



ANIL AGARWAL DIALOGUE 2015

The poor in climate change

MARCH 11 & 12

Diesel at crossroads: Science and Politics of luxury emissions

Anumita Roychowdhury
Centre for Science and Environment

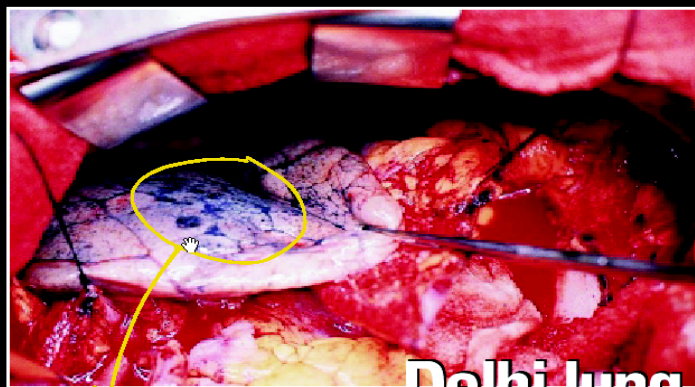


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The story so far in India.....



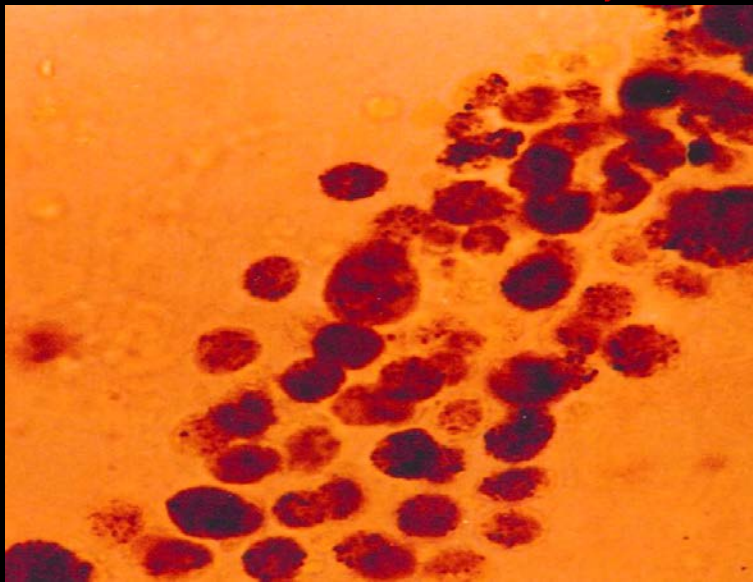
Delhi lung
Capital punishment

Look at these black spots on the lung. The unfortunate owner lives in Delhi and has been breathing polluted air. Air full of carbon particles which accumulate in the lungs (black spots). What you can't see is a cocktail of gases and tiny particles, even smaller than carbon that get into our bodies. Actually, you are getting polluted.

Scary? But those cars are so sexy!



Delhi winter smog



**Haze over the Ganges Delta,
NASA**

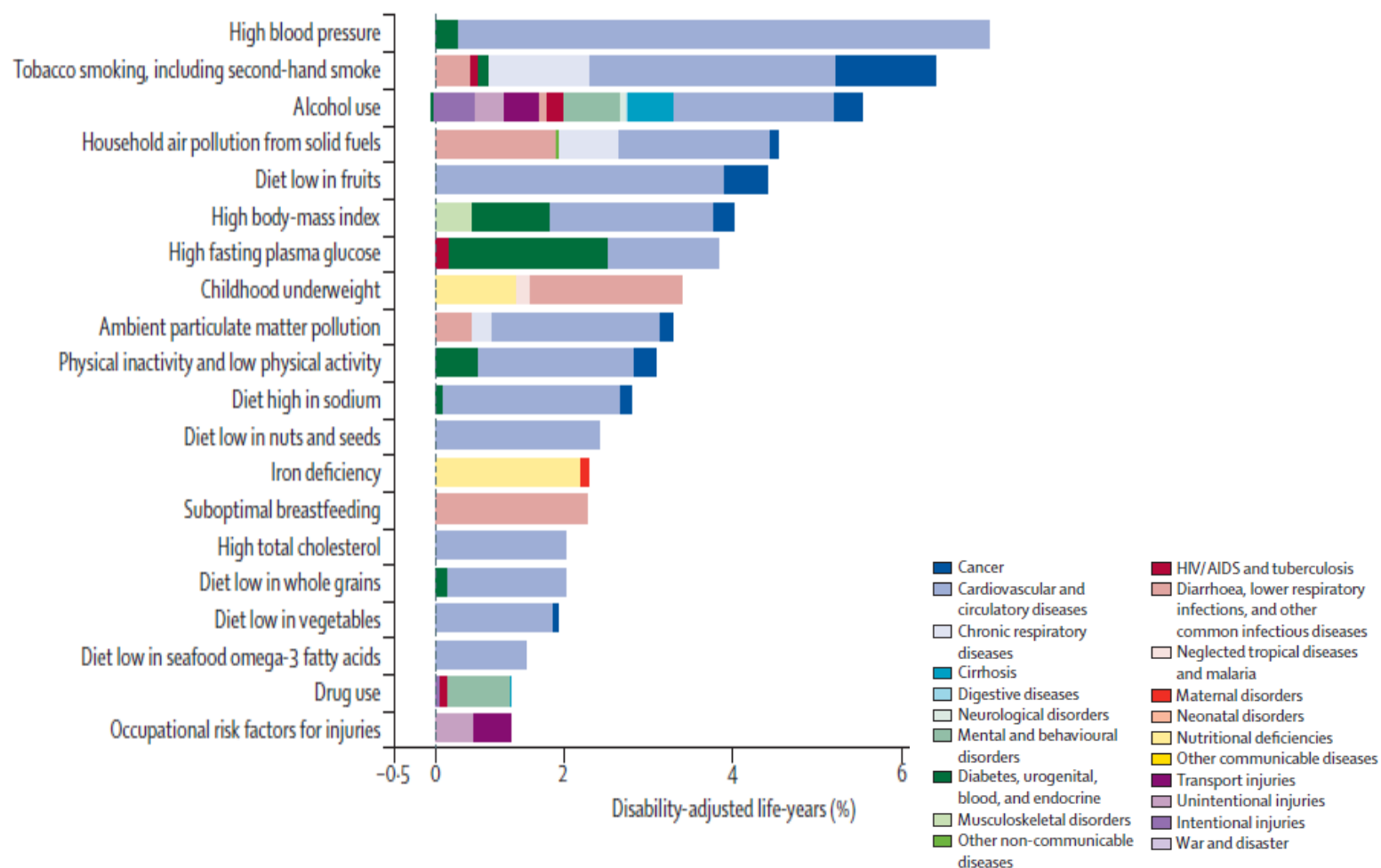




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Particulate pollution: Ninth largest killer in the world

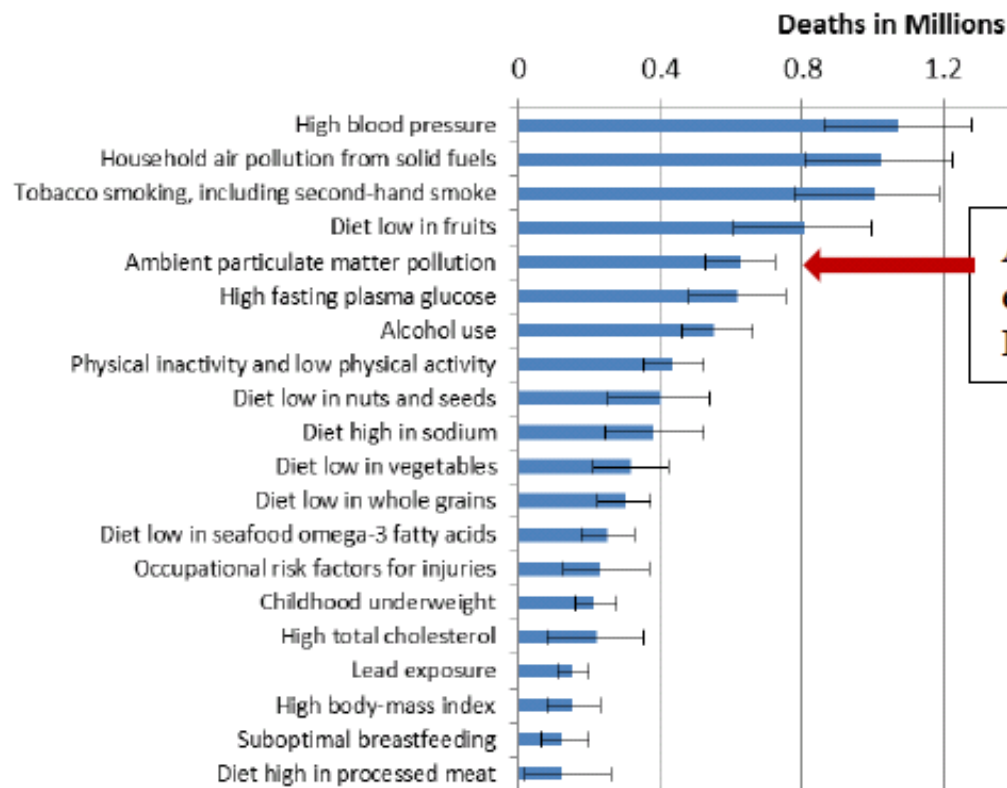




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Fifth largest killer in India.....

Leading Risk Factors for Deaths in 2010 in India



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

More than 18 million healthy life years lost due to air pollution.





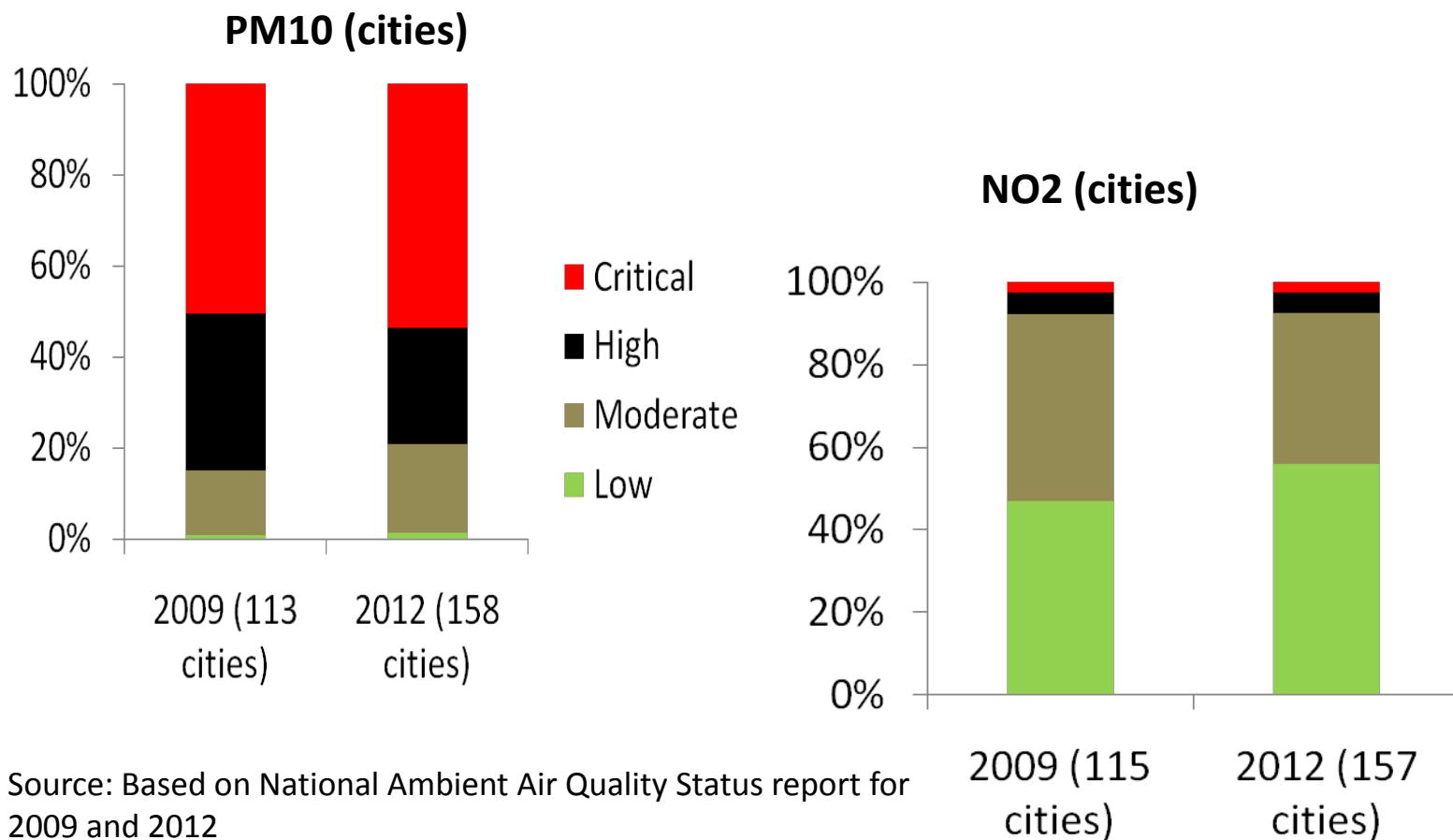
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Air quality: A national challenge....

PM10: Number of critically polluted cities have increased from 57 in 2009 to 85 in 2012. *Nearly half of Indian cities have critical pollution levels.*

NO2: Critically polluted cities have from 3 to 4 and highly polluted from 6-8





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Air quality: A national challenge....

Delhi has fought hard to get breathing space

On vehicles

- Introduced low sulphur fuels and petrol with 1 per cent benzene
- Mandated pre-mix petrol to two- and three-wheelers
- Moved from Euro I to Euro IV over the last decade
- Implemented largest ever CNG based public transport programme
- Capped the number of three-wheelers
- Phased out 15 year old commercial vehicles
- Strengthened vehicle inspection programme (PUC)
- Efforts made to divert transit traffic
- Set up independent fuel testing laboratories to check fuel adulteration

On industry

- Relocated polluting units
- Tighter controls on power plants. No new power plants.

Air quality monitoring

- Adopted new ambient air quality standards
- Expanded air quality monitoring and reporting

Other sources

- Emissions standards for generator sets
- Ban on open burning of biomass



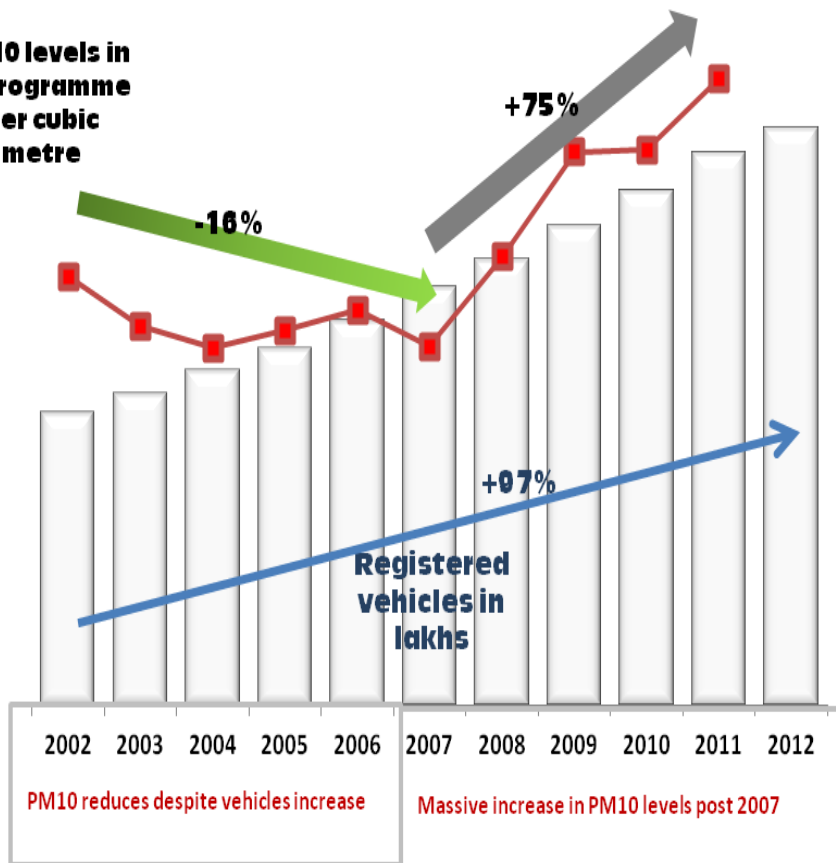


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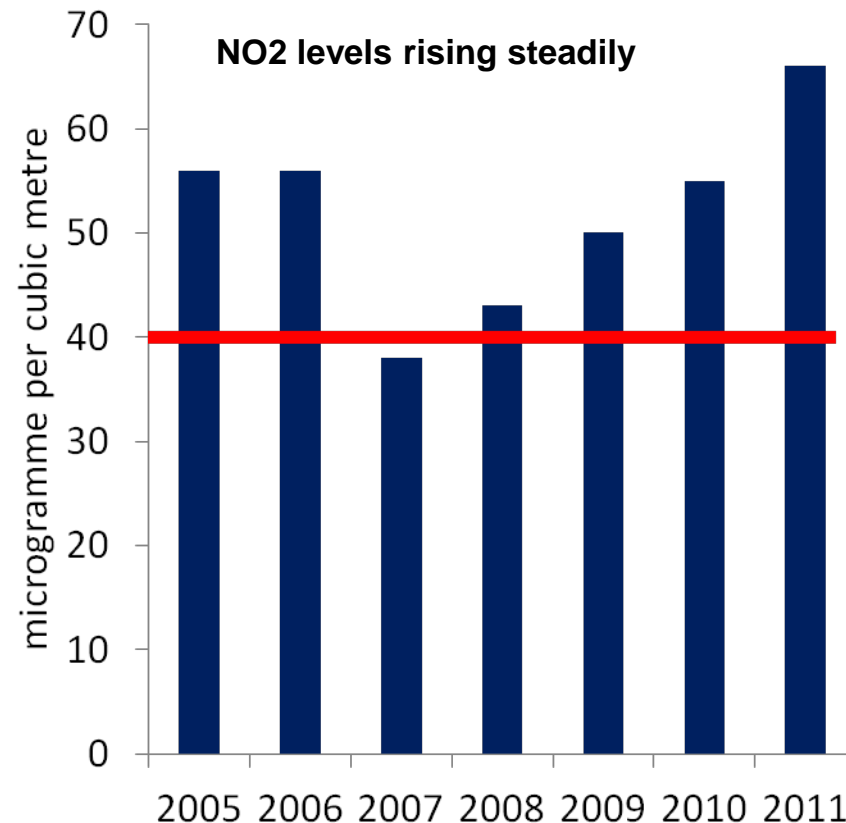
Delhi has lost its gains. After a short respite pollution curve turns upward

Particulate pollution decline and rise again due to rapid increase in vehicle numbers

PM10 levels in microgramme per cubic metre



NO2





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**Change in story line...
..... Also a climate rogue**



Global warming potential of short lived gases: IPCC Report (AR5 WGI)

Common Name	Notation	GWP 20-year	GWP 100-year	Source
Carbon Dioxide	CO ₂	1	1	AR5 WG1, Table 8.A.1
Carbon Monoxide	CO	18.6	5	AR5 WG1, Table 8.A.4; from Shindell et al. (2009)
Sulfur Dioxide	SO ₂	-268	-71	AR5 WG1, 8SM-23; from Shindell et al. (2009)
Oxides of Nitrogen	NO _x	-560	-149	AR5 WG1, Table 8.A.3; from Shindell et al. (2009)
Fossil Methane	CH ₄	85	30	AR5 WG1, Table 8.A.1
Nitrous Oxide	N ₂ O	264	265	AR5 WG1, Table 8.A.1
Black Carbon	BC	3200	900	AR5 WG1, Table 8.A.6; from Bond et al. (2013)
Organic Carbon	OC	-160	-43	AR5 WG1, Table 8.A.6; from Bond et al (2011)

AR5 WGI for the first time included estimates of GWP for black carbon.

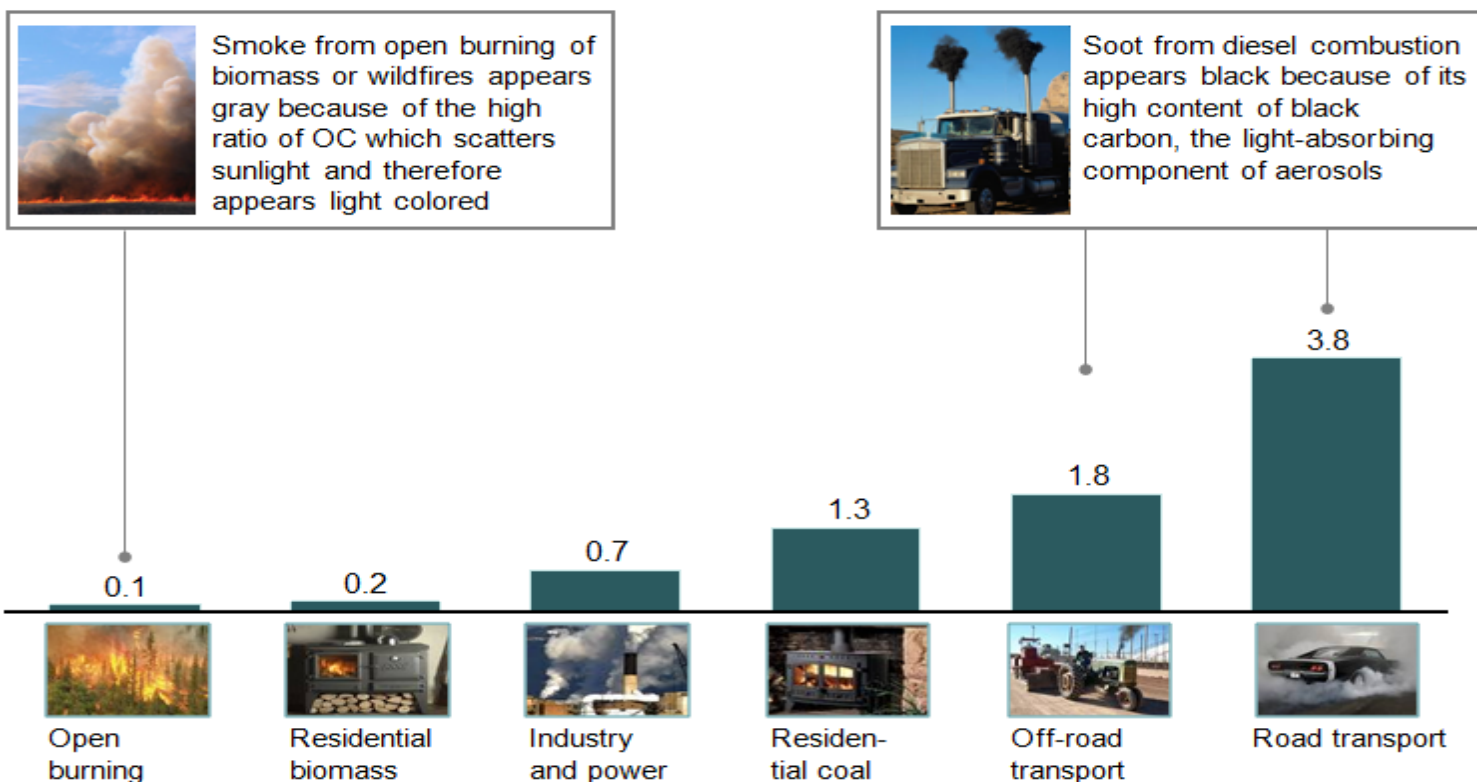
These are significantly higher values than earlier estimates



Some cool and some warm....

The exact threshold from negative to positive forcing for several sources especially biomass burning is still an area of uncertainty.....

Ratio of black carbon to organic carbon



Note: All sources emit significant quantities of other pollutants that may warm or cool the climate, including CO₂ (warming), NO_x (ozone and N₂O warming, nitrate cooling), and SO₂ (sulfate cooling)

SOURCE: Non-CO₂ Climate Forcers Report (2010), Bond (2007), GAINS



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**Black carbon mitigation in
transport sector.....
... A win-win for health and climate**

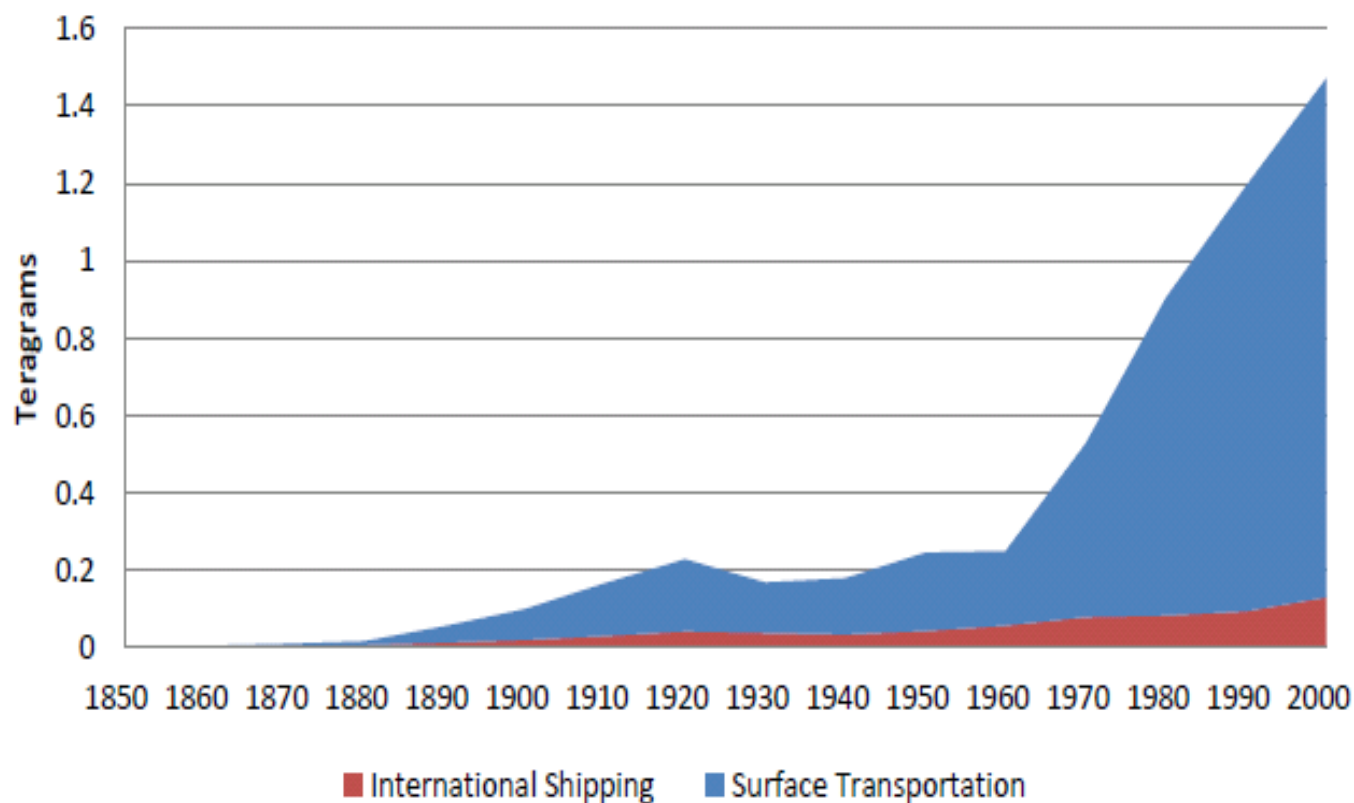




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Global BC from transportation sector



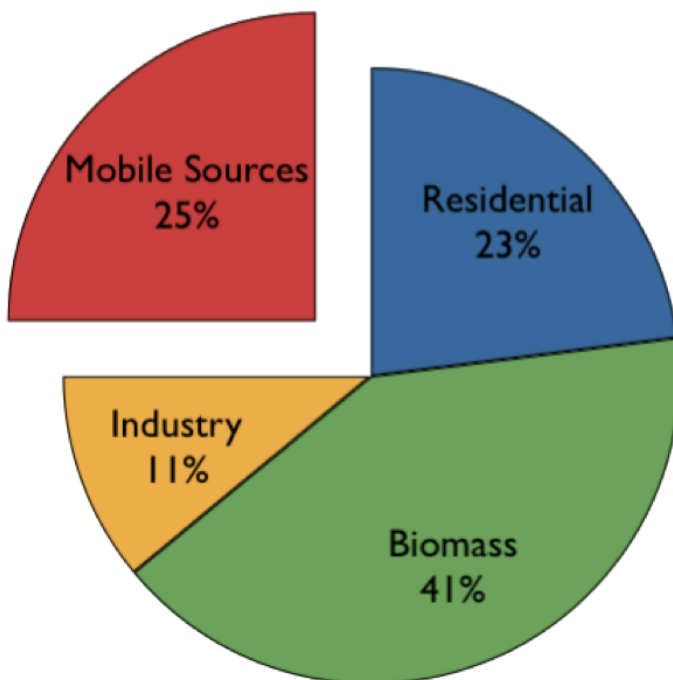
Source: World Bank 2014



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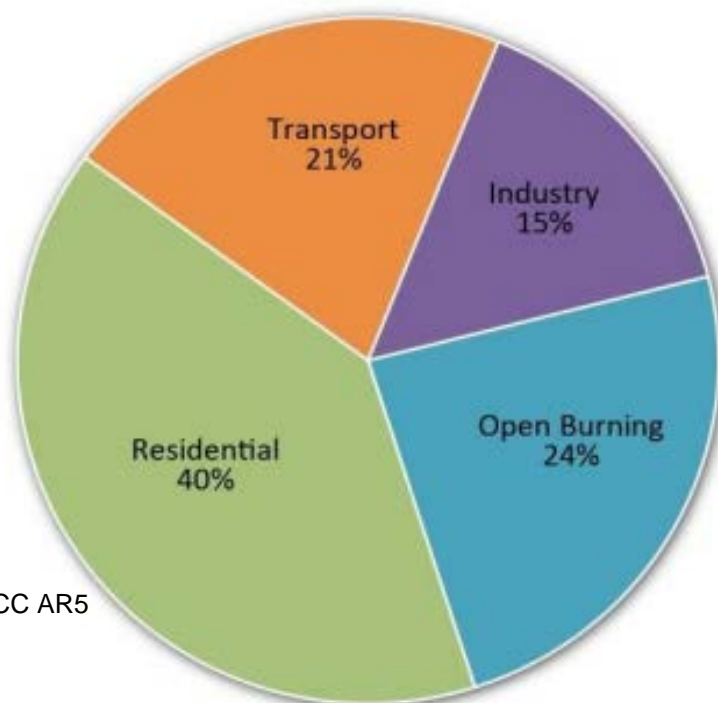


Vehicles responsible for ~25% of global black carbon emissions



Source: Bond et al., GBC 2007 + van der Werf, 2006 + updates for IPCC AR5

**UNEP: Sectoral emissions of BC in India.
In India transport is responsible for 21%**



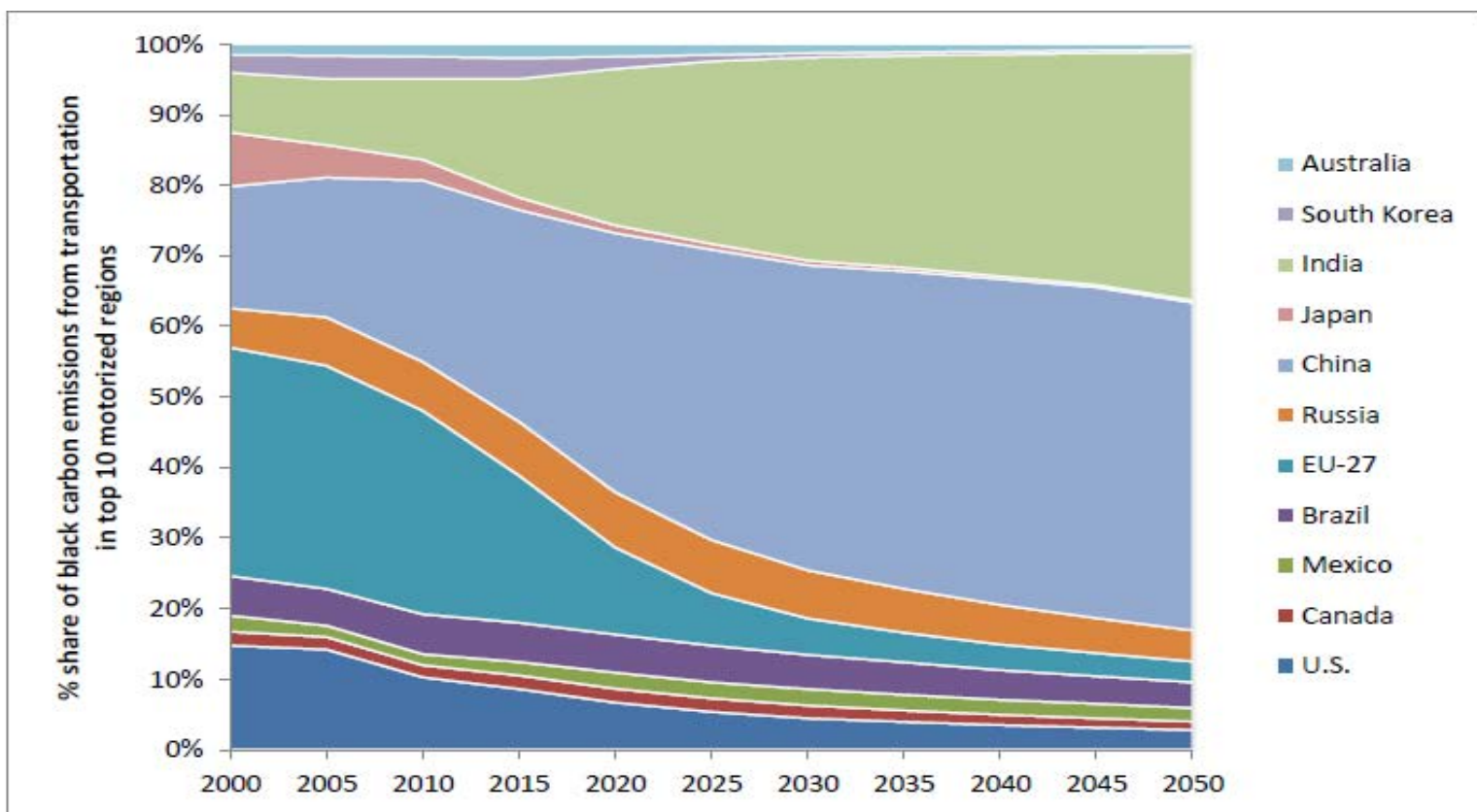


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Black carbon emissions by transportation by region among top 10 motorised nations 2000-2050

Though overall global black carbon emissions will decline by 2050, the relative position of the countries will shift depending on fuel consumption and level of technology.



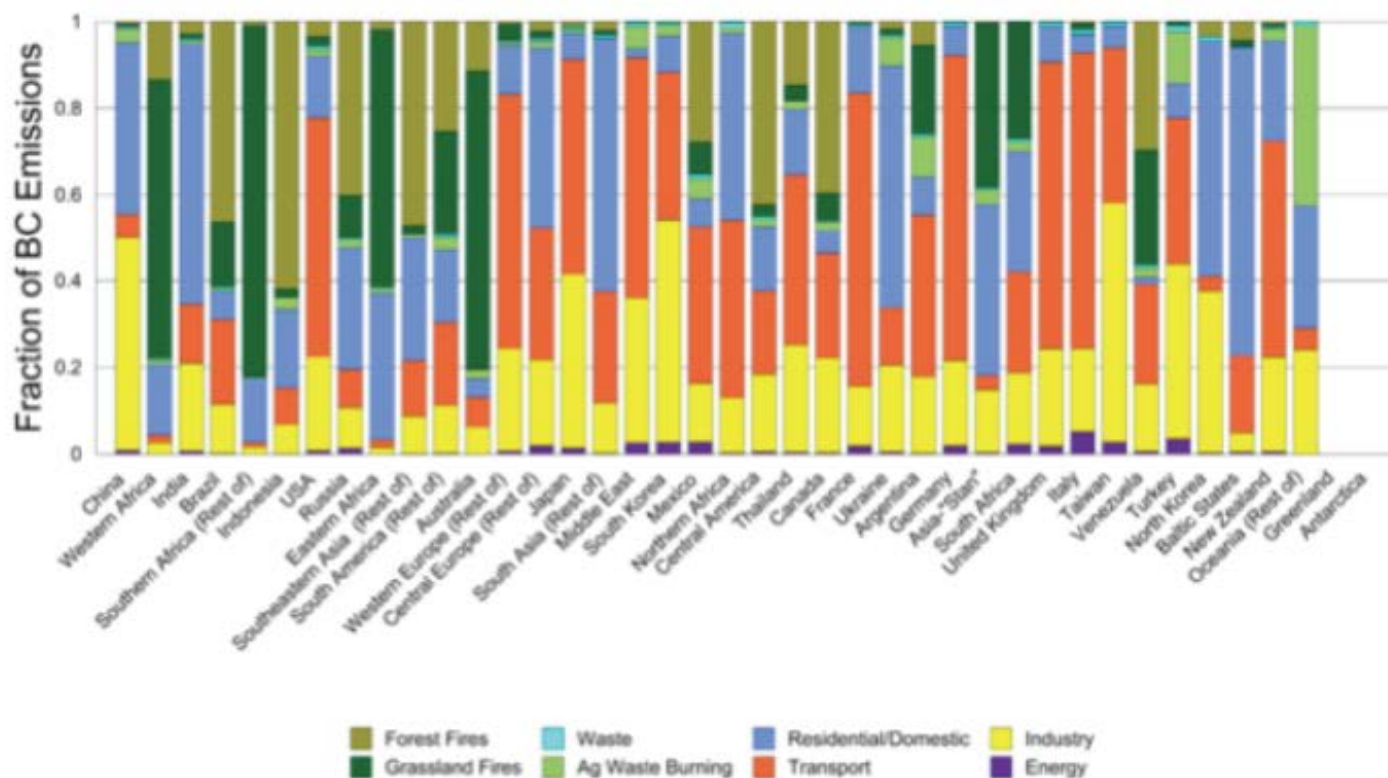
Source: World Bank and ICCT 2014



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Share of black carbon from different sources in different regions

Regions where biomass and open burning are controlled share of transport and diesel black carbon are higher



Source: Lamarque et al 2010 and USEPA

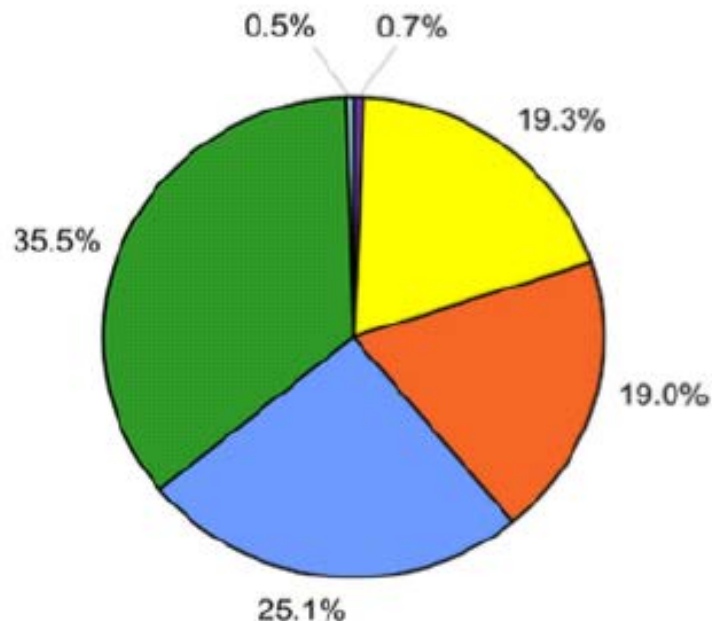


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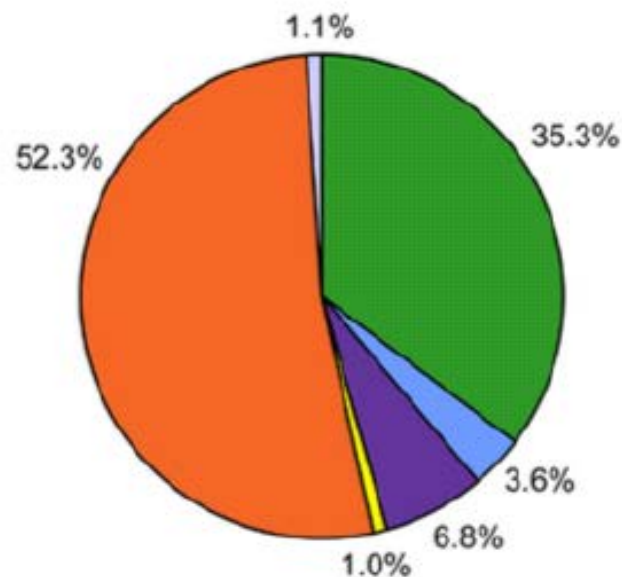


Share of black carbon emissions from different sectors in the US....

Global BC Emissions, 2000 (7,600 Gg)



U.S. BC Emissions in 2005 (0.64 Million Tons)



Open Biomass Burning
(Includes Wildfires)

Transport

Energy/Power

Domestic/Residential

Industry

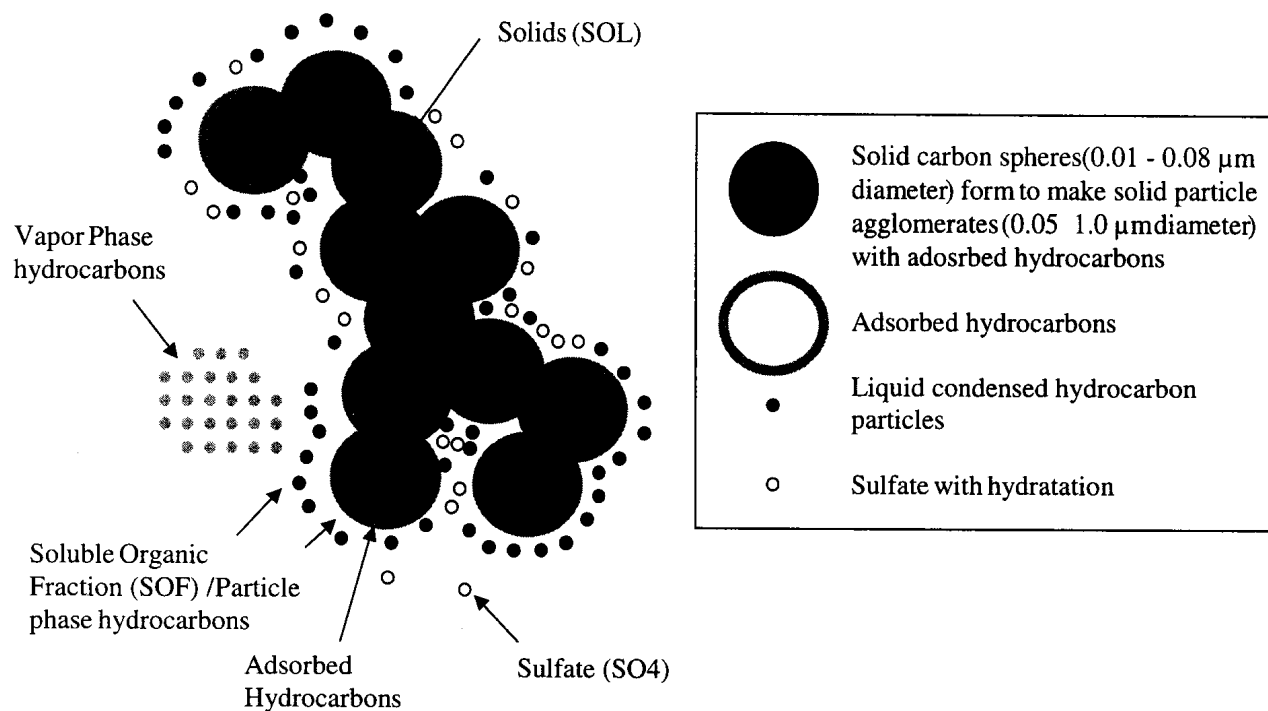
Other

Source: Lamarque et al 2010 and USEPA



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Black Carbon is the Core of Diesel PM



‘Bounding the role of black carbon’ Report 2013:

- Globally diesel BC is expected to be 20 per cent of the total BC emissions
- Total emissions from gasoline are less than 10% of diesel BC emissions, although gasoline vehicles are more numerous

Source: World Bank 2014

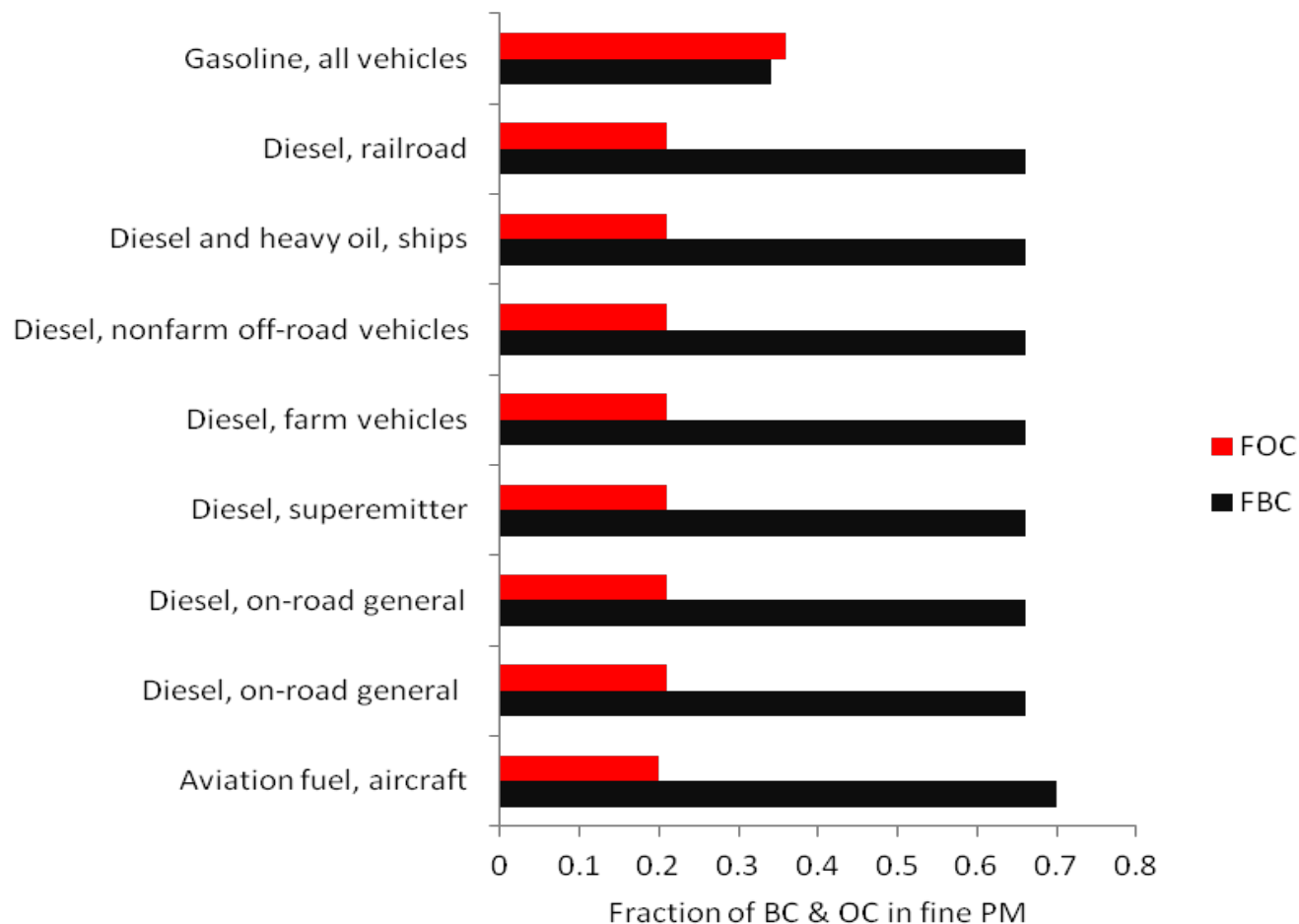




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Diesel BC vs Gasoline BC: Diesel loses



•Tami C. Bond et al 2004, JOURNAL OF GEOPHYSICAL RESEARCH, VOL. 109, D14203, doi:10.1029/2003JD003697, 2004



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We are already worried about diesel-- WHO: Diesel particles are class 1 carcinogen.. And many more effects.....

Strong link with lung cancer.....

Toxic Air Contaminant	Unit Risk/Million People	Detection limit (ppb)
Acetaldehyde	2.7	0.10
Benzene	29	0.05
1,3-Butadiene	170	0.04
Carbon Tetrachloride	42	0.02
Chromium, Hexavalent	150,000	0.06 (in nanogram)
<i>Para</i> -Dichlorobenzene	11	0.30
Formaldehyde	6	0.10
Methylene Chloride	1	0.10
Perchloroethylene	5.9	0.01
Diesel particulate matter	300	N/A

Note: Unit Risk represents the number of excess cancer cases per million people per microgramme per cubic meter TAC concentration over a 70 year lifetime exposure

A diesel particulate matter unit risk value of 300 is used as a reasonable estimate in the "Risk Reduction Plan to reduce Particulate Matter Emissions from Diesel Fuelled Engines in vehicles (ARB, October 2000)

Source: California Air Resource Board



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Lessons from vehicle producing countries.....



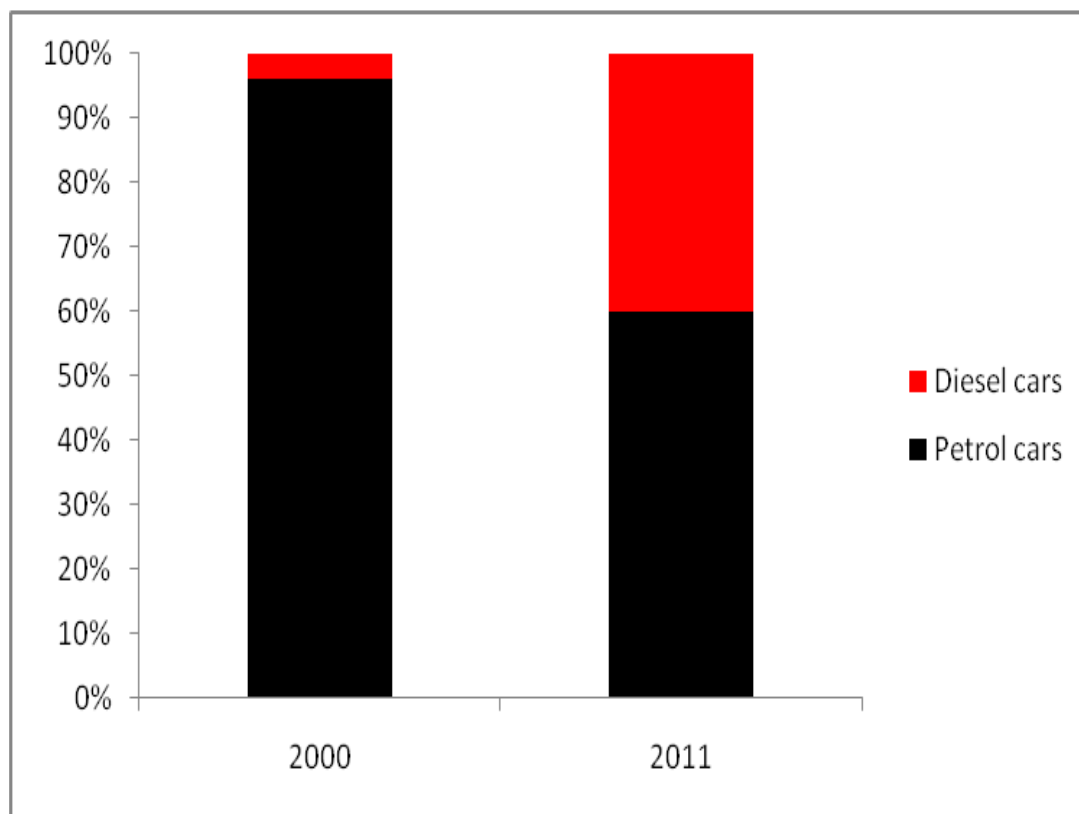


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India -- dieselised.....

Diesel car share jump from 4% in 2000 to 53% in 2012
Some decline reported after diesel price deregulation this year



Source: Based on market data

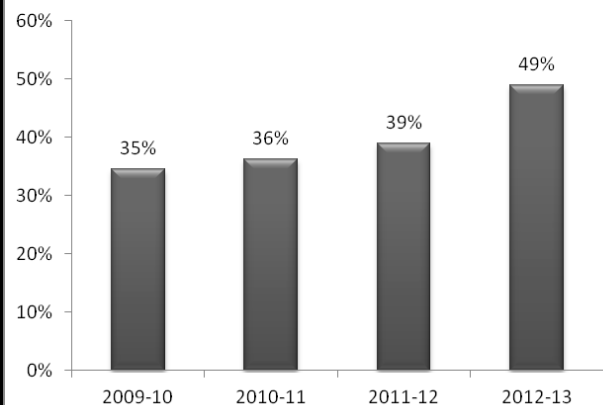


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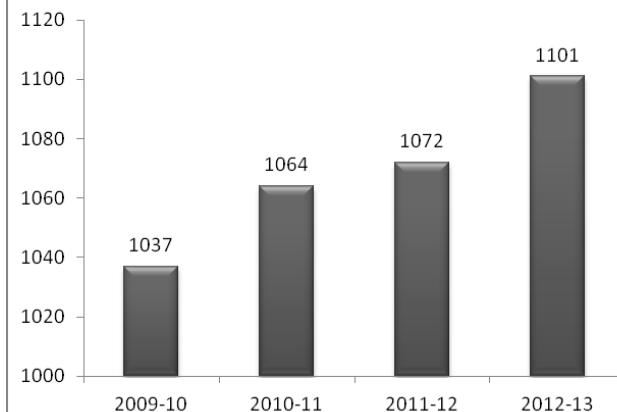
Diesel vehicles locking up enormous energy and carbon...

- Average weight and engine size during 2009-10 and 2012-13 has increased by 6%.
- On an average the weight and size of new vehicles is increasing at a rate of 2%. While 87% of petrol cars have engine size below 1.2 litres, 40% of diesel 1.5 litre and above.
- Even at a moderate and flat growth rate of 20 per cent a year, the total diesel cars in 2020 will be double the size of the total car sales today.

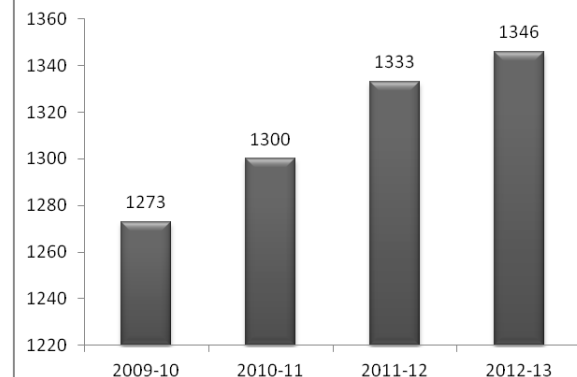
Share of diesel cars in new car sales



Average Weight (kg)



Average Engine Size (cc)



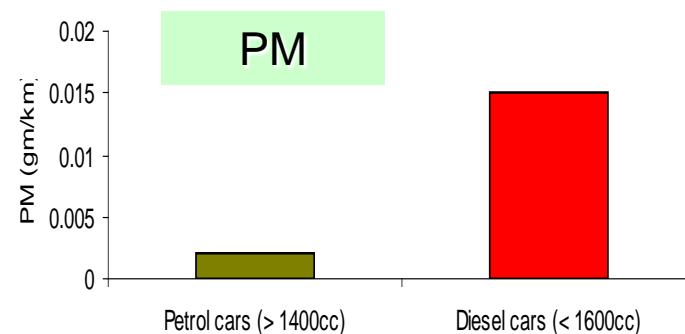
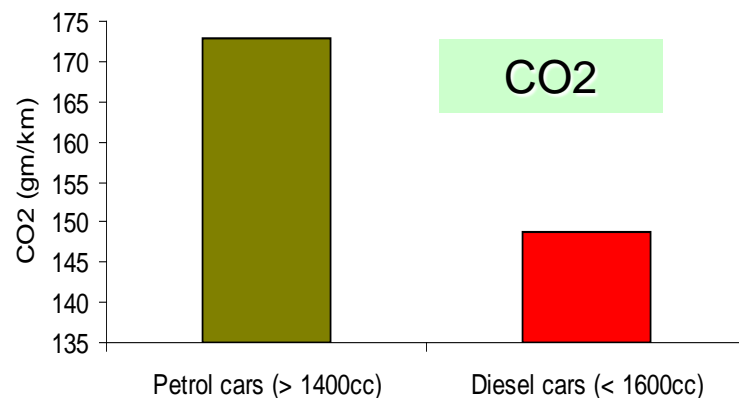


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Why diesel makes us climate insecure?

- **Black carbon emissions from diesel vehicles are several times more heat trapping** than CO₂
- **CO₂ emissions from the upstream diesel refining process will increase:** European Commission has found lifetime pollution costs of Euro IV compliant diesel car is much higher than petrol cars.
- **Rebound Effect:** Diesel fuel has **higher carbon content than petrol**. If more diesel is burnt encouraged by its cheaper prices and more driving, more heat-trapping CO₂ will escape.
- **Nullifies marginal greenhouse gas reduction benefit of diesel car**
-

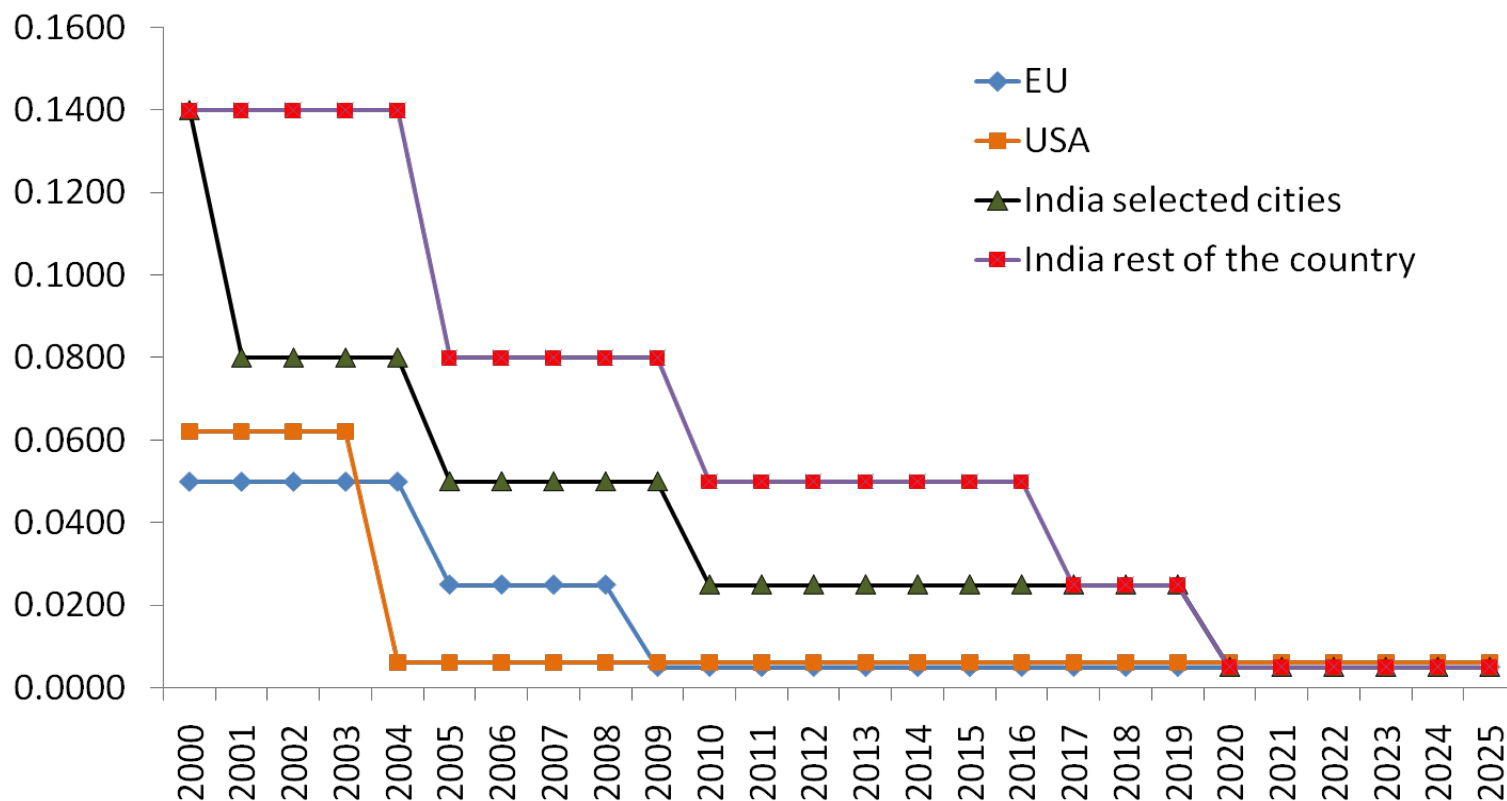




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Emissions standards trajectory in India.....

**India: Euro IV norms 10 years behind
Europe; Euro III 15 years behind Europe
Leapfrog to Euro VI standards in 2020**



Source: India, Euro standards, Germany
Compiled from Diesel Net, USA data

Note: Europe has additionally introduced particle number standards at Euro V level

Future norms of US and Europe are tightening NOx norms for diesel more



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Very high ratio of Black Carbon to Organic Carbon in diesel emissions

World Bank study 2014: Fleet-wide averages taken in a global emissions inventory model shows black carbon share of PM2.5 emissions for diesel vehicles for European standards is very high (in %)

	Euro I	Euro II	Euro III	Euro IV	Euro V	Euro VI
LDV	70	80	72	69	25	25
Bus	65	65	61	83	83	7
LHDT	70	81	72	69	23	25
MHDT	70	80	72	68	23	25
HHDT	65	65	61	83	83	8



Source: World Bank 2014



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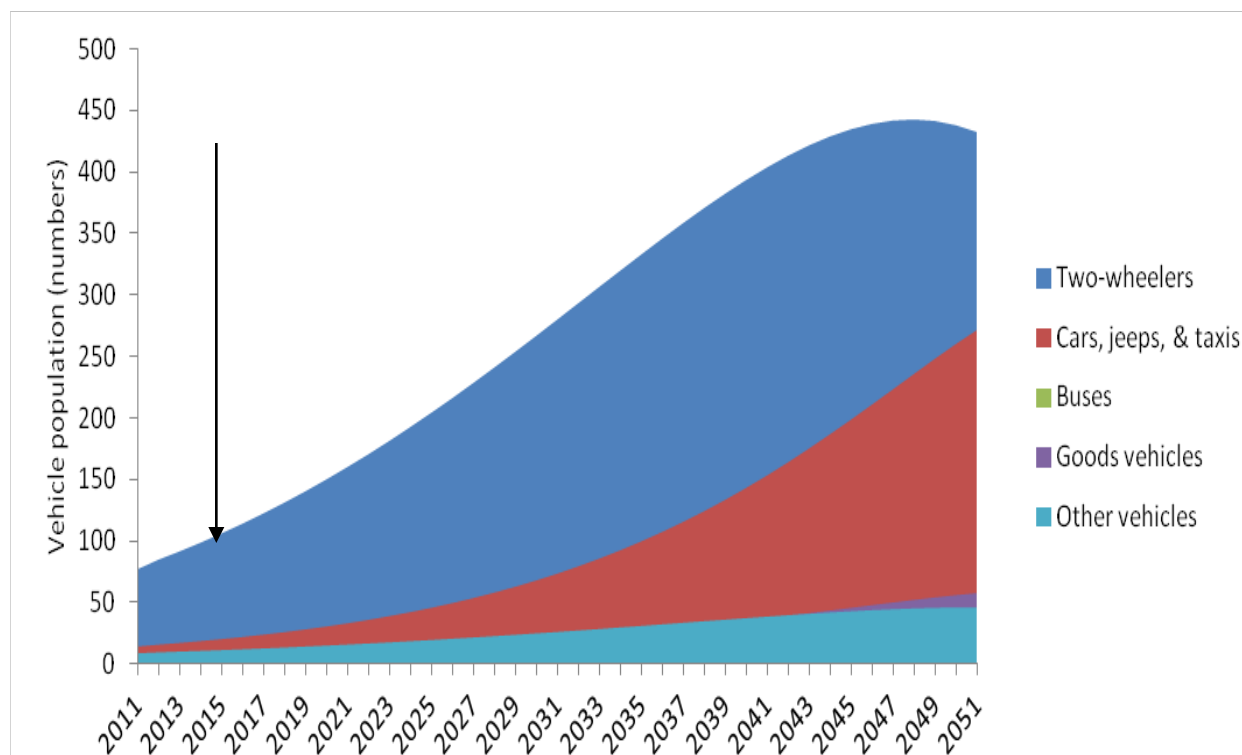


Importance of early action

New official proposal: Too little too late.....

- 2017-18: Euro IV nationwide
- 2020-21: Euro V nation-wide: (with 10 ppm sulphur fuels)
- 2024-25: Euro VI nation-wide

Need to leapfrog to Euro VI nation-wide in 2020



Source: CSE



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China: Taming diesel

- Dieselization of car fleet has not been such a problem. Very small differential between diesel and petrol prices.
- As a policy matter government officials have discouraged light duty diesels. Diesel cars banned in Beijing.
- Proposal from China's Ministry of Environmental Protection (MEP) State Council to introduce 10 PPM sulphur fuel by end of 2017.
- Proposal of quicker steps in key regions.
- Beijing has already introduced Euro V emissions standards.





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Diesel in Europe.. A mistake?

Massive dieselisation in Europe – 50-75%

- Price differential between diesel and petrol; high taxation that puts premium in fuel economy and CO2 mitigation and fuel efficient car led to this.....

Recent rethink on diesel in Europe:

- Directive of the European Court of Justice on violation of air pollution standards in UK. Implications for rest of Europe

Vehicle tax rates introduced in UK in 2001 that incentivised diesel vehicles but penalised petrol cars to reduce CO2 has now been dubbed as a '**Blunder**'...

- France to phase out diesel cars. French Premier says diesel was a '**mistake**'





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European trajectory: Post Euro VI?

Euro VI + action on off-road sources
and ships + walk + cycle+ public
transport + compact city
design.....





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The US moving towards technology forcing regulations...

- Car segment has not dieselized as it has in Europe.
- The US does not maintain differential between petrol and diesel prices. Consumer preference has remained in favour of petrol vehicles.
- The US also sets the same NOx standard for diesel cars as for petrol cars.
- Relatively higher diesel penetration in the recent years has coincided with the introduction of tighter emissions standards of Tier II.
- **Heavy duty truck and bus fleet as well as off-road vehicles are an important source of black carbon emissions.**





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The US trajectory....Post Tier II?

Tier 3 emissions standards: move technology trajectory towards zero emissions

California's black carbon mitigation programme:

- Mitigation of in-use emissions programme for heavy duty vehicles -- retrofitting or re-powering of old diesel engines,
- Reducing emissions from off-road vehicles and non-road transport; Marine pollution.
- Focus on rail based freight movement.





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Opportunities in vehicle importing countries...





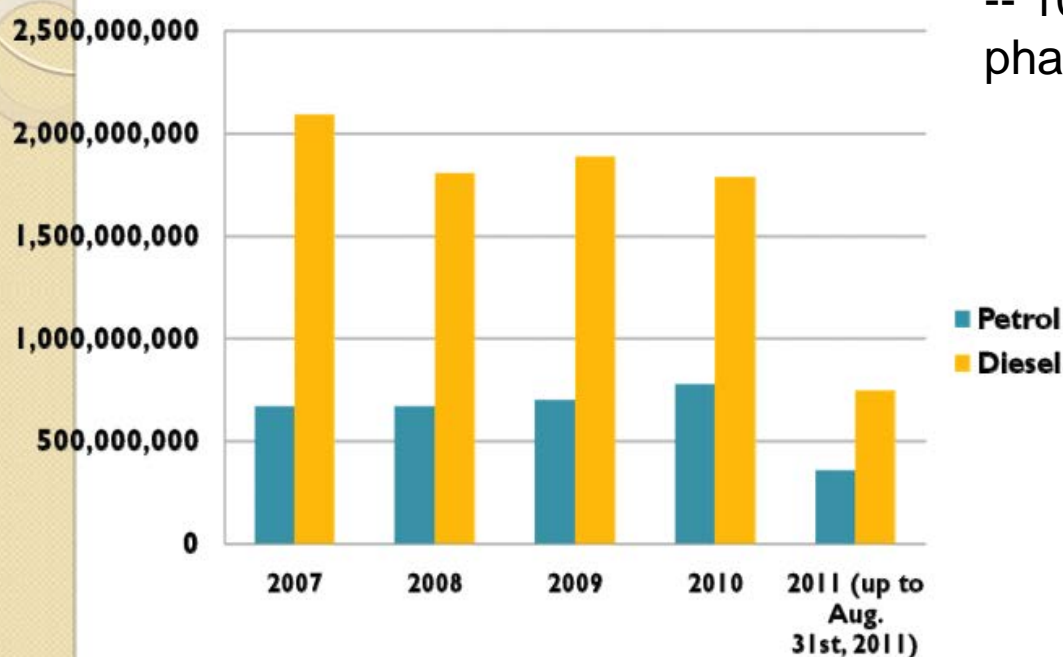
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Sri Lanka: Remarkable impact of fiscal measures on diesel market

- High import duty etc on all cars.
- Double the tax on diesel cars
- Tax concession for hybrids
- 10 ppm sulphur diesel phase-in started...

Change of Fuel Consumption





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Emerging roadmap in Africa region

An opportunity.....

Action on low sulphur fuels: Since January 2015:

East Africa: Kenya, Uganda, Rwanda, Burundi and Tanzania moved to 50 ppm.

North Africa: Morocco, Tunisia and Mauritius have met 50 ppm or below target

Nigeria and South Africa: Euro II emissions standards

South Africa to leapfrog to 10 ppm by 2017. Six refineries to build capacity. Proposed to meet EU 5 Vehicle emissions





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Importance of early action

India– Due to the emissions standards roadmap in force, the black carbon emissions in 2015 are nearly 47% lower than they would have in the absence of the policy. (ICCT Estimates)

Saved more than 6,300 premature deaths in India's 337 largest cities because of PM_{2.5} reductions in 2010. This translated into economic benefits of about Rs. 50,000 crore in 2010 -- 0.7 of India's GDP that year.

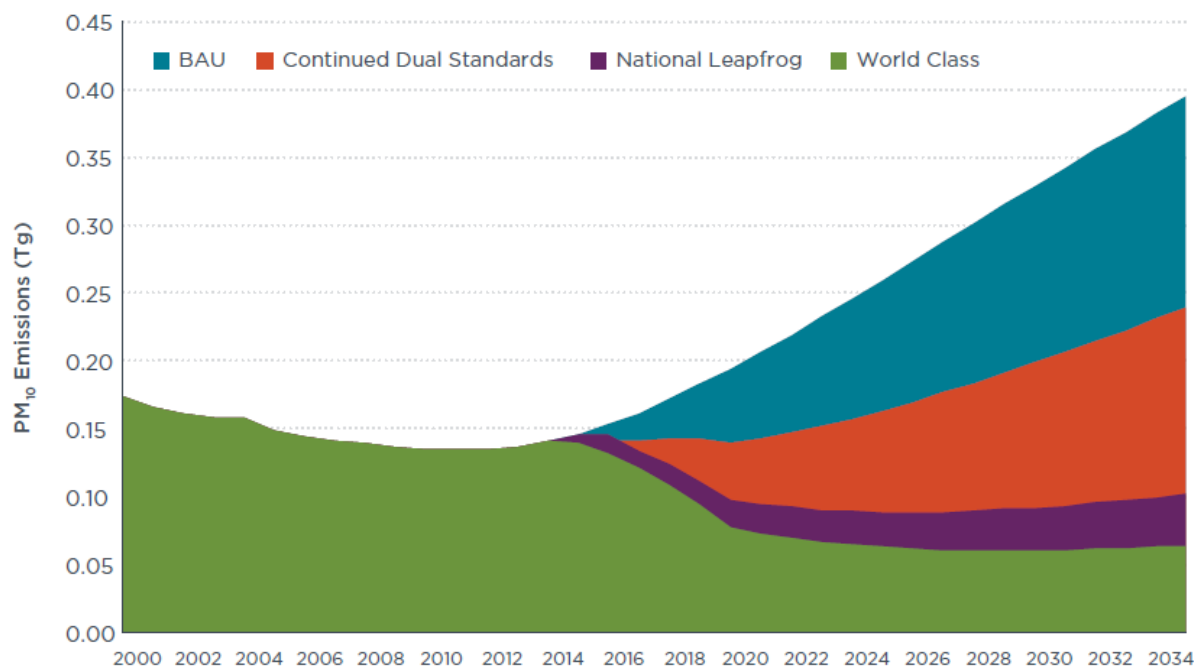


Figure ES-7: Projected total PM₁₀ emissions with further policy action (2010–2035)

Source: ICCT



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**Lessons: -- Opportunity in technology
leapfrog and mobility transition.....**



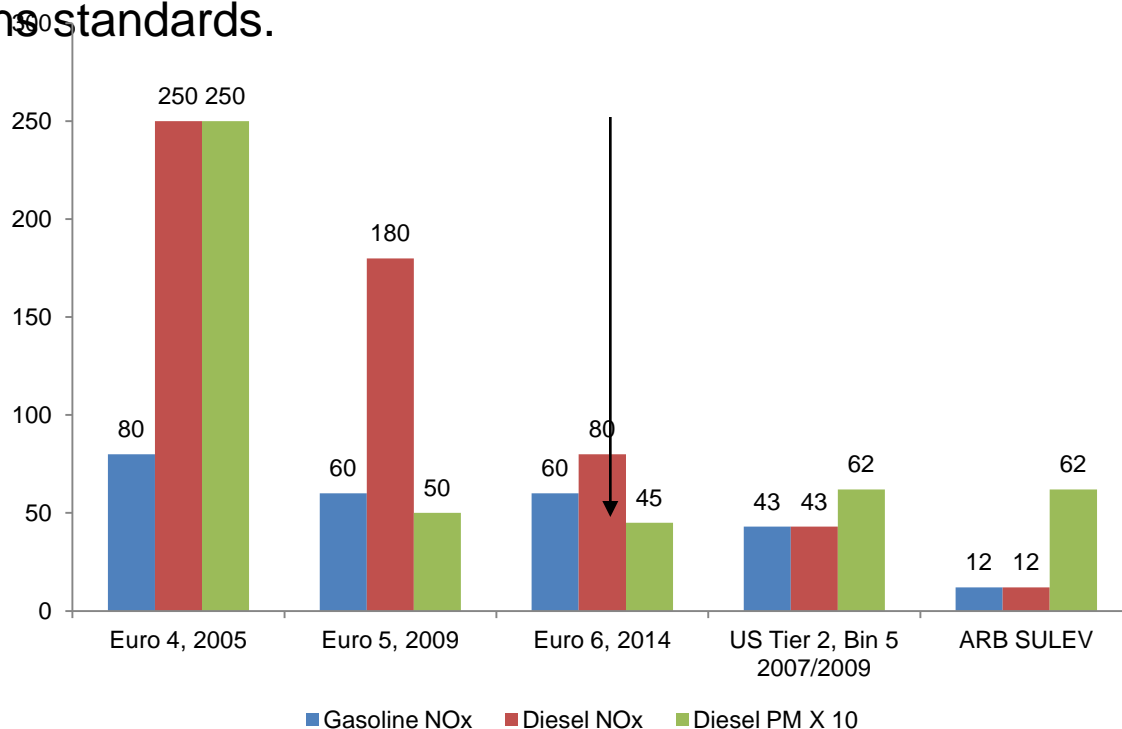


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Need leapfrog...

- **Euro VI** -- NOx limits for diesel and petrol vehicles narrow down but remain. Has more stringent limits for heavy duty vehicles.
- Particle number standards force use of a diesel particulate filter in heavy duty vehicles.
- Need stringent in-use vehicle regulations and compliance programme
- Fleet renewal programme for heavy duty vehicles based on stringent emissions standards.





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Increased vehicle activity.....Need mobility transition

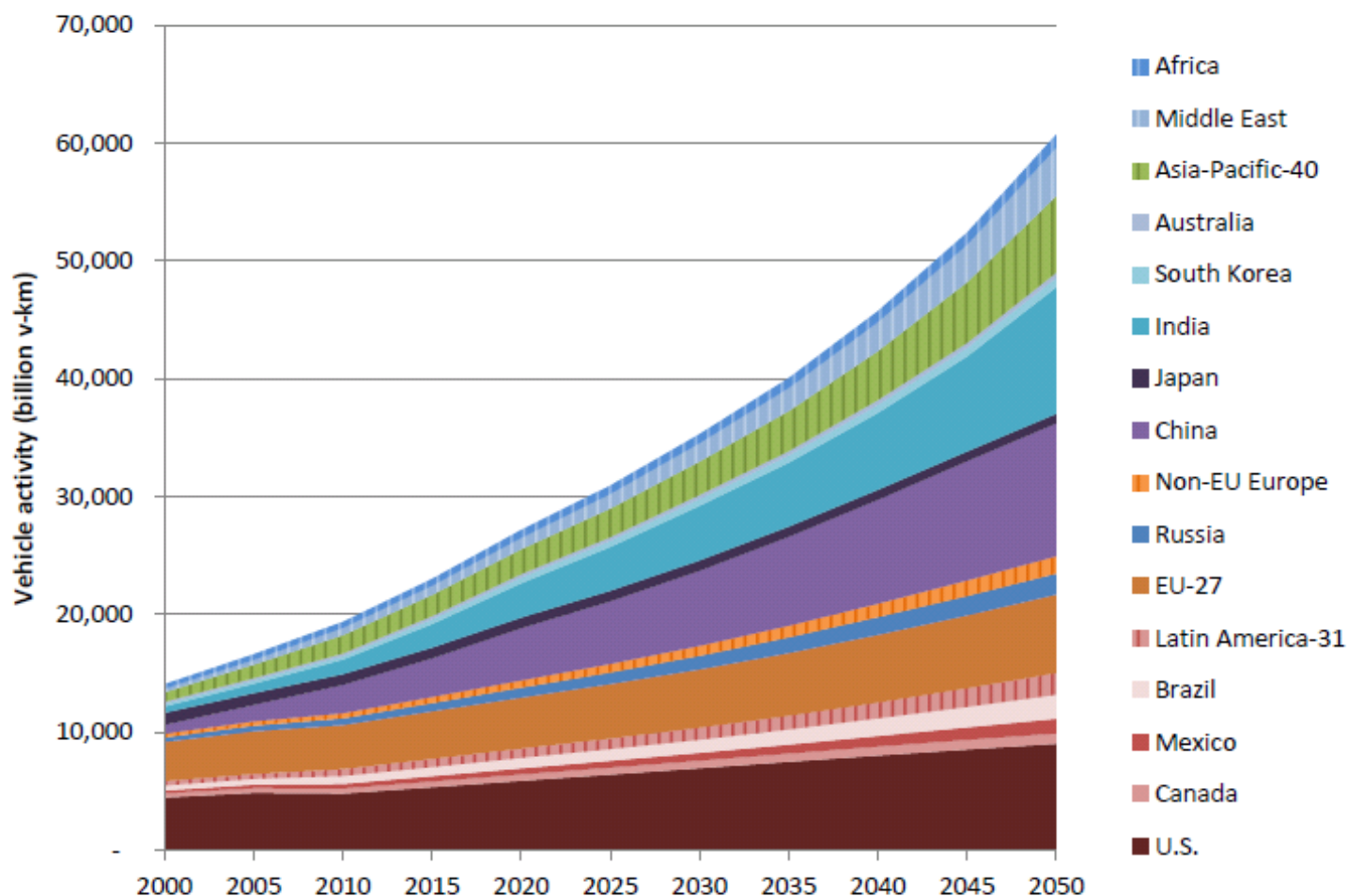


Figure 1-2: Vehicle Activity Forecast By Region, to 2050. Source: Data from Facanha et al. (2012).

Source: World Bank 2014



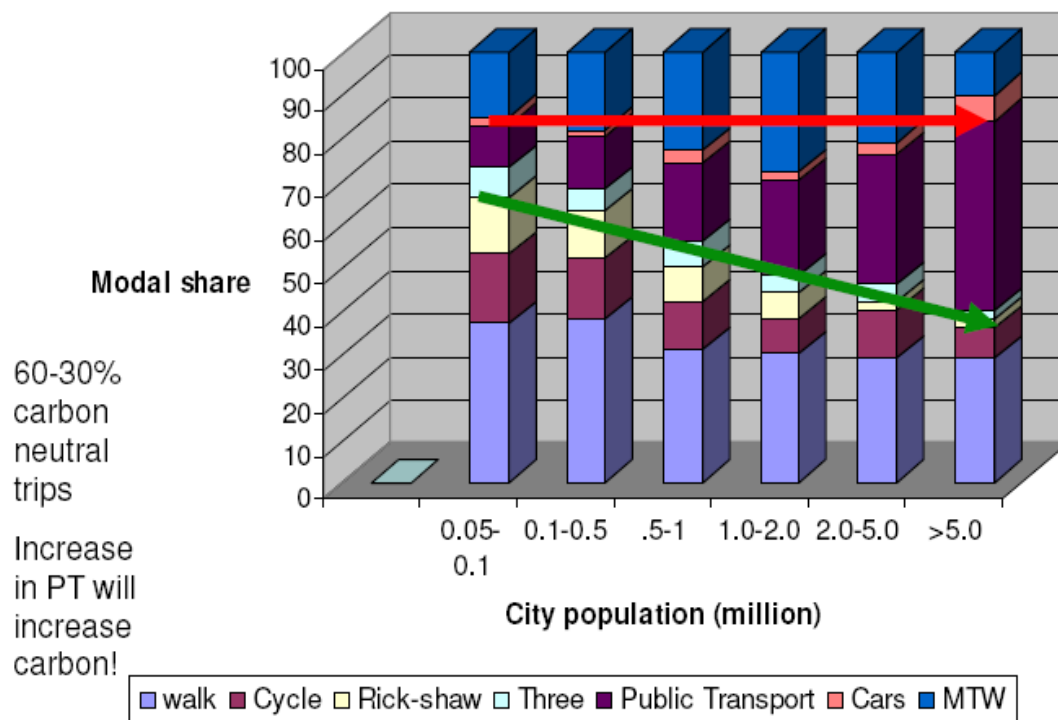
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India's opportunity: Reinvent mobility

Majority in India walk, cycle and use public transport.
Protect this baseline and improve.....Need preventive action

Urban Mobility

PT and NMV based, MTW majority personal vehicles





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Integrate co-benefit indicators with air pollution regulations

World Bank study for India (July, 2013):

- Outdoor air pollution is 29% of the total environmental damages
- Health cost of PM10 – 3% of GDP
- PM10 mitigation cost less than 1% of GDP
- Annual savings from health benefits can be more than USD 100 billion.. And CO2 emissions can be reduced by upto 60%





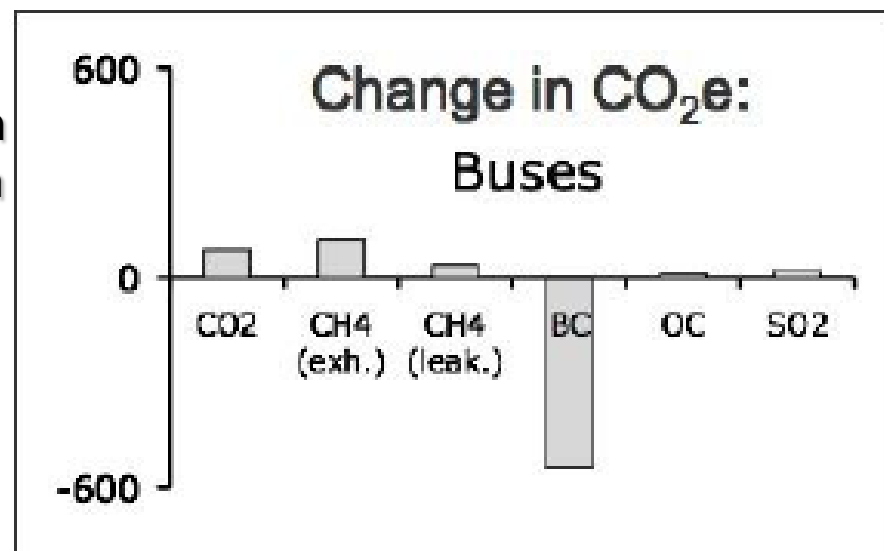
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Co-benefit from Delhi CNG bus programme

Delhi CNG programme

New study shows that in comparison with the warming potential of black carbon emissions from the older diesel fleet, CNG has been less warming.....

- When black carbon from diesel is not considered estimated CO₂ (e) increase due to switch
- When black carbon is taken neutral Upto 30% reduction in



Source: Conor Reynolds and M
Kandlikar, British Columbia
2008





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Action on diesel black carbon is a win-win....

- Need upward harmonisation
- **Leapfrog emission standards.** National roadmap to accelerate move towards Euro VI vehicles and fuels (with 10 ppm sulphur fuels).
- **Need investments in refineries to produce clean fuels**
- **Need fiscal measures** to accelerate the roadmap.
- **Accelerate fleet turn over of heavy duty vehicles linked to stringent emissions standards.**
- **Reinvent mobility – walk, cycle, use public transport.**
- **Build compact cities** to reduce vehicle miles travelled
- **Increase the share of rail based passenger and freight transport**
- **Phase in action on off-road and non-road transport emissions**

Leverage the opportunity for co-benefits of health and climate





Thank You.....