

International response to black carbon science: Implications for transport policy in developing and developed countries

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Key Messages

- ✦ BC science suggests diesel engines are a major contributor to health and climate impacts
- ✦ International transport policy has responded with a set of best practices for addressing these impacts
- ✦ These best practices are:
 - ✦ Require all new diesel engines to meet Euro 6/VI, US 2010, Tier 3 or equivalent emission standards
 - ✦ Cap diesel fuel sulfur content at 10 parts per million
 - ✦ Target and replace high emitting diesel engines
- ✦ These actions will significantly reduce the health impacts of vehicle emissions exposure and reduce near-term climate change

What scientific studies have informed BC transport policy?

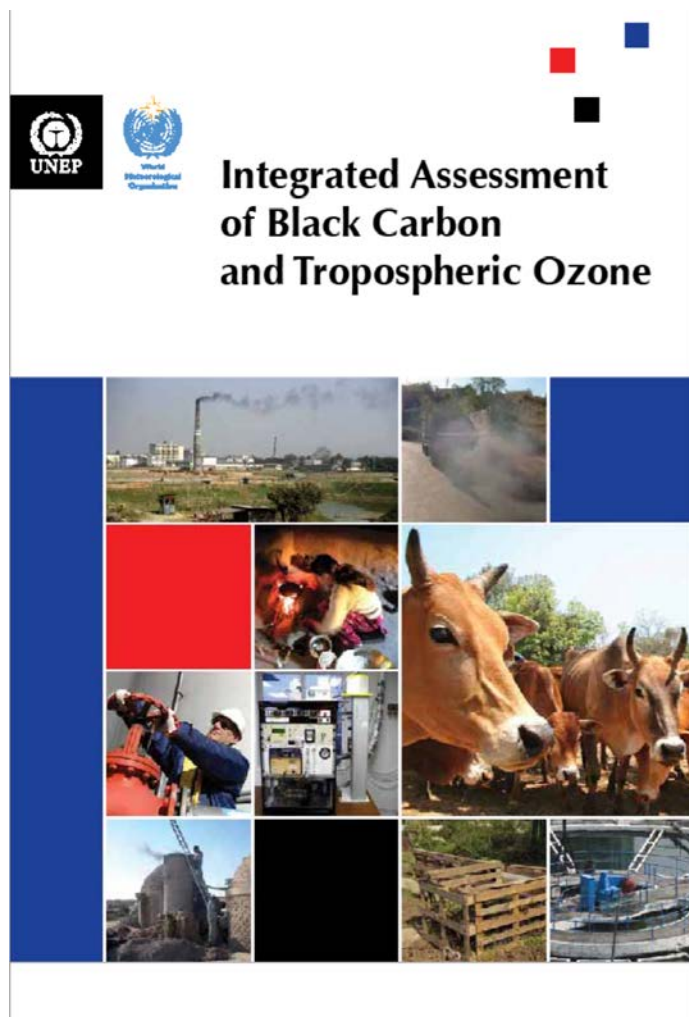
Alternative Scenario (Hansen et al, 2000)



“Concievably a reduction of climate forcing by 0.5 W/m^2 or more could be obtained by reducing **black carbon emissions from diesel fuel and coal.**”

“ If the World Bank were to support investments in modern technology and air quality control in **India** and China, for example, the reductions in tropospheric ozone and **black carbon** would not only improve local health and agricultural productivity but also benefit global climate and air quality.”

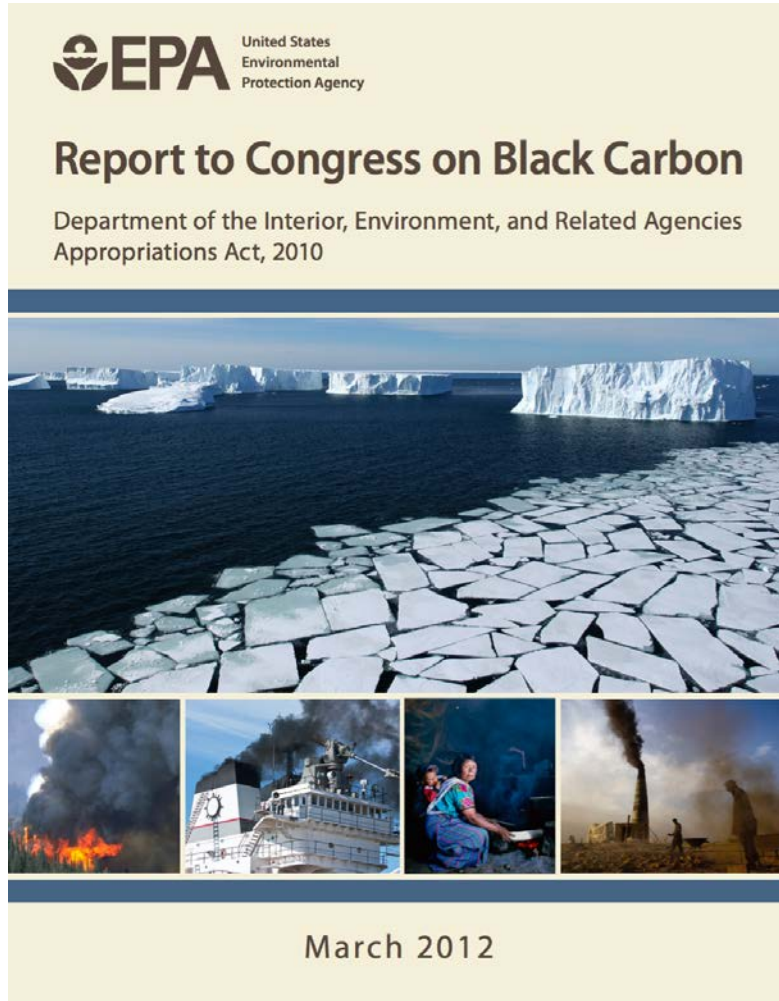
UNEP Integrated Assessment of Black Carbon and Tropospheric Ozone (Shindell et al, 2011)



Diesel BC measures
among 16 total measures to
reduce radiative forcing
from short-lived substances

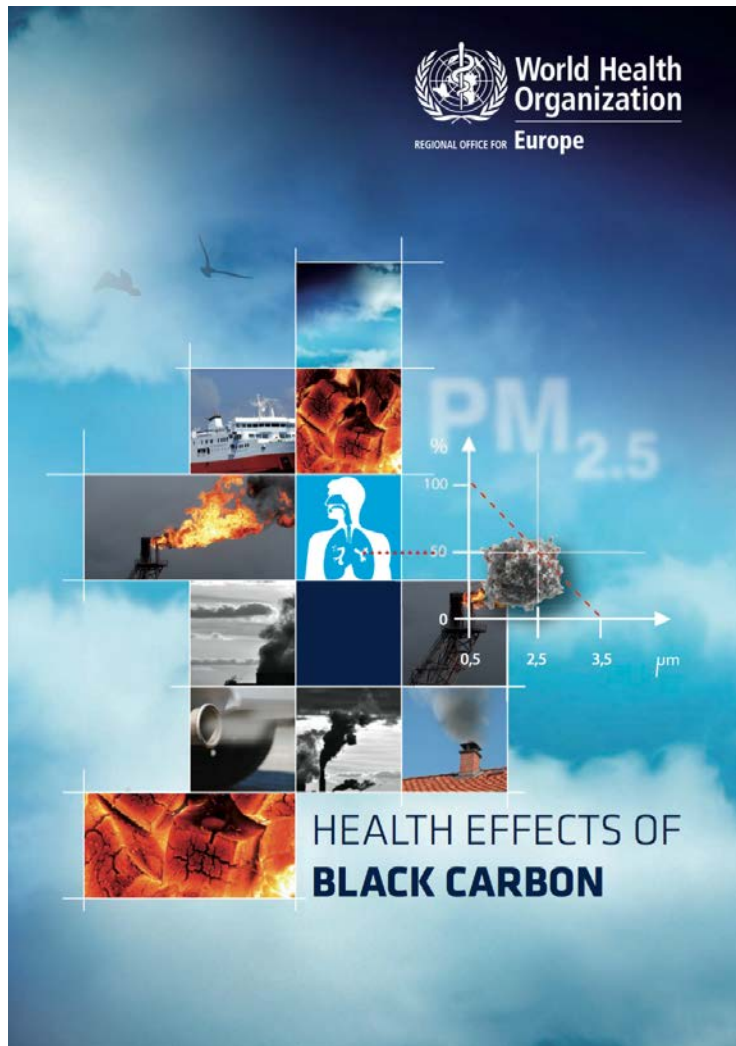
1. Diesel particulate filters
as part of a Euro 6/VI
package for road and off-
road diesel vehicles
2. Elimination of high-
emitting vehicles in on-road
and off-road transport

US EPA Report to Congress on Black Carbon (2012)



“The most important BC emissions reduction opportunities globally include residential cookstoves in all regions; brick kilns and coke ovens in Asia; and mobile diesels in all regions. “

WHO Report on Health Impacts of Black Carbon (2012)

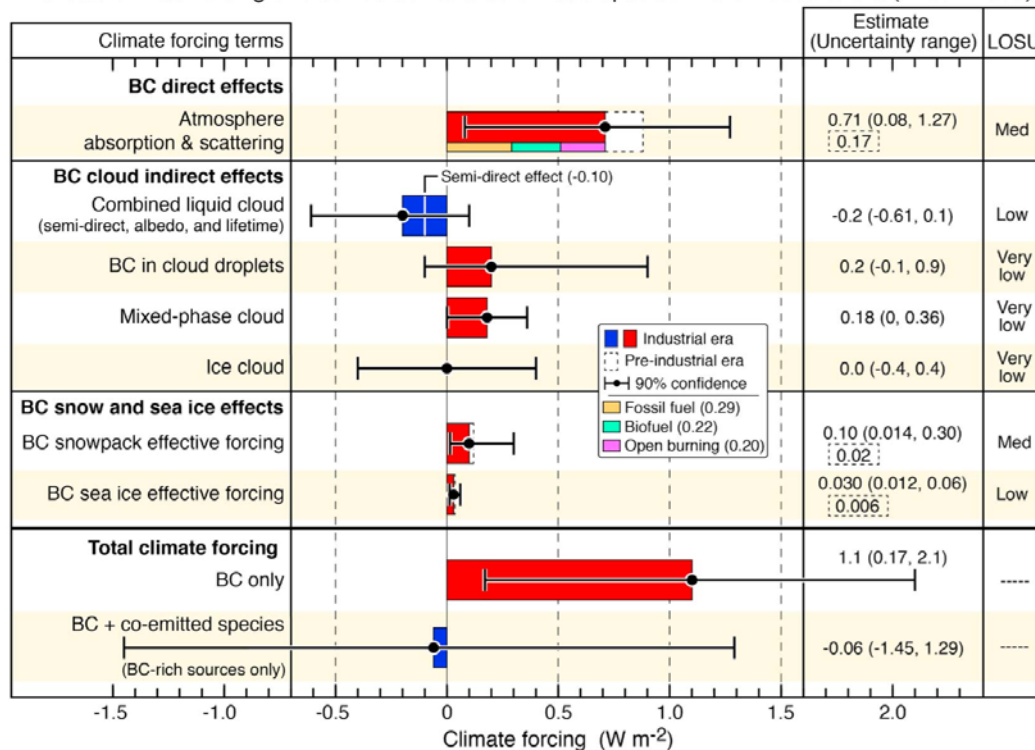


“BC may not be a major directly toxic component of fine PM, but it may operate as a universal carrier of a wide variety of chemicals of varying toxicity..”

“...removing particulates with a modern diesel particle trap ...resulted in a complete absence of cardiovascular effects.”

Bounding the Role of Black Carbon in the Climate System (Bond et al, 2013)

Global climate forcing of black carbon and co-emitted species in the industrial era (1750 - 2005)



“We estimate that **black carbon**, with a total climate forcing of **+1.1 W m²**, is the **second most important human emission in terms of its climate forcing** in the present-day atmosphere”

“**Diesel sources of BC appear to offer the most promising mitigation opportunities** in terms of near-term forcing and maturity of technology and delivery programs.”

What has been the international policy response?

International Maritime Organization Adopts Research Plan on Black Carbon (2011)



“...ship emissions of black carbon and other particulate matter affecting the Arctic region need to be addressed specifically as an integral part of the Organization's work on prevention of air pollution from ships and its contribution to combat climate change and global warming.”

- 60th Meeting of the Marine Environmental Protection Committee

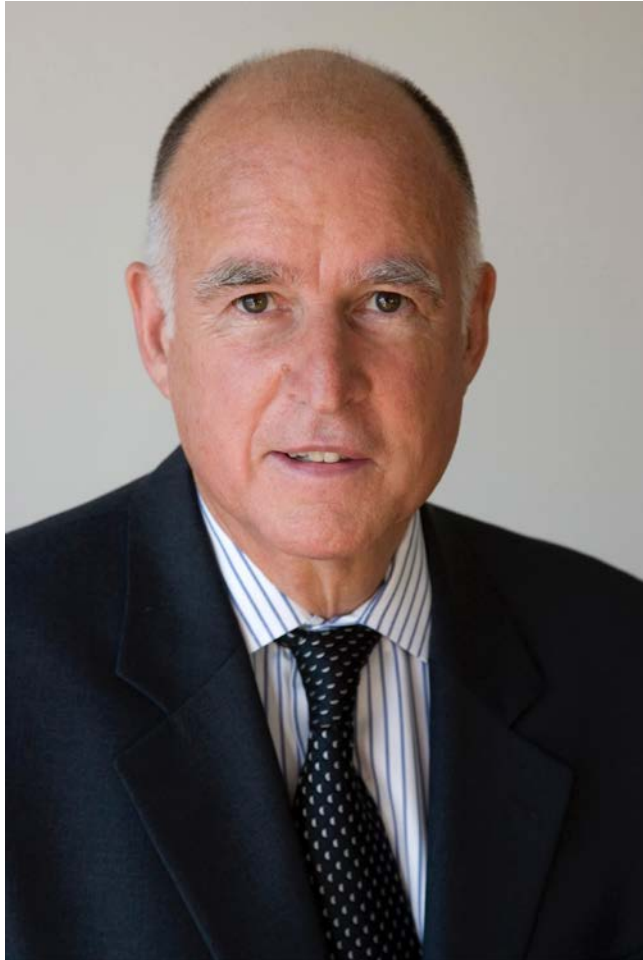
Climate and Clean Air Coalition Established: Adopts Heavy-Duty Diesel Initiative (2012)



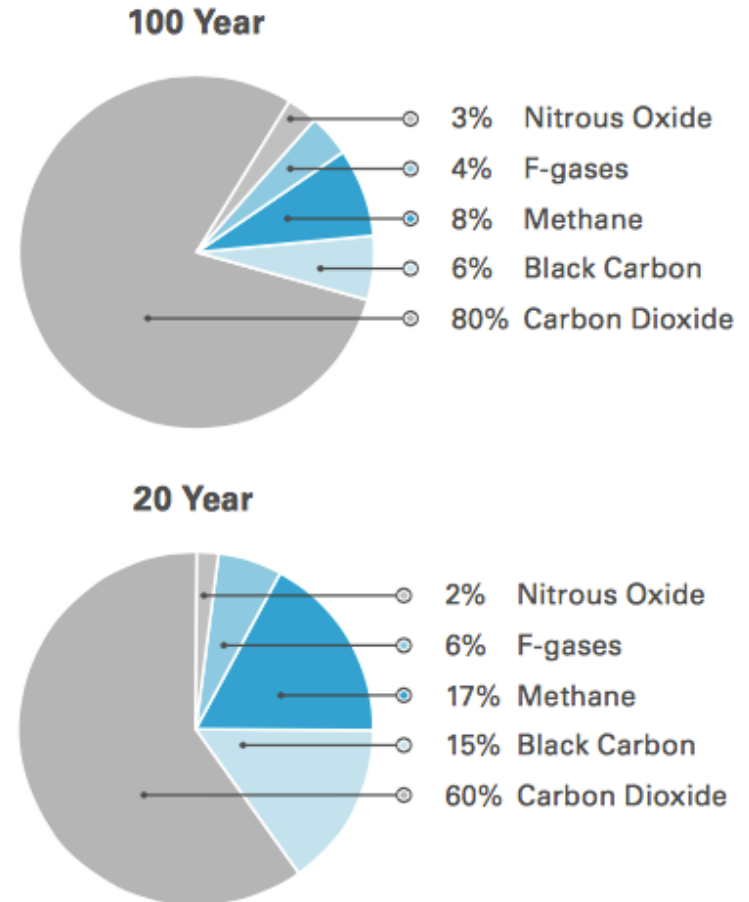
Diesel BC Activities

- ✦ Global Fuel Sulfur Strategy
- ✦ Technical support to Mexico, China and Indonesia
- ✦ Soot-Free Urban Bus Project
- ✦ Low-Sulfur Fuels in Western and Southern Africa
- ✦ Green Freight Project

California adopts law SB 605 to require plan by 2016 to address short-lived climate pollutants



California 2012 GHG Inventory



Norwegian Environment Agency Presents Action Plan on Short-Lived Climate Pollutants (2014)

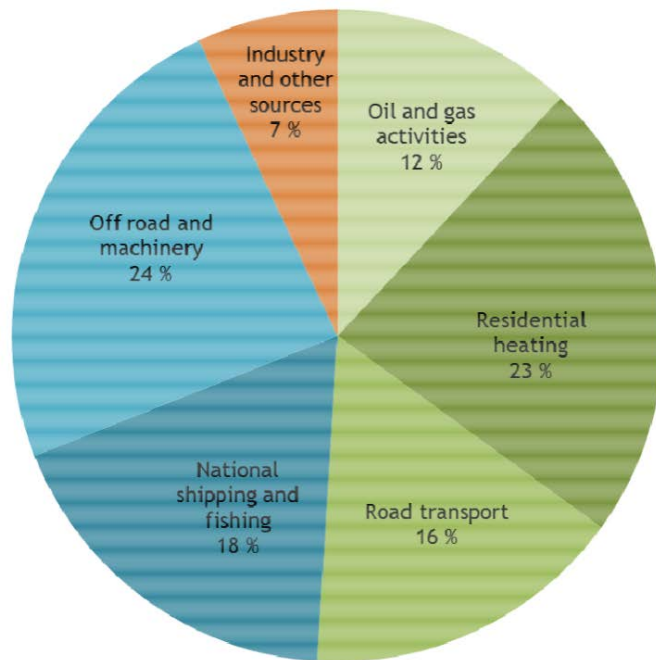


Figure 1: Distribution of sources for Norwegian 2011 emissions of black carbon [7, 8].

BC Transport-Related Measures

- ✦ DPF retrofit on construction machinery, coastal vessels, & fishing boats, mobile rigs, light-duty vehicles, tractors, & heavy-duty vehicles
- ✦ Bus fuel switching to food waste biogas

Historical Footnote: BC Science Used to Justify United States Decision Not to Sign Kyoto Protocol (2001)

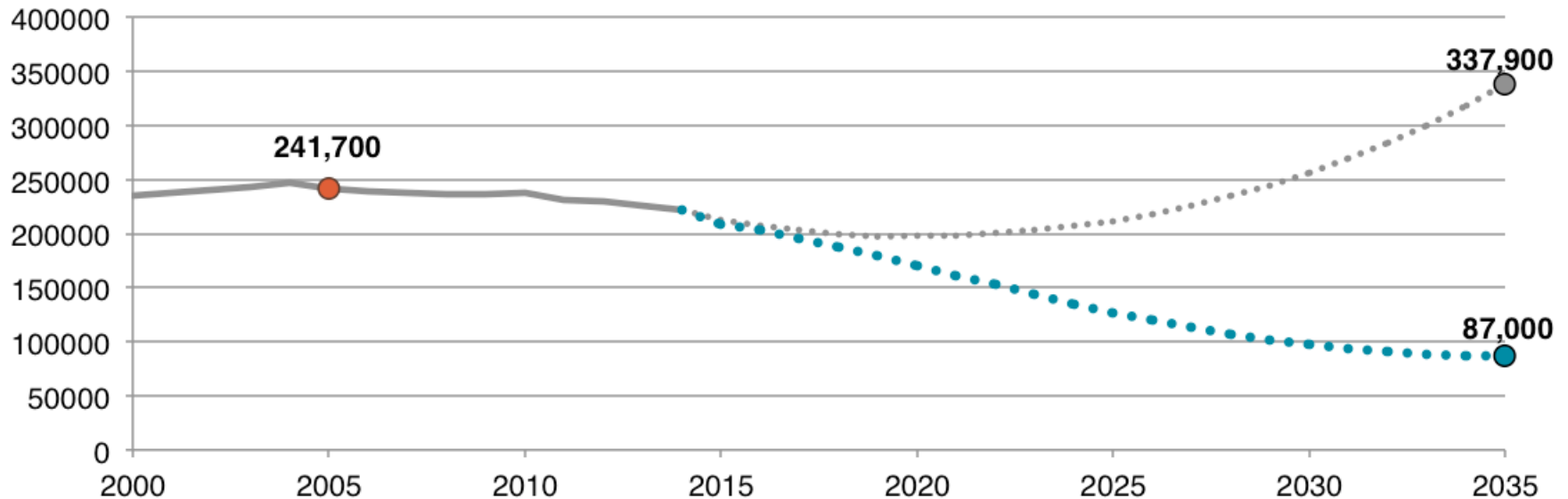


“Kyoto also failed to address two major pollutants that have an impact on warming: black soot and tropospheric ozone. Both are proven health hazards. Reducing both would not only address climate change, but also dramatically improve people's health.”

Implications for Transportation Policy

Trajectory of health impacts from vehicle emissions exposure: 2000-2035

Annual premature mortality from tailpipe PM_{2.5} Exposure



* 2005 estimate from Chambliss, S. E., Silva, R., West, J. J., Minjares, R., & Zeinali, M. (2014). Estimating source-attributable health impacts of ambient fine particulate matter exposure: global premature mortality from surface transportation emissions in 2005. *Environmental Research Letters*. Trends from 2000-2035 from Chambliss, S., Miller, J., Facanha, C., Minjares, R., & Blumberg, K. (2014). *The Impact of Stringent Fuel and Vehicle Standards on Premature Mortality and Emissions* (pp. 1–96). Washington, DC: International Council on Clean Transportation.

Top Countries Ranked by Premature Deaths from Vehicle Emissions in 2005

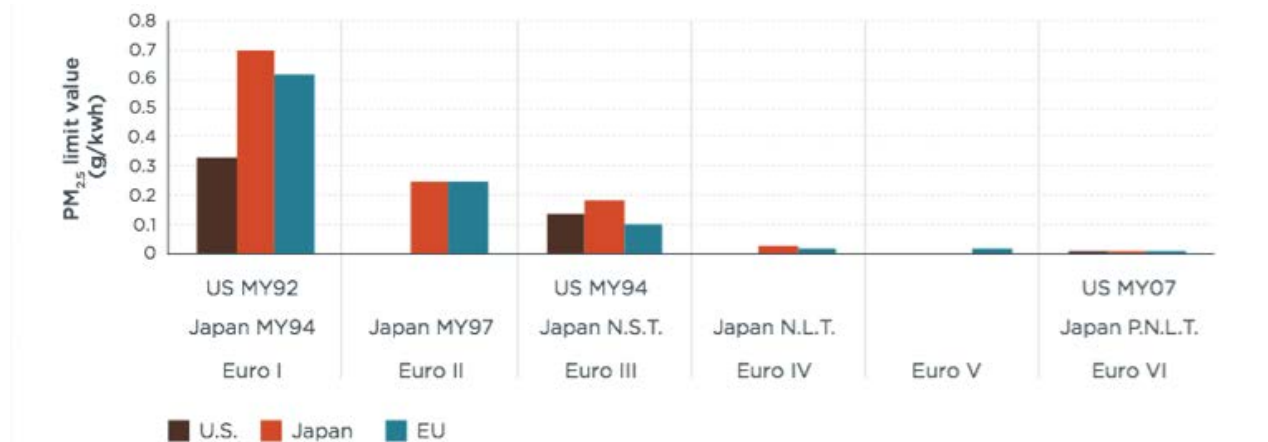
Rank	Country	2005 mortality from surface transportation	Cumulative %
1	China	56600	23%
2	European Union - 28	55090	46%
3	India	31800	59%
4	United States	24600	70%
5	Japan	13800	75%
6	Russia	7300	78%
7	Ukraine	6900	81%
8	Indonesia	4300	83%
9	Egypt	3900	85%
10	Mexico	3900	86%
11	South Korea	3000	87%
12	Turkey	2900	89%
13	Iran	2600	90%
14	Thailand	2300	91%
15	Bangladesh	1700	91%
16	Canada	1500	92%
17	North Korea	1100	92%
18	Vietnam	1100	93%
19	Belarus	1000	93%
20	Malaysia	1000	94%
21	Brazil	900	94%

Adopted Euro 6/VI or Equivalent
 2015 Top Ten Vehicle Markets

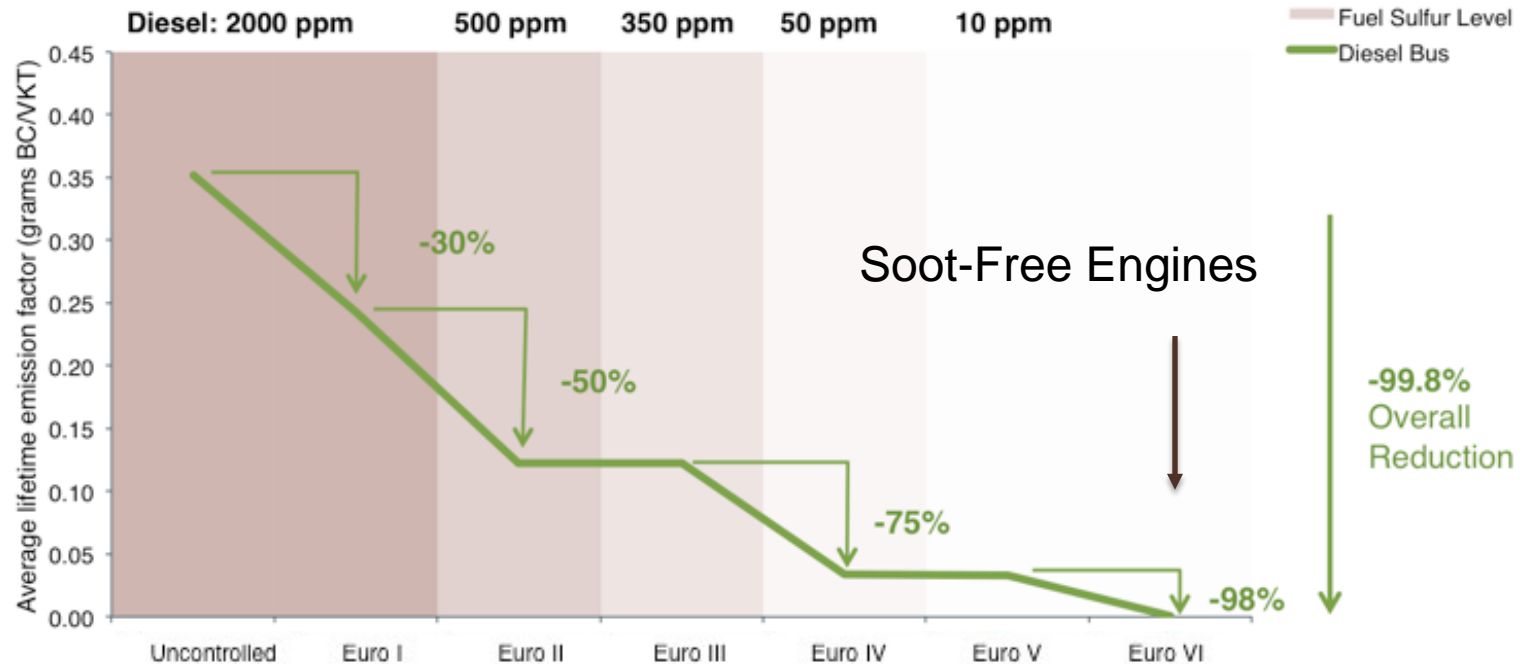
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Effect of Vehicle and Fuel Standards on Black Carbon

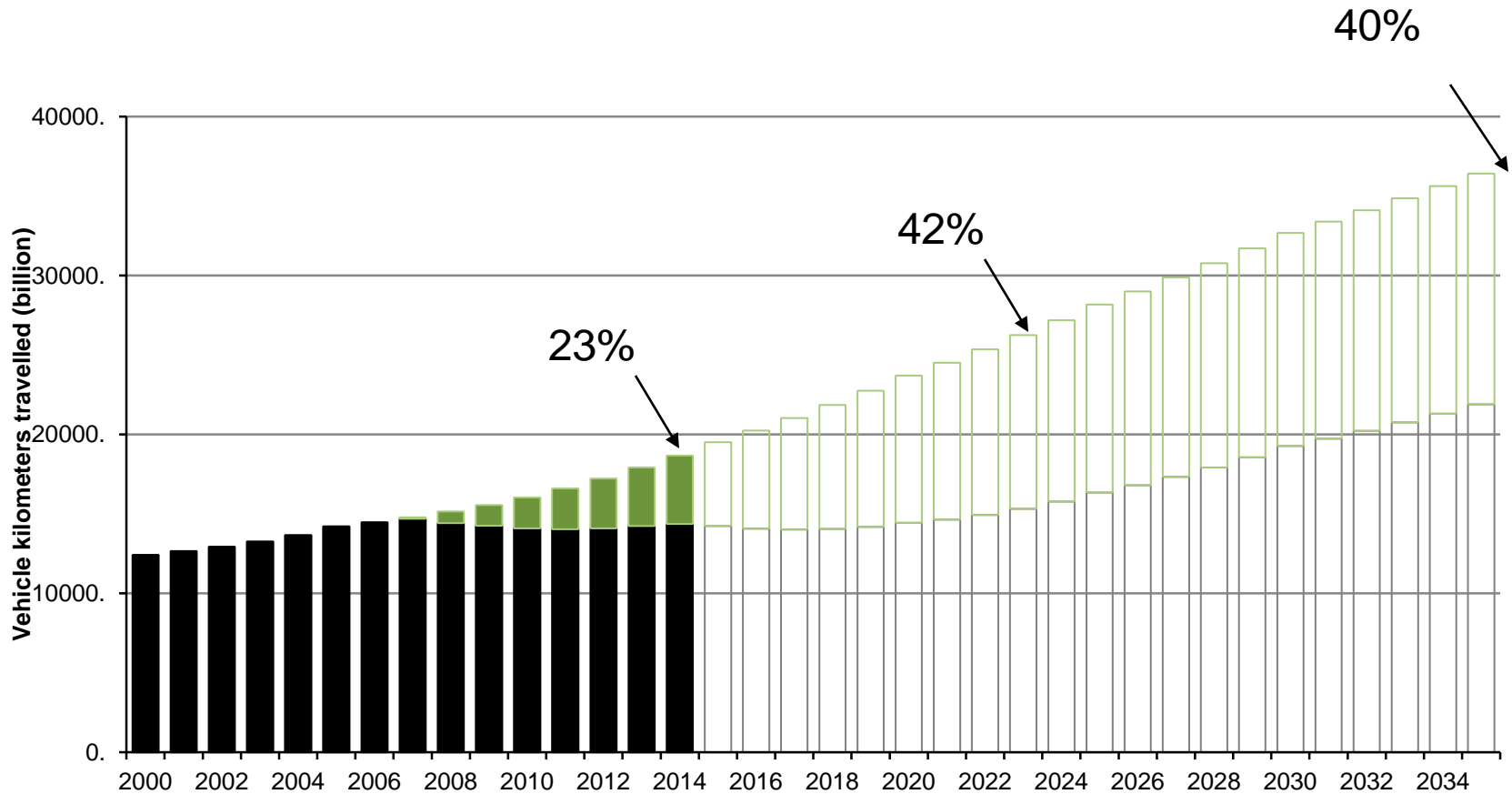
PM_{2.5} Limits



Parallel BC Reductions

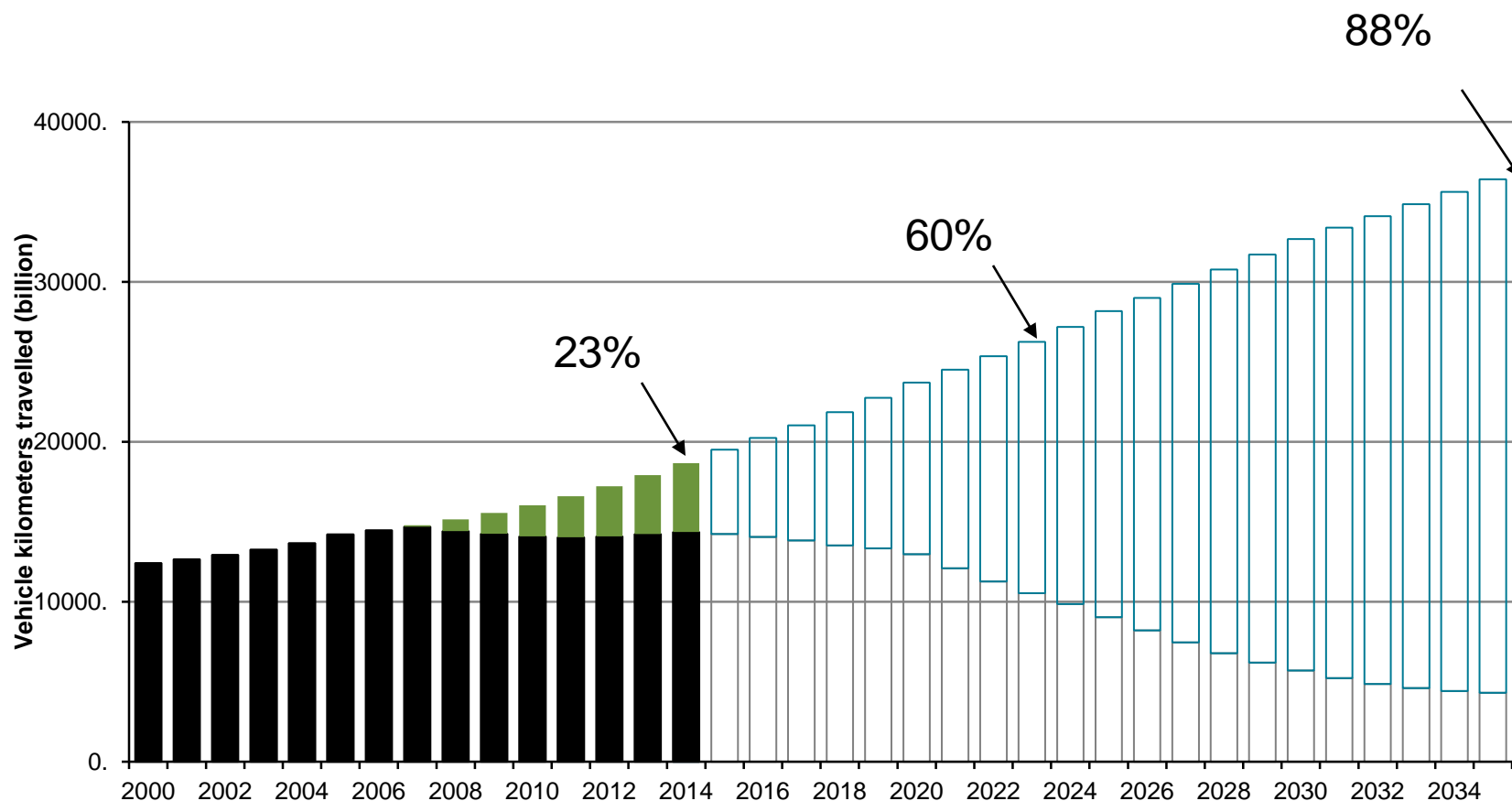


Share of global vehicle activity that meets best practice emission standards*



* Captures on-road vehicles only and does not include two-or three-wheelers. US Tier 2 assumed equivalent to Euro 6.

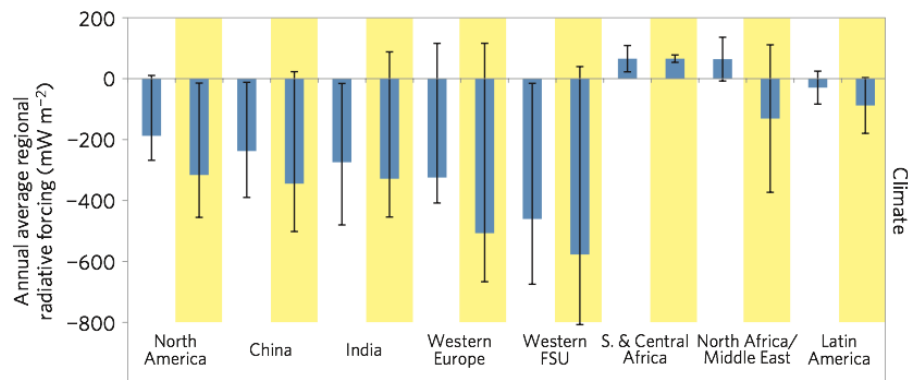
Potential share of global vehicle activity that can meet best practice emission standards*



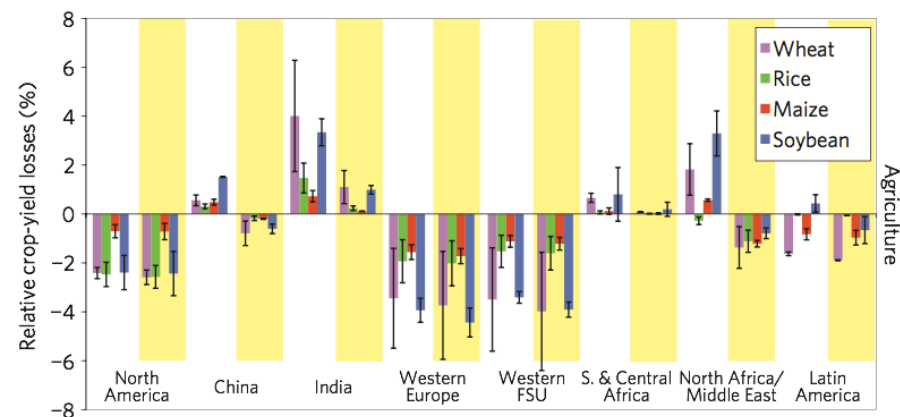
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Climate, Health, and Agricultural Benefits of Vehicle Emission Controls

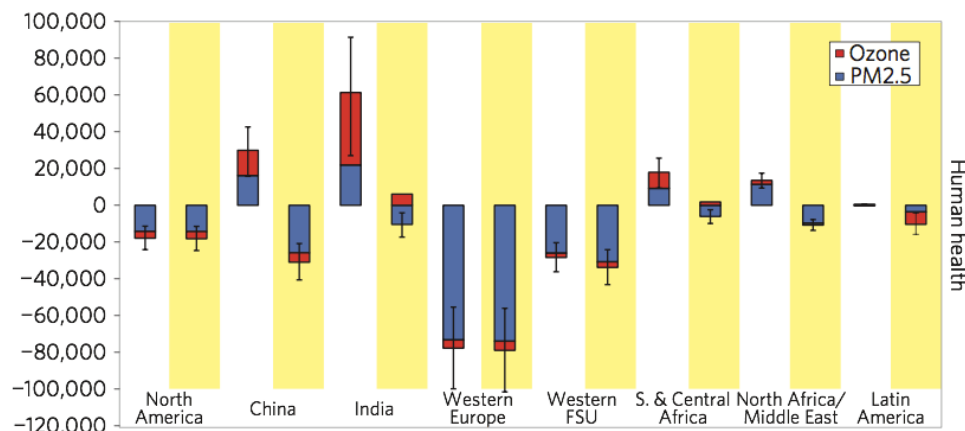
0.2 degrees C avoided



6-20 MMT avoided food crop losses



120,000-280,000 early deaths avoided



Thank You!

Ray Minjares
Clean Air Program Lead
International Council on Clean Transportation

Additional Slides

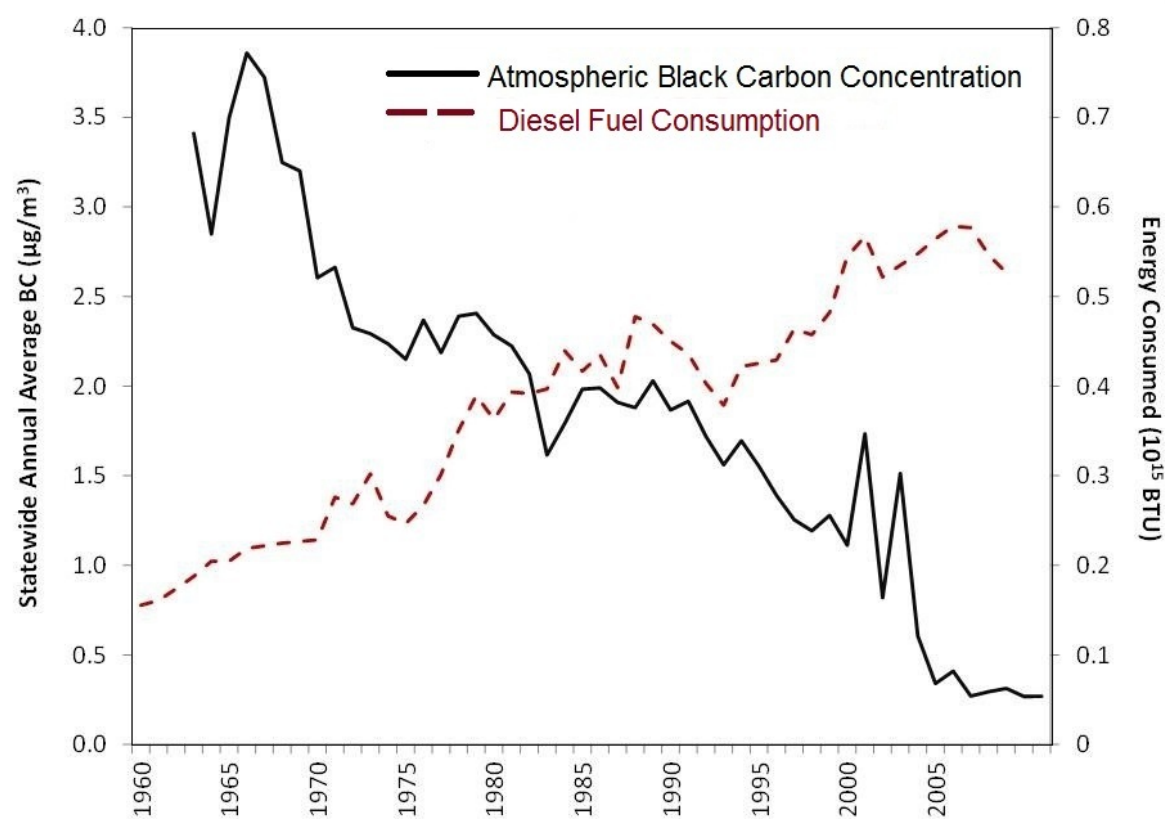
Can Reducing Black Carbon Emissions Counteract Global Warming? (Bond & Sun, 2005)



“We synthesize results from published climate-modeling studies to obtain a global warming potential for black carbon relative to that of CO₂ (680 on a 100 year basis).”

CARB Research Report on Black Carbon

California de-Linkage of BC pollution and diesel activity



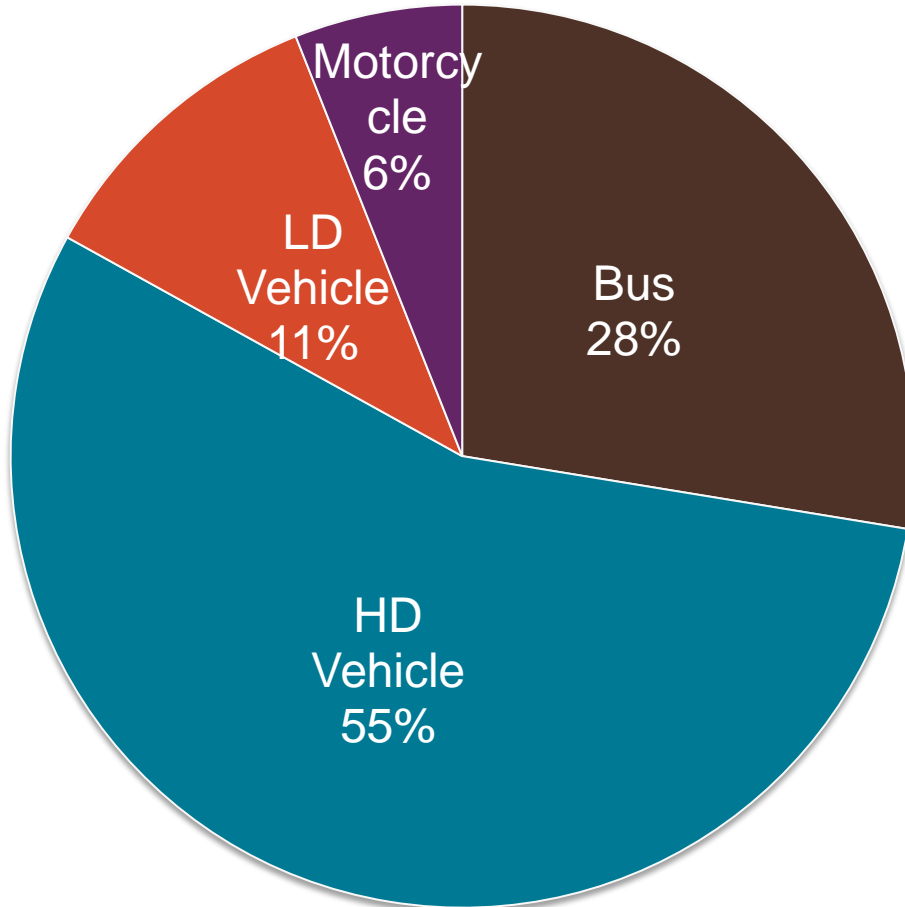
“...reductions in black carbon as a result of clean air regulations were equivalent to r

LRTAP Recommends Voluntary BC Control Measures

China Adopts National BC Emissions Inventory

Diesel Contribution to Transport-Related PM_{2.5} and Black Carbon

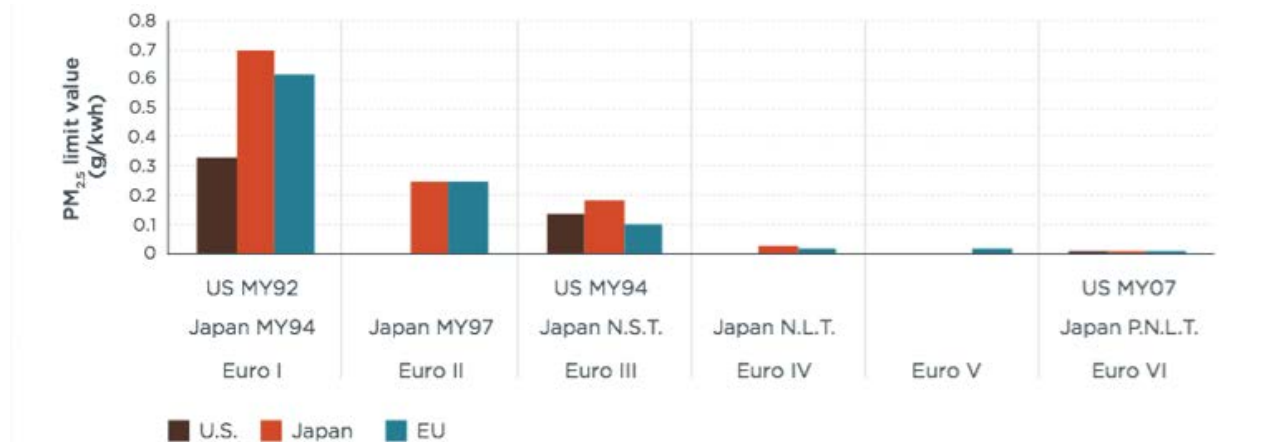
Share of PM_{2.5} in 2010, by Mode



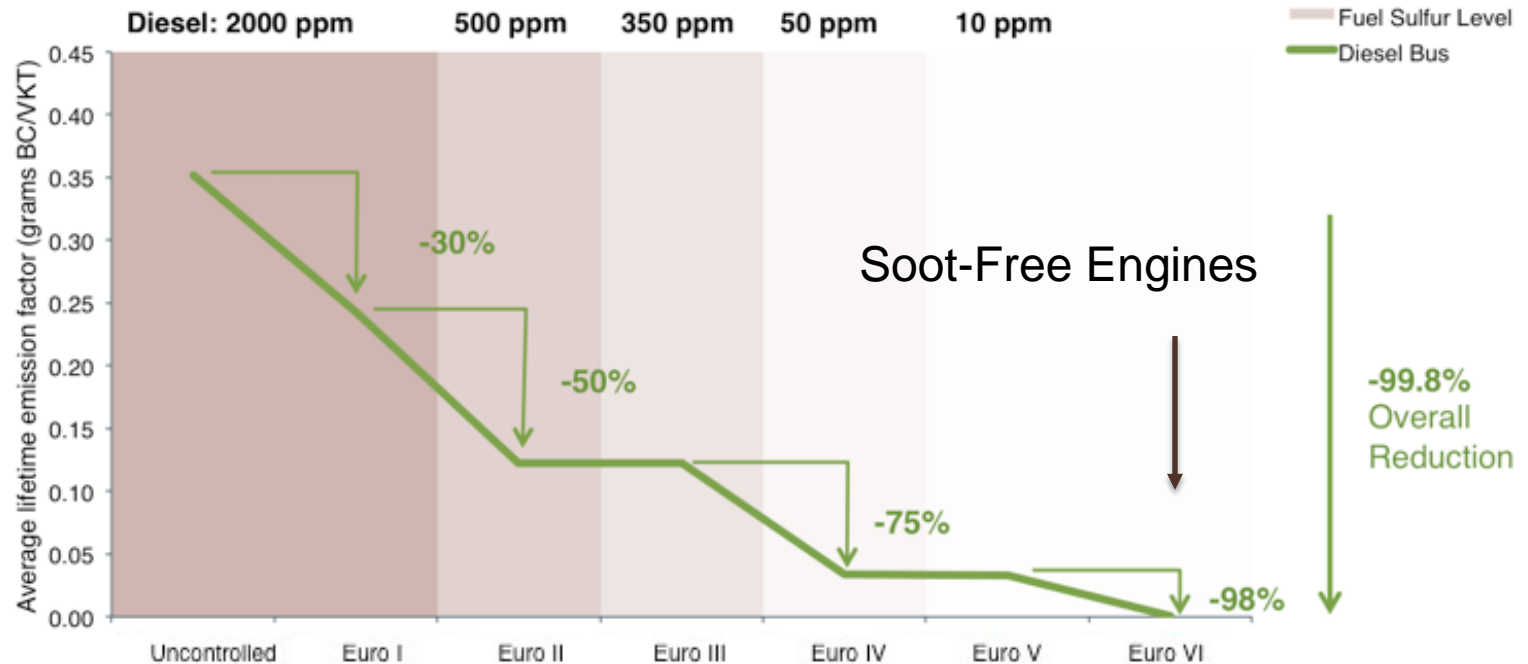
- More than 80 percent of transport-related PM_{2.5}
- About 99 percent of transport-related BC

Effect of Vehicle and Fuel Standards on Black Carbon

PM_{2.5} Limits



Parallel BC Reductions



Best Practice Policies for National Diesel BC Control

New engine standards

Euro 6/VI or equivalent for on-road + filter-forcing standards for off-road and marine engines

Fuel quality standards

10-15ppm diesel fuel sulfur limit

In-Use Programs

Scrappage/replacement of high emitting engines

City-Level Control Strategies

Commit to soot-free engines in public fleets

Invest in refueling stations to provide cleaner fuels

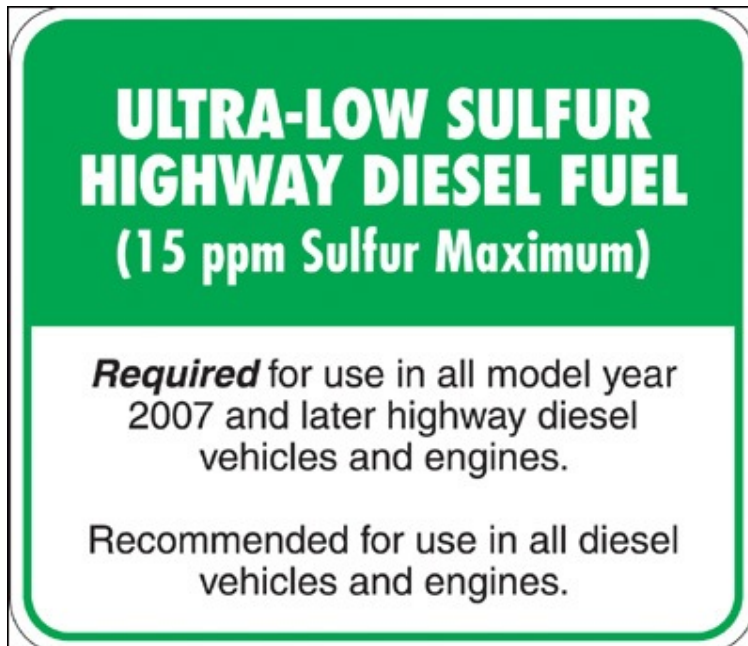
Adopt low-emission zones

Adopt vehicle scrappage programs

Technological Strategy for Diesel PM/BC Control

Ultra-low Sulfur Fuel +

Emissions After Treatment



The Evolution of the Soot-Free Engine



No retrofit system
Uncontrolled Diesel Exhaust
(Level 1)

Old technology
Little black carbon removal
Little ultrafine PM removal
Does not remove lube oil ash



Retrofitted with
Diesel Oxidation Catalyst (DOC)
(Level 1)

Old technology
Little black carbon removal
Little ultrafine PM removal
Does not remove lube oil ash



Retrofitted with
Partial Filter
(Level 2)

Little black carbon removal
Little ultrafine PM removal
Does not remove lube oil ash



Retrofitted with
Diesel Particulate Filter (DPF)
(Level 3)

New Technology
Used on all new trucks since 2007
>85% black carbon removal
>85% ultrafine removal
>85% lube oil ash removal