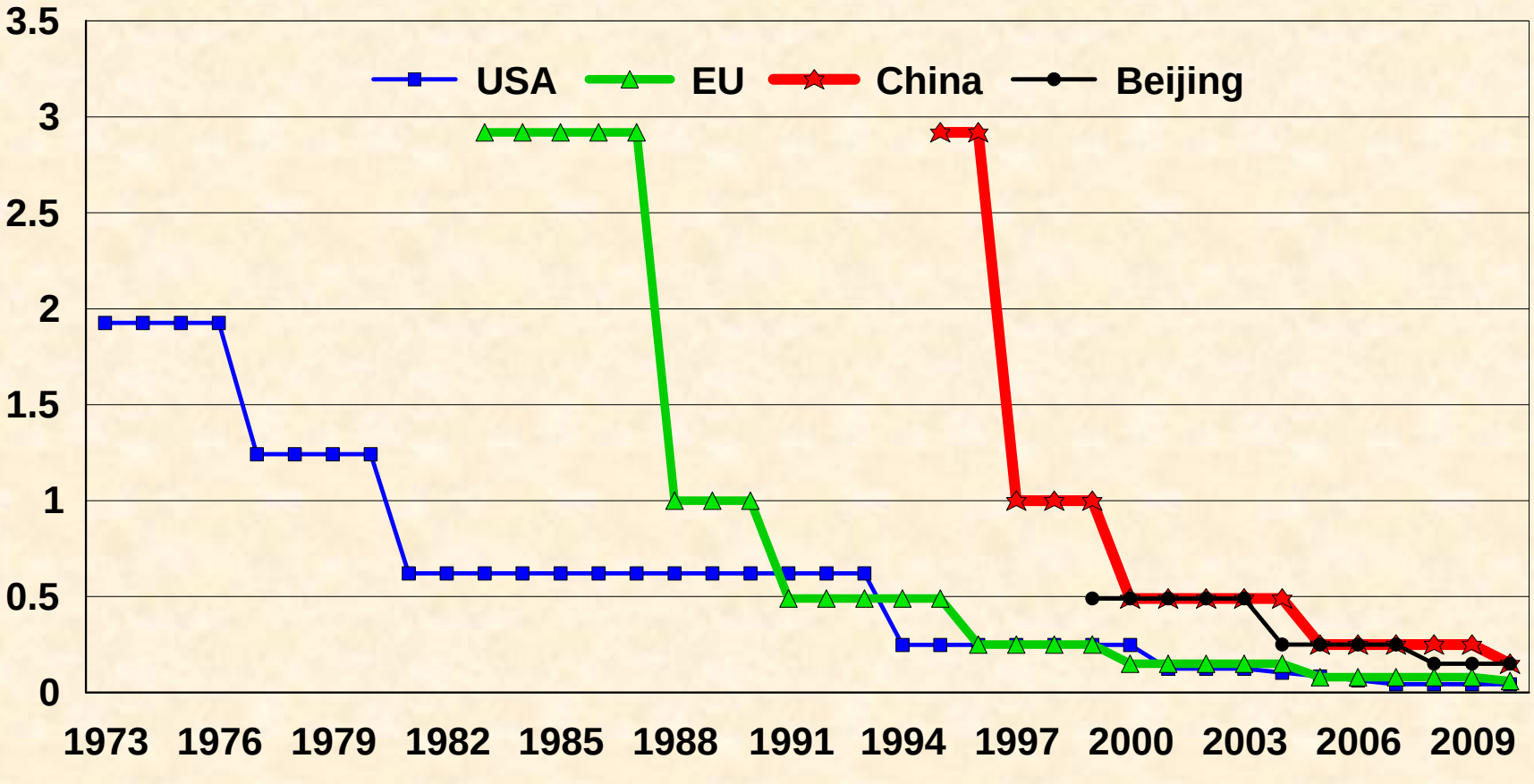
Tier 4 diesel (2004)

Locomotive/Marine

Trends in Passenger Car Exhaust Emissions Standards

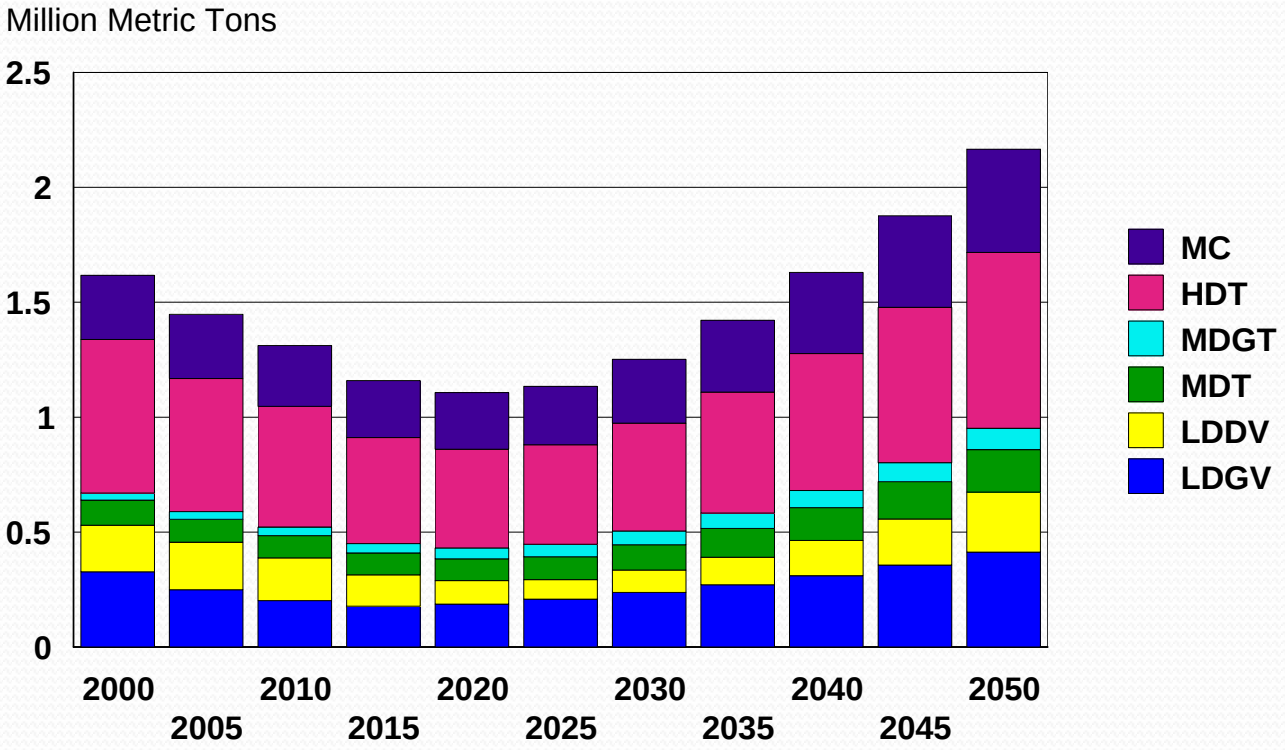
NOx Emissions Standards

Grams/Kilometer



Particulate Emissions By Road Vehicle Type

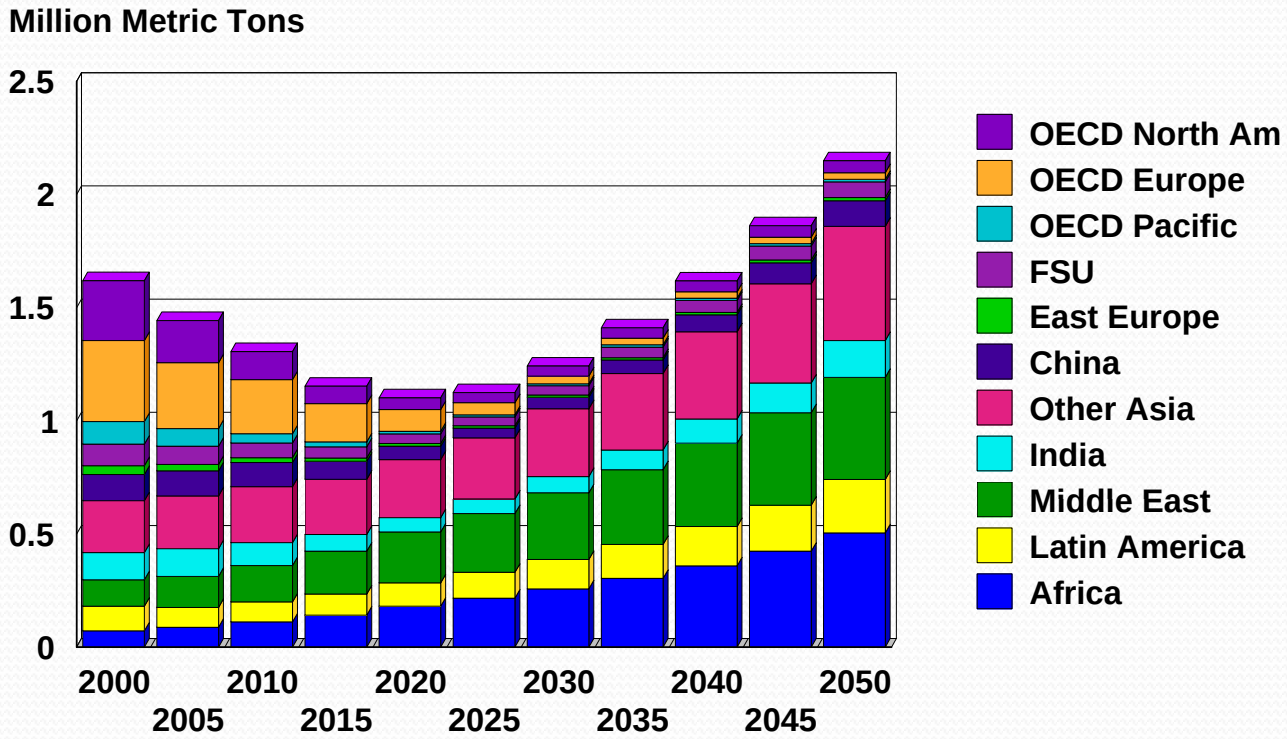
Base Case



Road Vehicle Emissions By Country

Particulate Matter

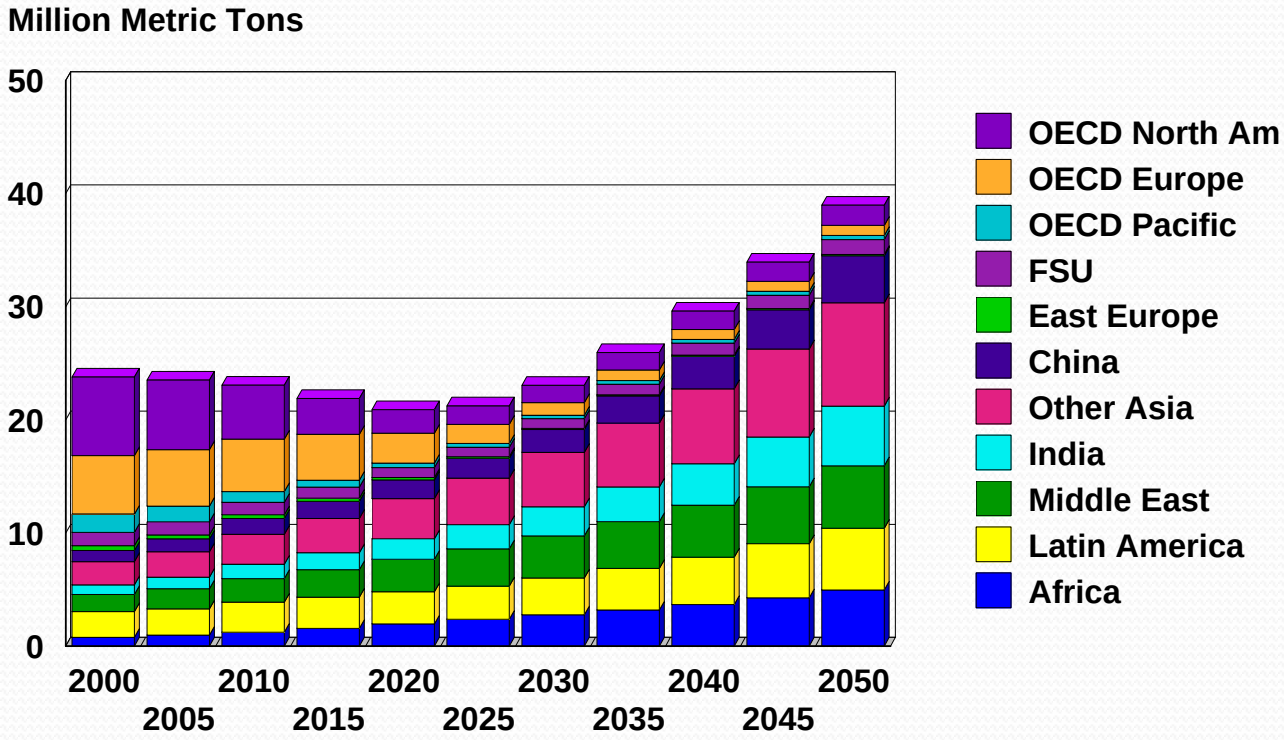
Base Case



Road Vehicle Emissions By Country

Nitrogen Oxides

Base Case



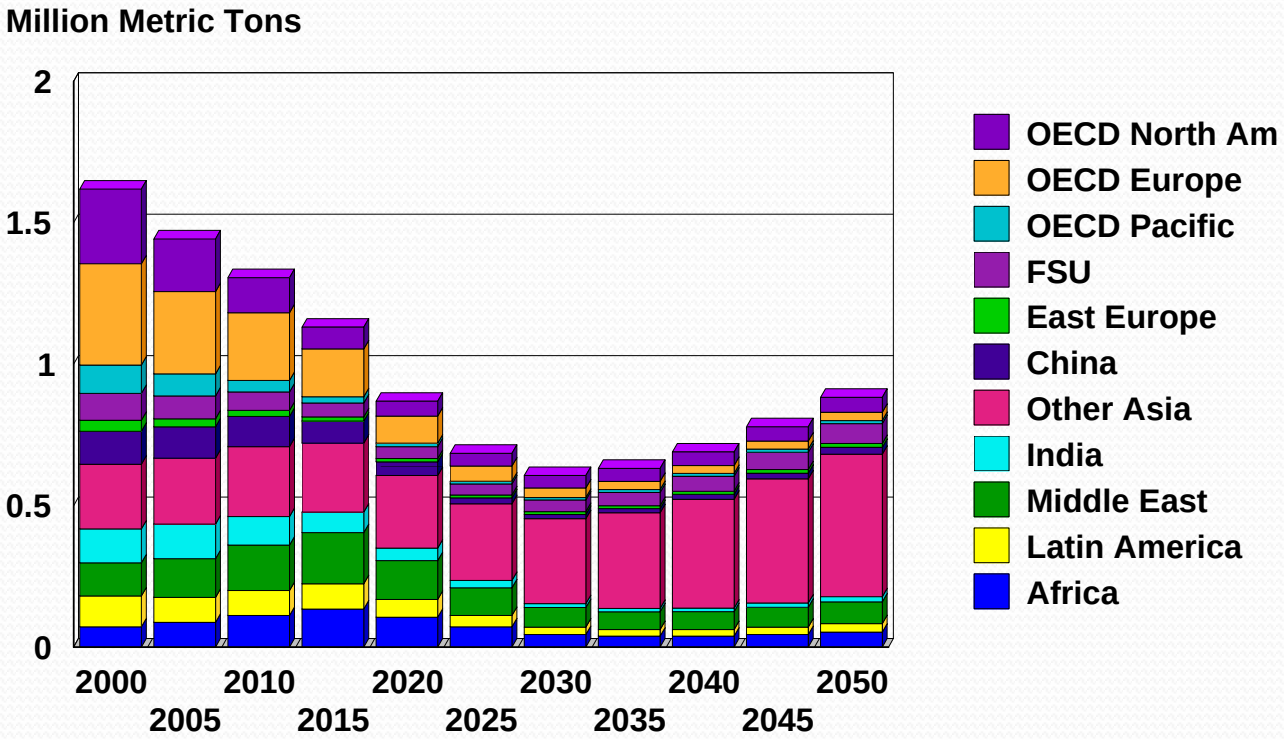
Targets of Opportunity

- China 2015 Euro 6 & Euro VI
- India 2015 Euro 6 & Euro VI
- Brazil 2015 Euro 6 & Euro VI
- Africa 2015 Euro 4& Euro IV, MC Euro 3
- Middle East 2015 Euro 4 & Euro IV, MC Euro 3
- Latin America 2015 MC Euro 3

Road Vehicle Emissions By Country

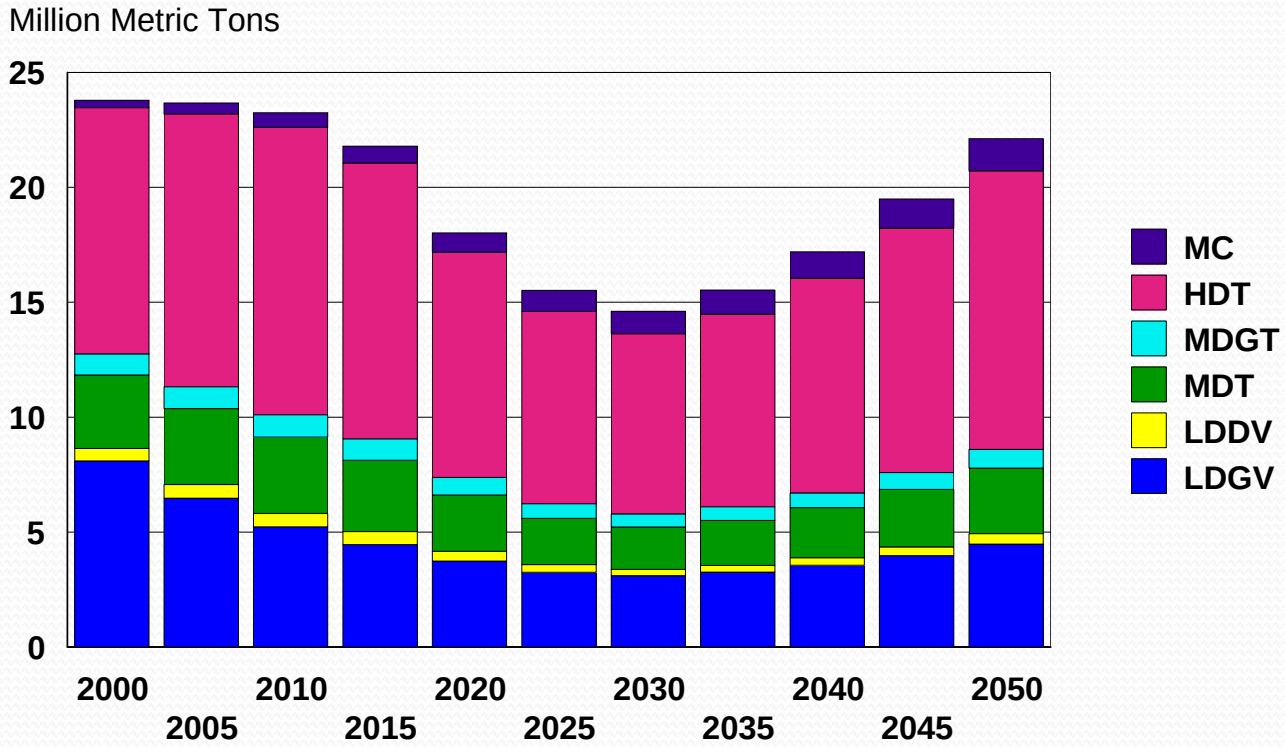
Particulate Matter

Tight Standards Case

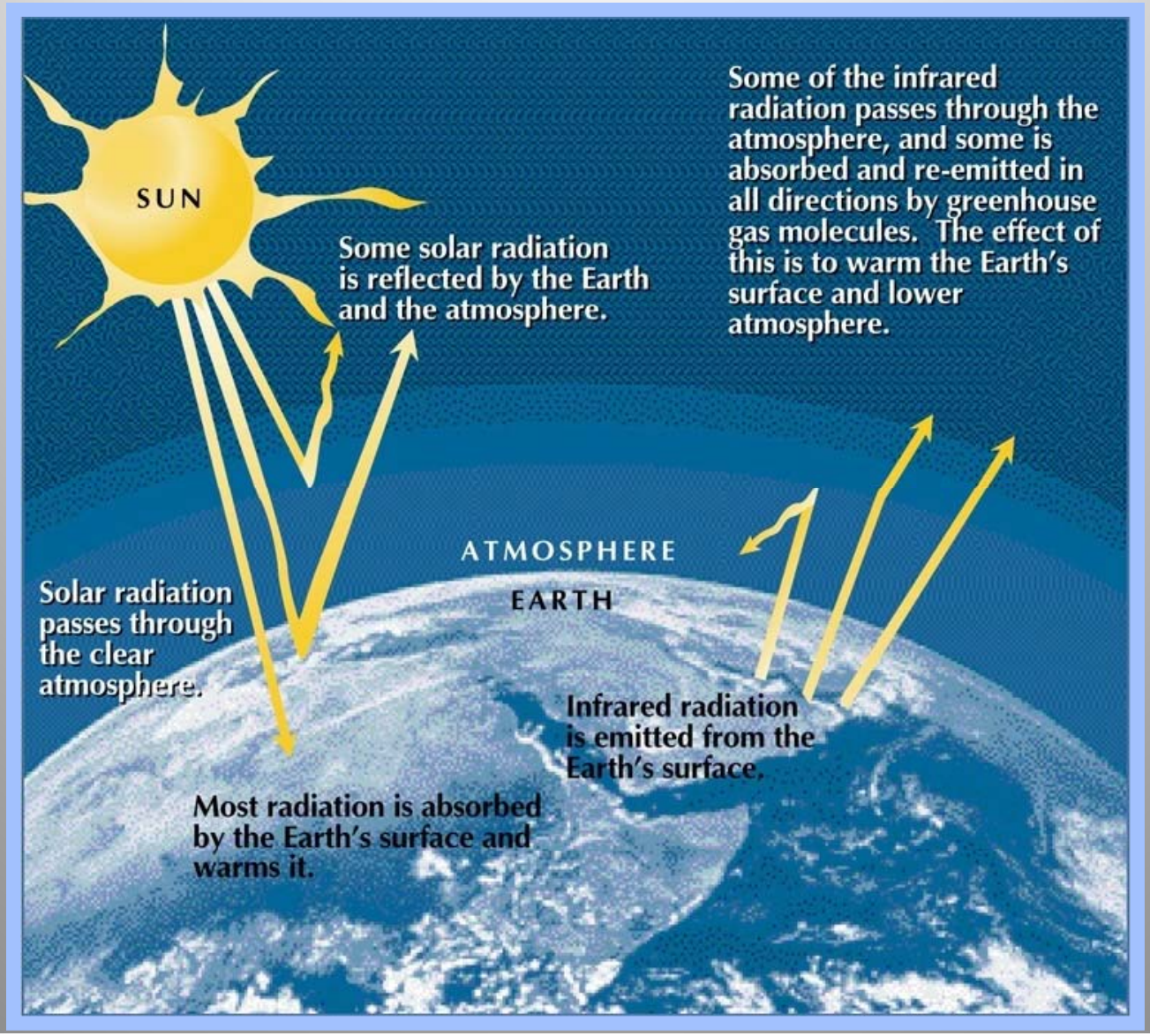


Nitrogen Oxide Emissions By Road Vehicle Type

Tight Standards Case

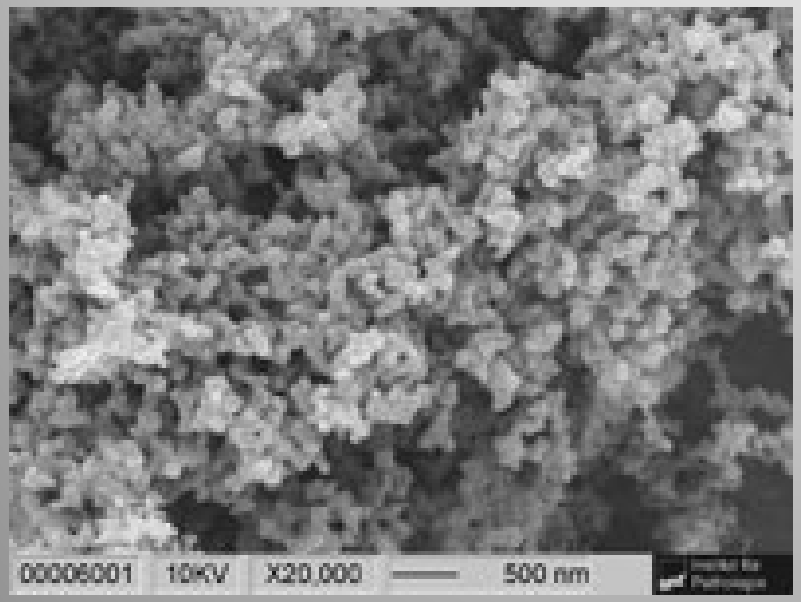


The Greenhouse Effect



Relative Albedo

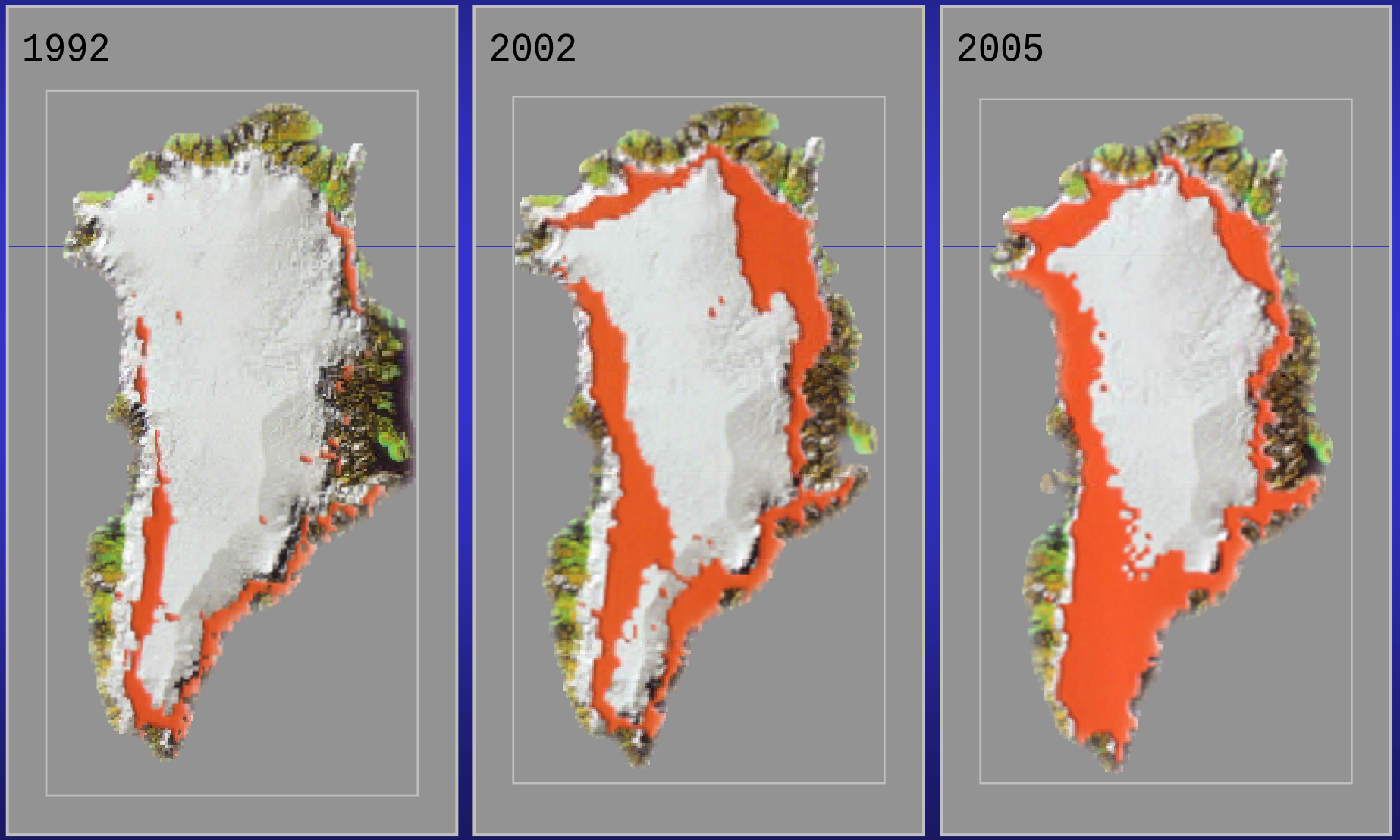
Measured from 0.00 (dark) to 1.00 (bright)



Black Carbon = 0.04

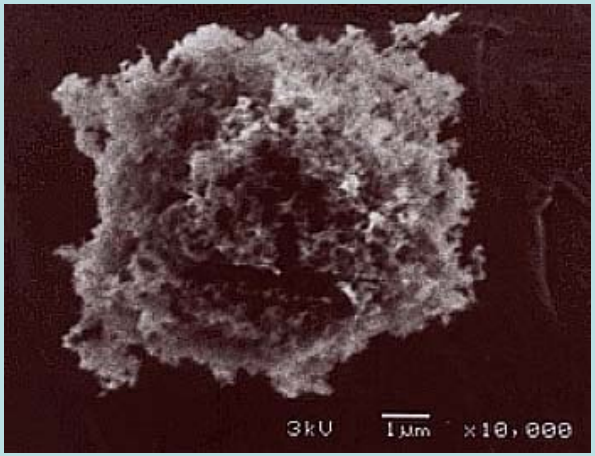
Fresh Snow = 0.9

Impacts Appear To Be Accelerating



What is Black Carbon?

- BC = light absorbing carbonaceous particles formed during incomplete combustion
  - "quasi-graphitic" - includes char, charcoal, tarry matter, soot
  - may be called elemental carbon (EC), C_{soot}, C_{brown}
- Part of fine particulate matter
  - Less than 1 micron in diameter
- Co-emitted with other pollutants
  - CO2, CO, OC, SOx, NOx, etc.
- Part of total aerosols
  - Including sulfates, nitrates, organic acids, sea salt, dust

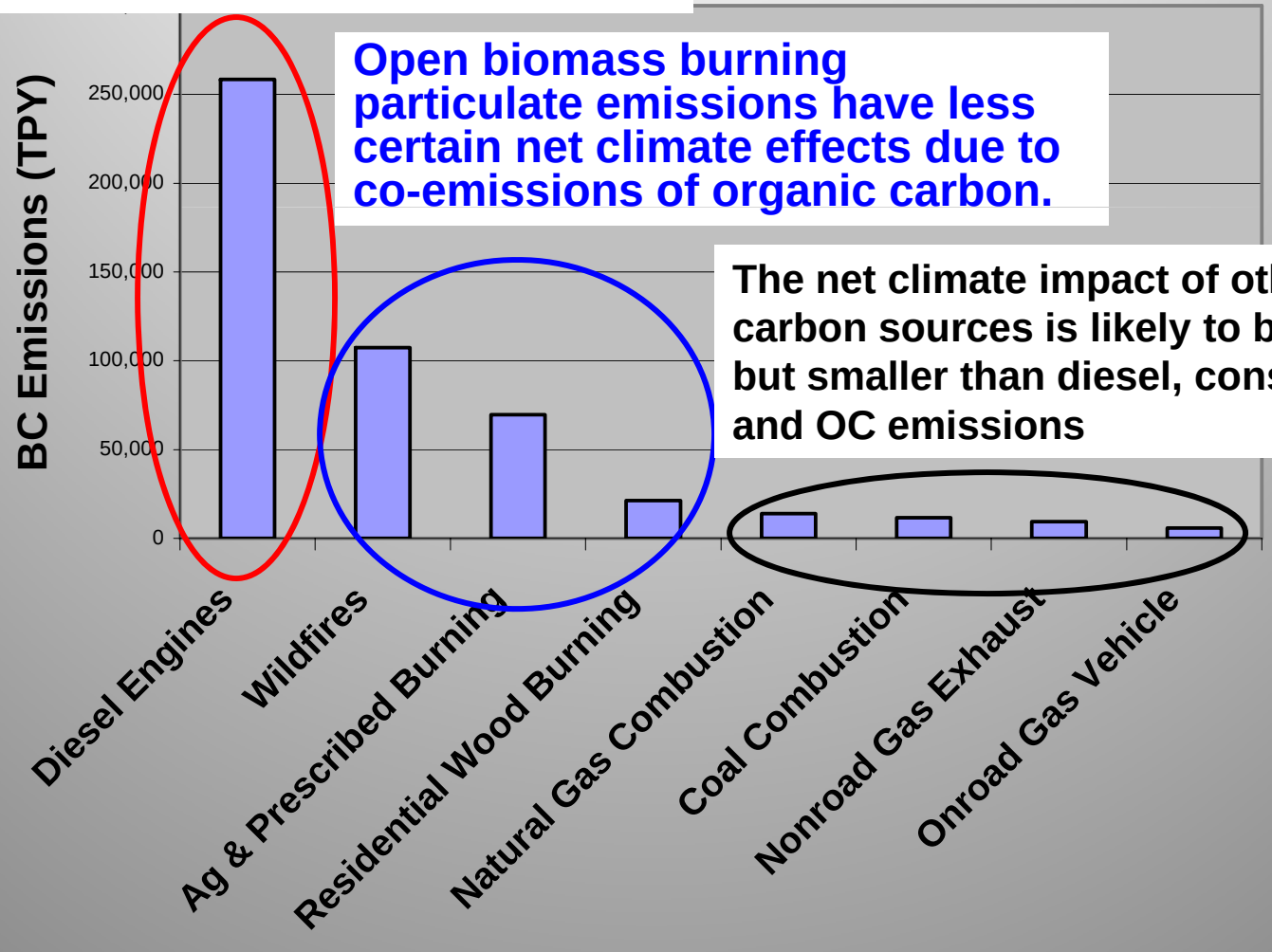


U.S. Black Carbon Emissions, 2002

In the United States, diesel engines particulate emissions have the strongest warming impact due to large BC and small OC emissions

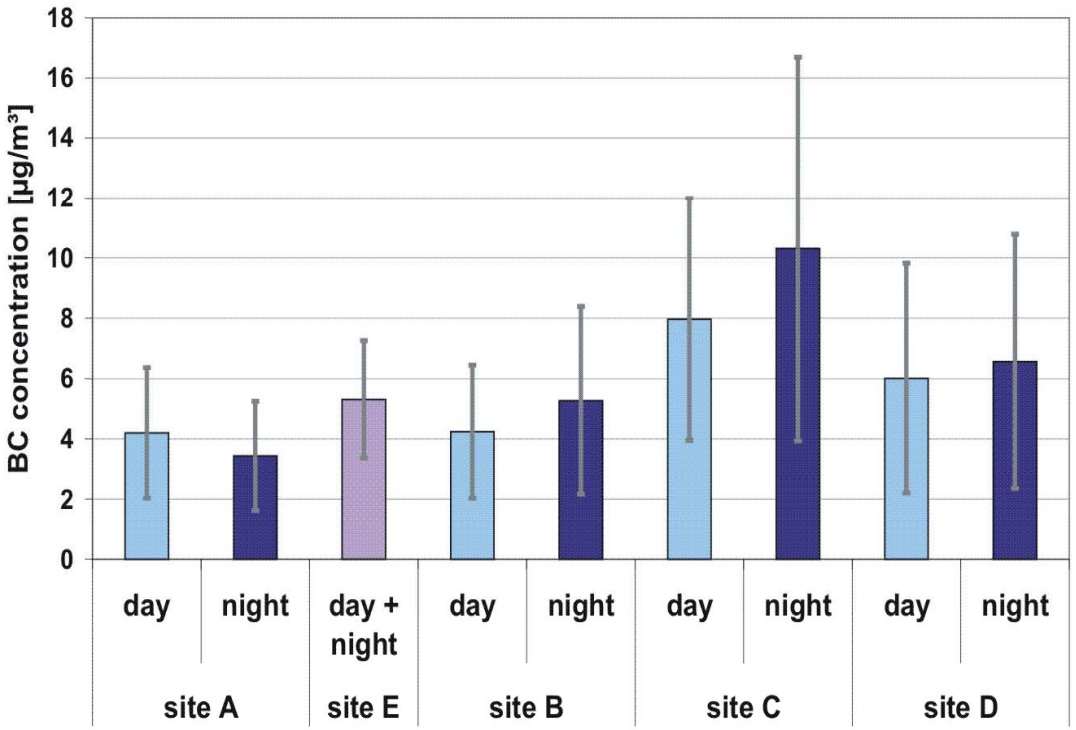
Open biomass burning particulate emissions have less certain net climate effects due to co-emissions of organic carbon.

The net climate impact of other black carbon sources is likely to be warming, but smaller than diesel, considering BC and OC emissions



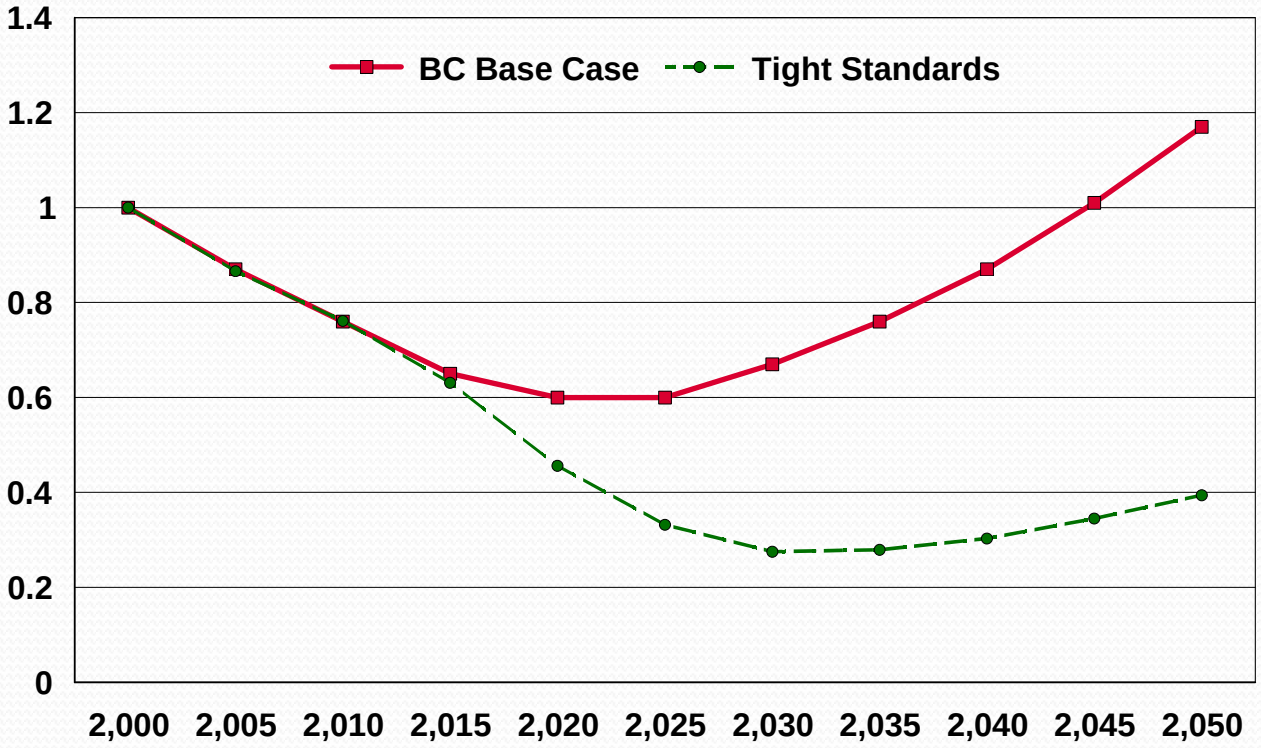
Average BC concentrations for site A to D for the sampling period from August 2005 to August 2007.

- For the majority of the sampled weeks, night samples showed higher BC concentrations than day samples. This observation could be explained by the regulation, that lorries are only allowed to drive during night time in most parts of Beijing.

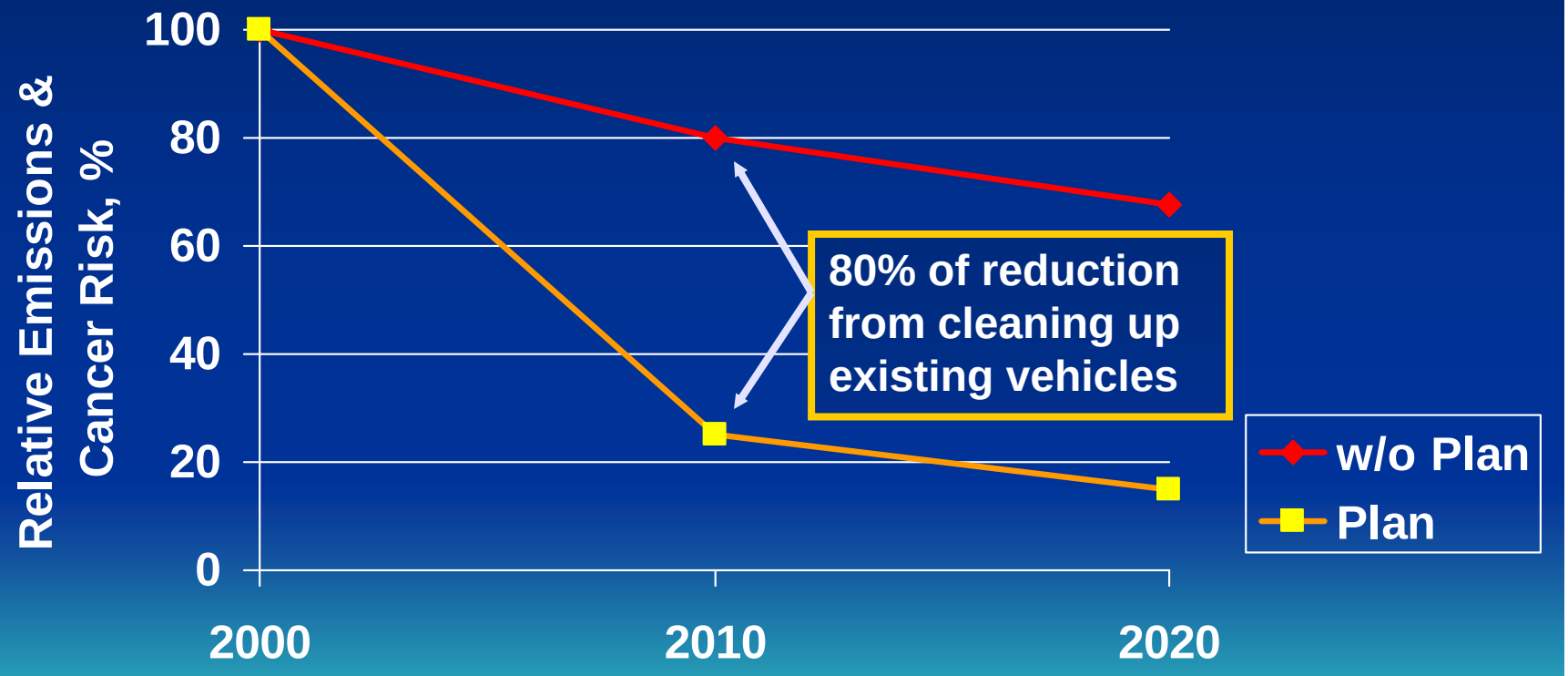


Global Trends in On Road Vehicle Black Carbon Emissions

Normalized to 2000



Importance of Cleaning Up In-use Diesels



Particulate Filters Being Applied To Various Types of Vehicles

Small tractor

Long haul
heavy-duty truck

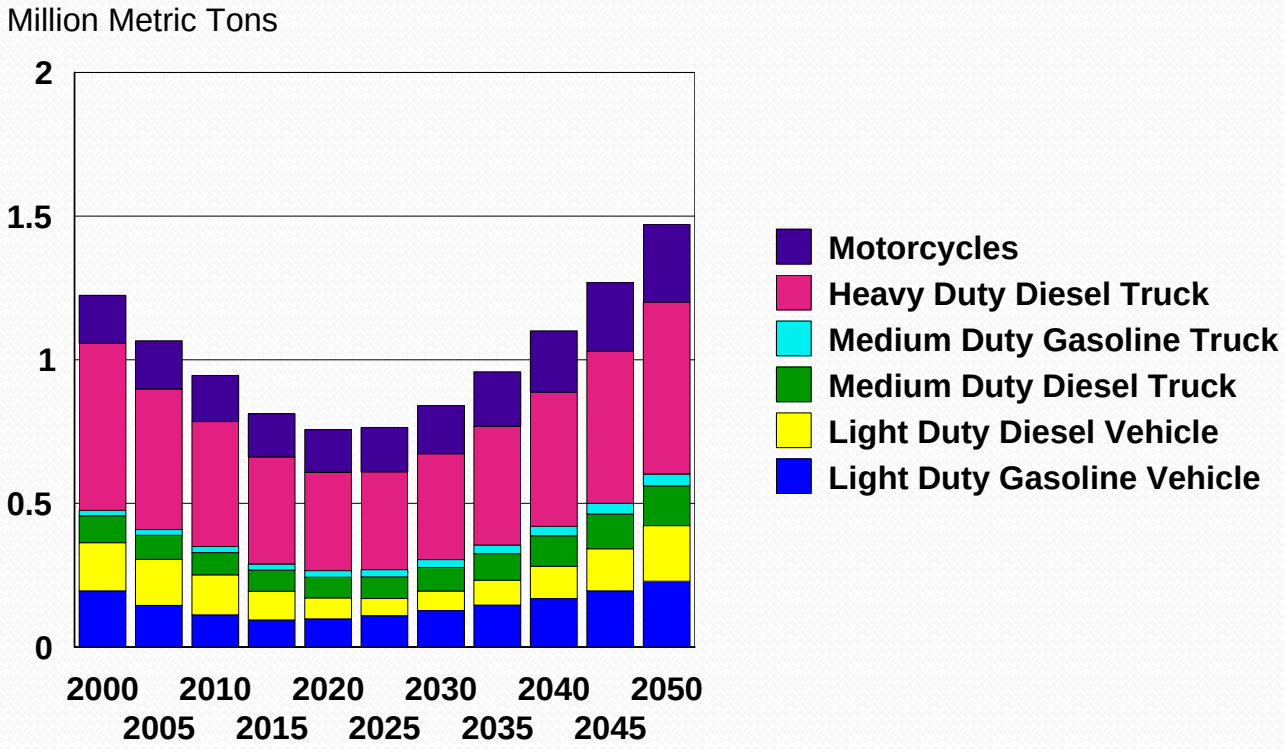
School bus

Port equipment

Earth mover

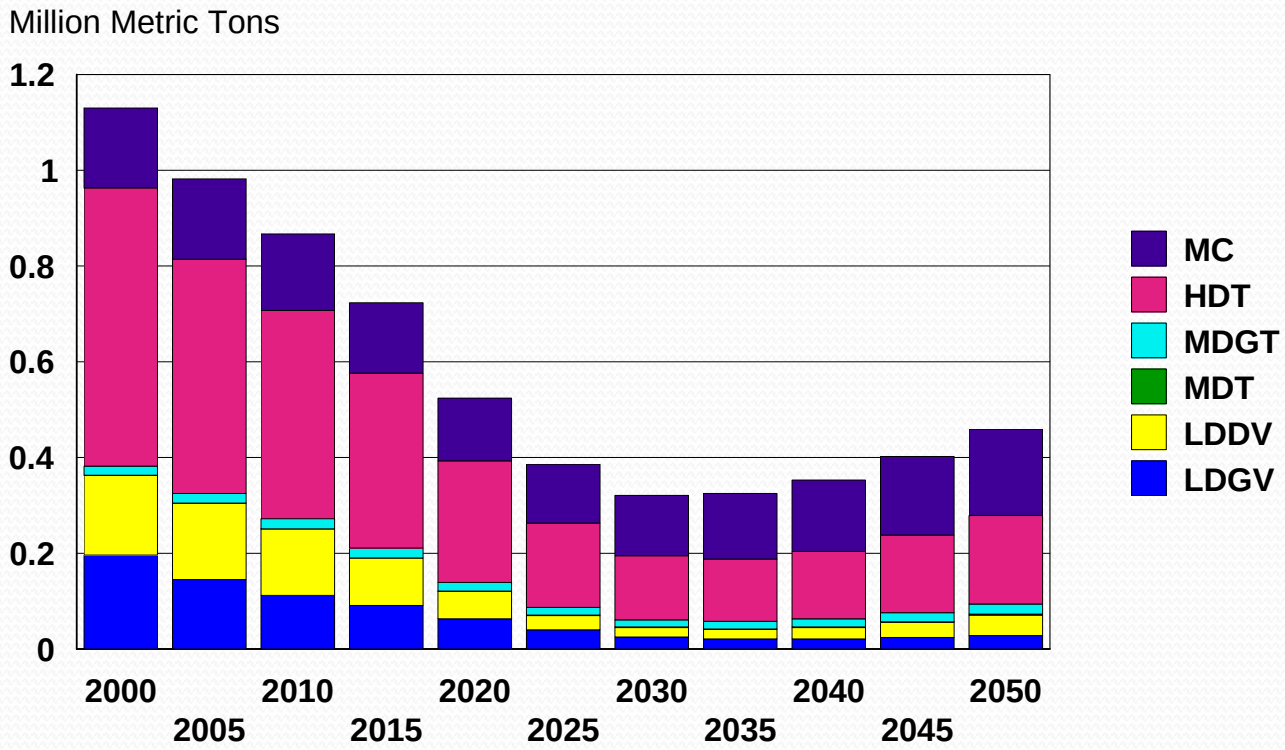
Black Carbon Emissions By Road Vehicle Type

Base Case



Black Carbon Emissions By Road Vehicle Type

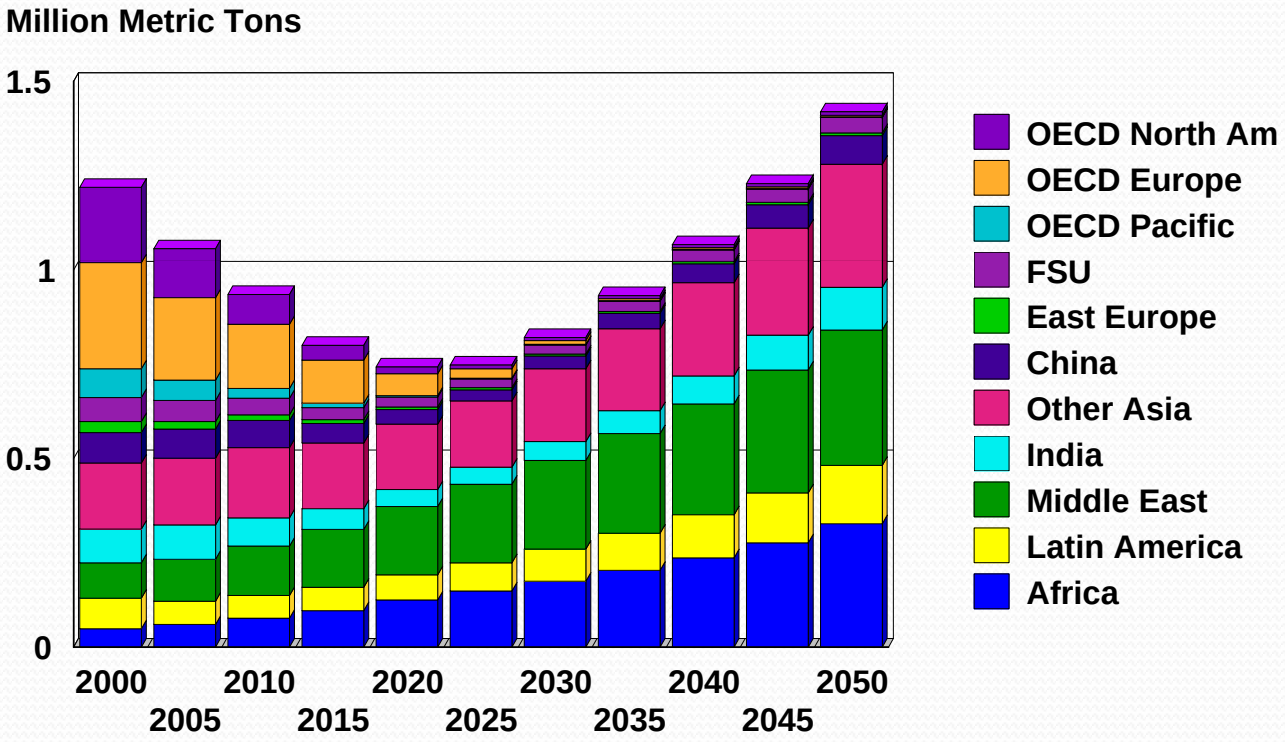
Tight Standards Case



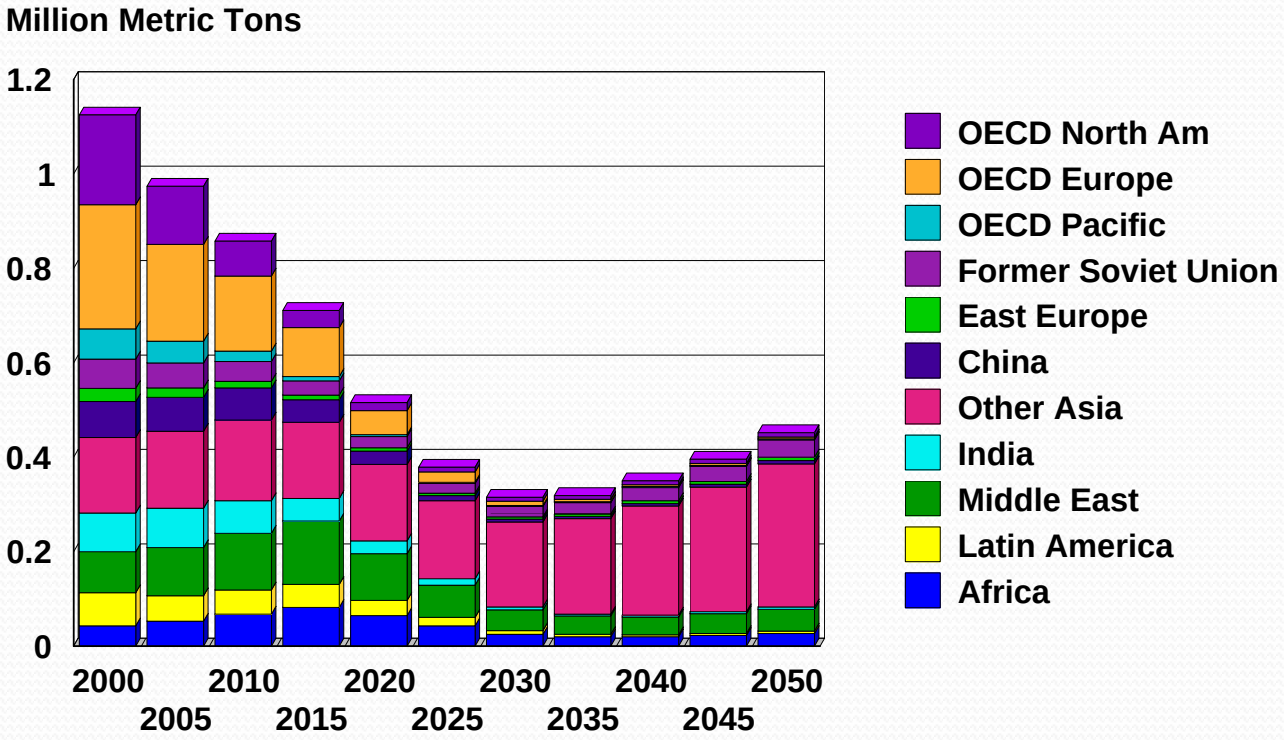
Road Vehicle Emissions By Country

Black Carbon

Base Case

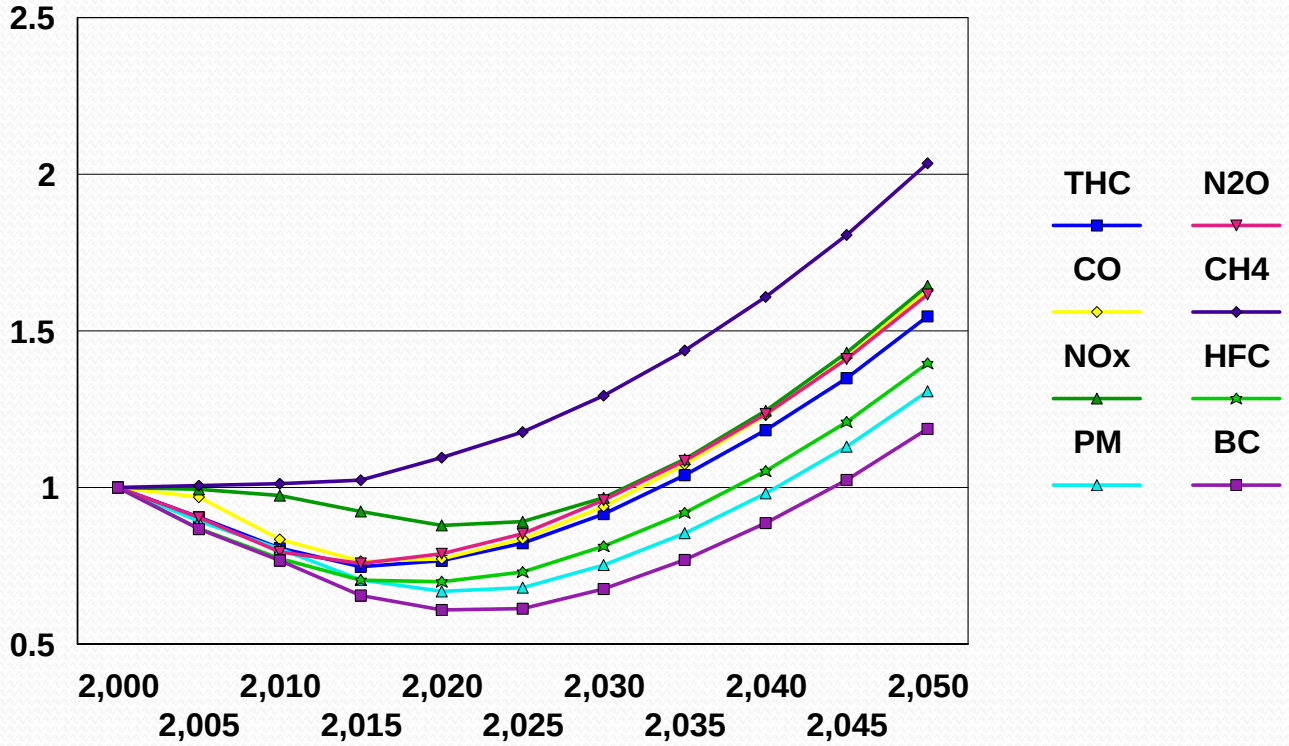


On Road Black Carbon Emissions
Tighter Standards Case

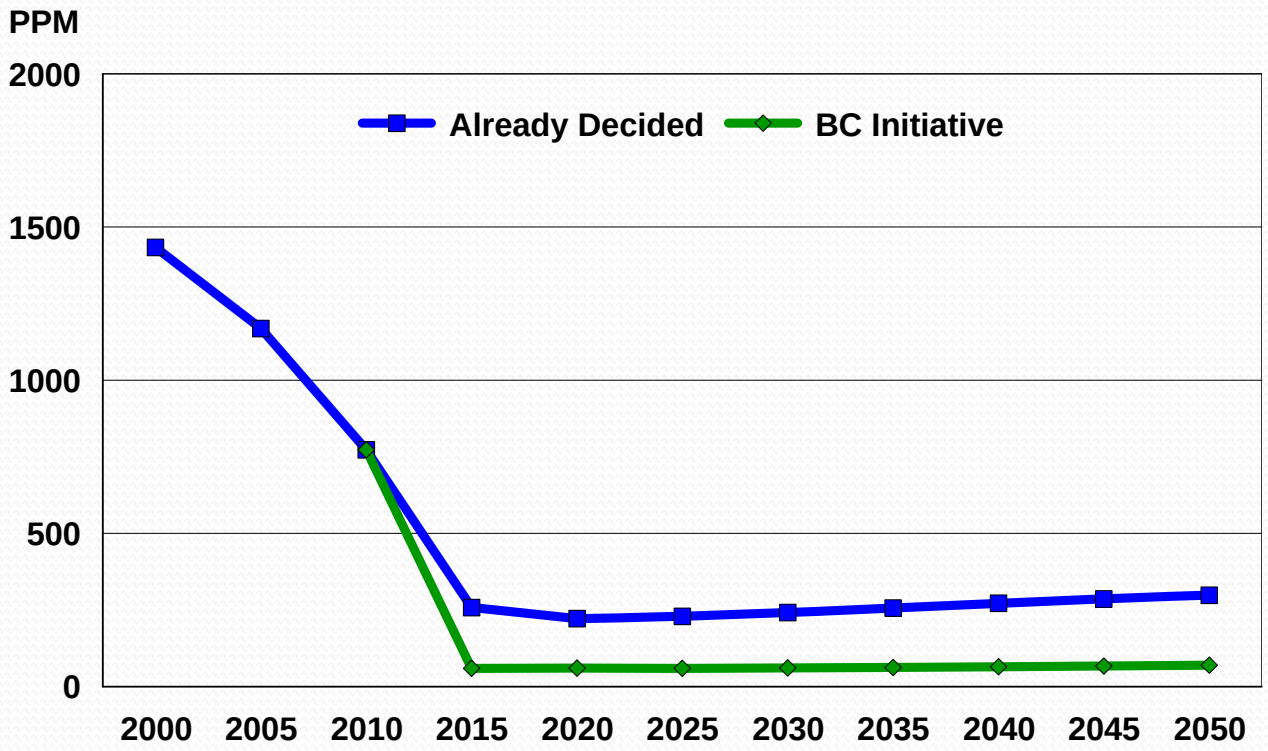


Global Trends in On Road Vehicle Emissions

Normalized to 2000

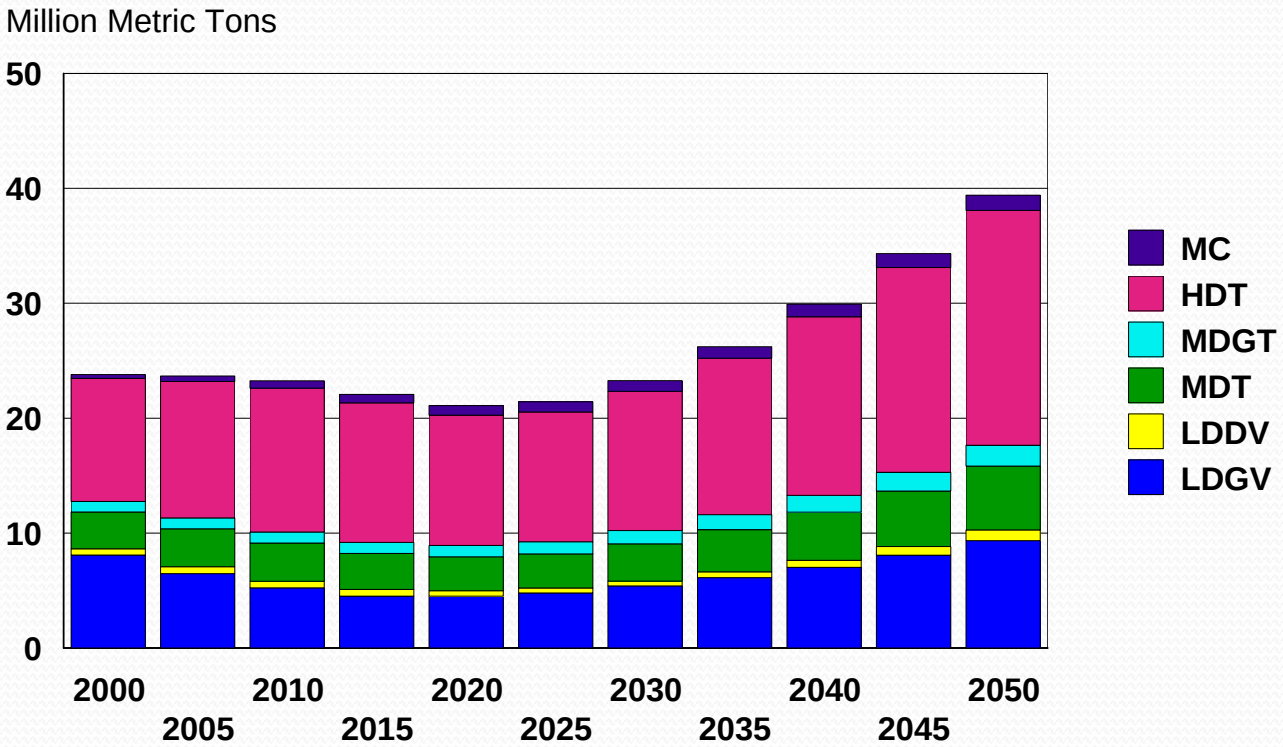


Average Global Sulfur Levels in Diesel Fuel



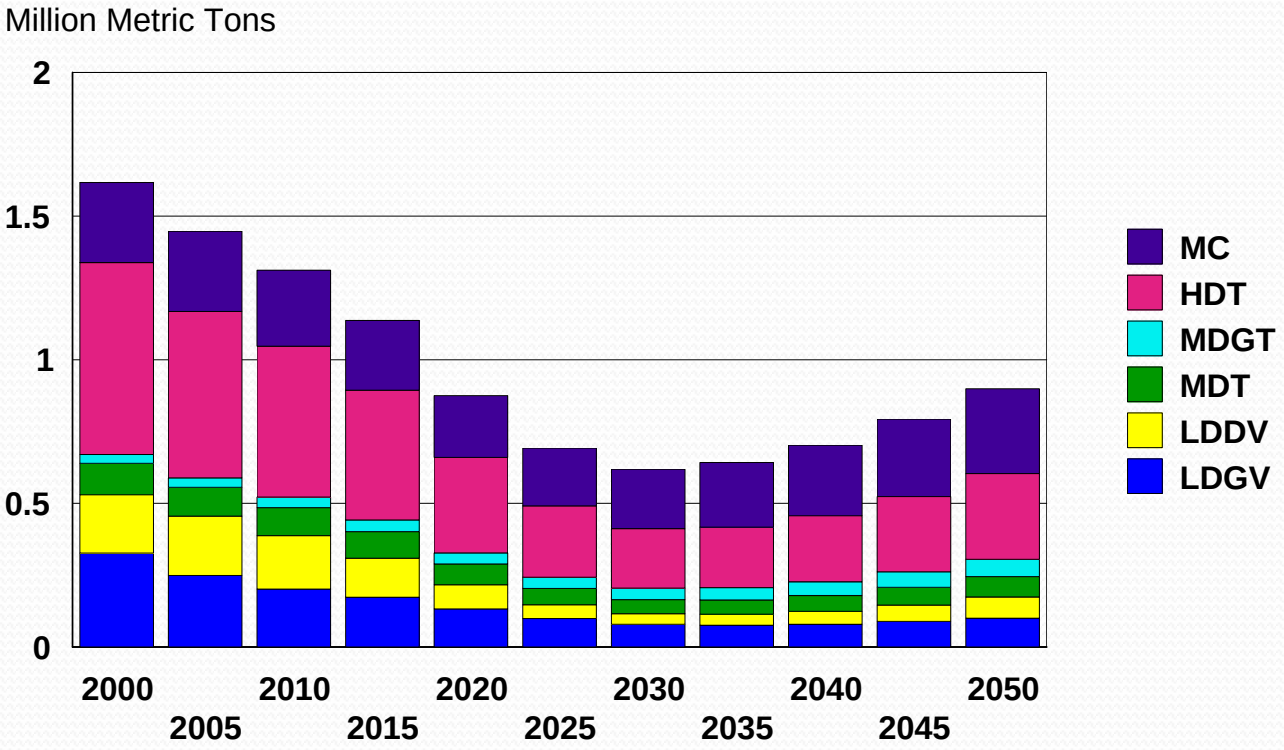
Nitrogen Oxide Emissions By Road Vehicle Type

Base Case



Particulate Emissions By Road Vehicle Type

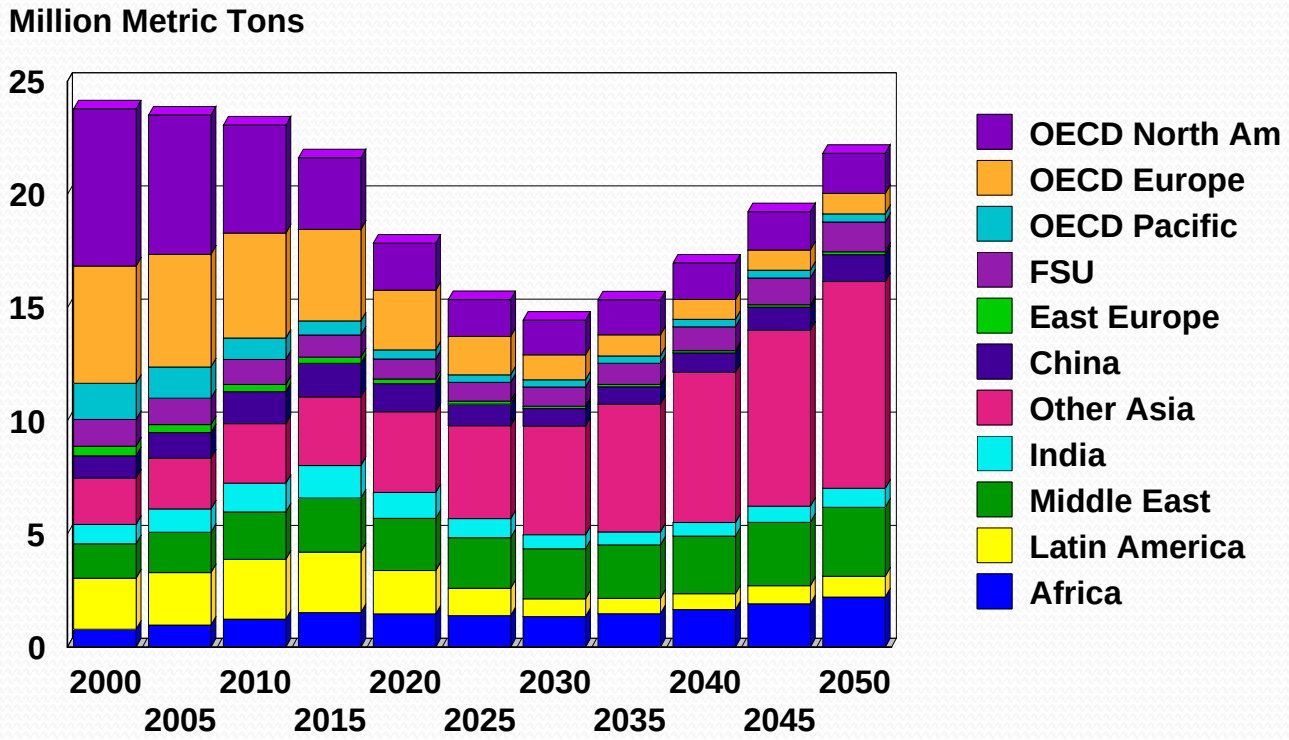
Tight Standards Case



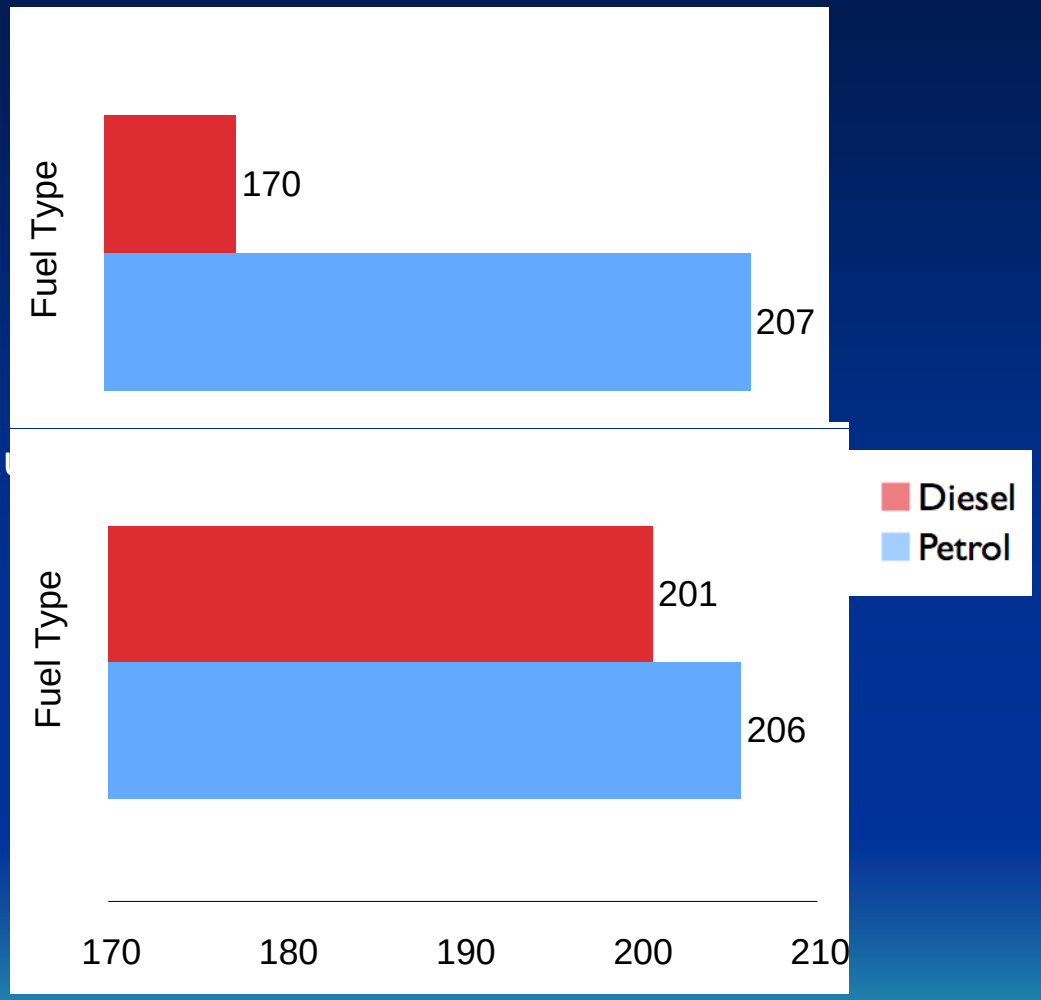
Road Vehicle Emissions By Country

Nitrogen Oxides

Tight Standards Case



Black Carbon Reduces Diesel Benefit

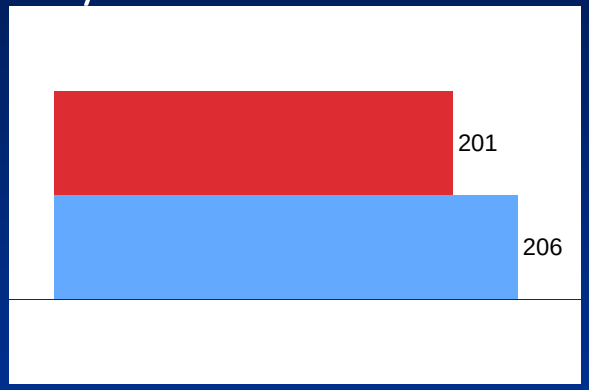


Source: ICCT Analysis

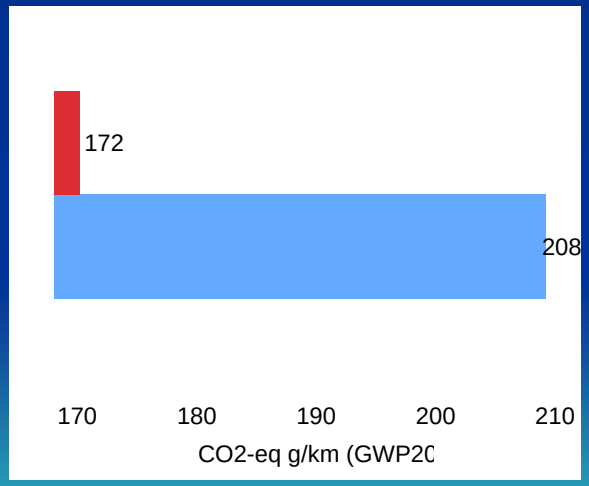
Results are preliminary and have not yet been reviewed by ICCT participants.

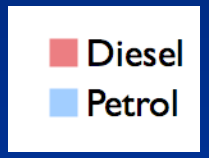
Emission Controls Enhance Diesel Benefit

Euro 3/4 Diesel without DPF vs Petrol



Diesel with DPF vs Petrol





Benefit

2%

17%

Source: ICCT Analysis

Results are preliminary and have not yet been reviewed by ICCT participants.