Transport Sector in India

Carbon Emissions:

Technology Mitigation Options through 2030

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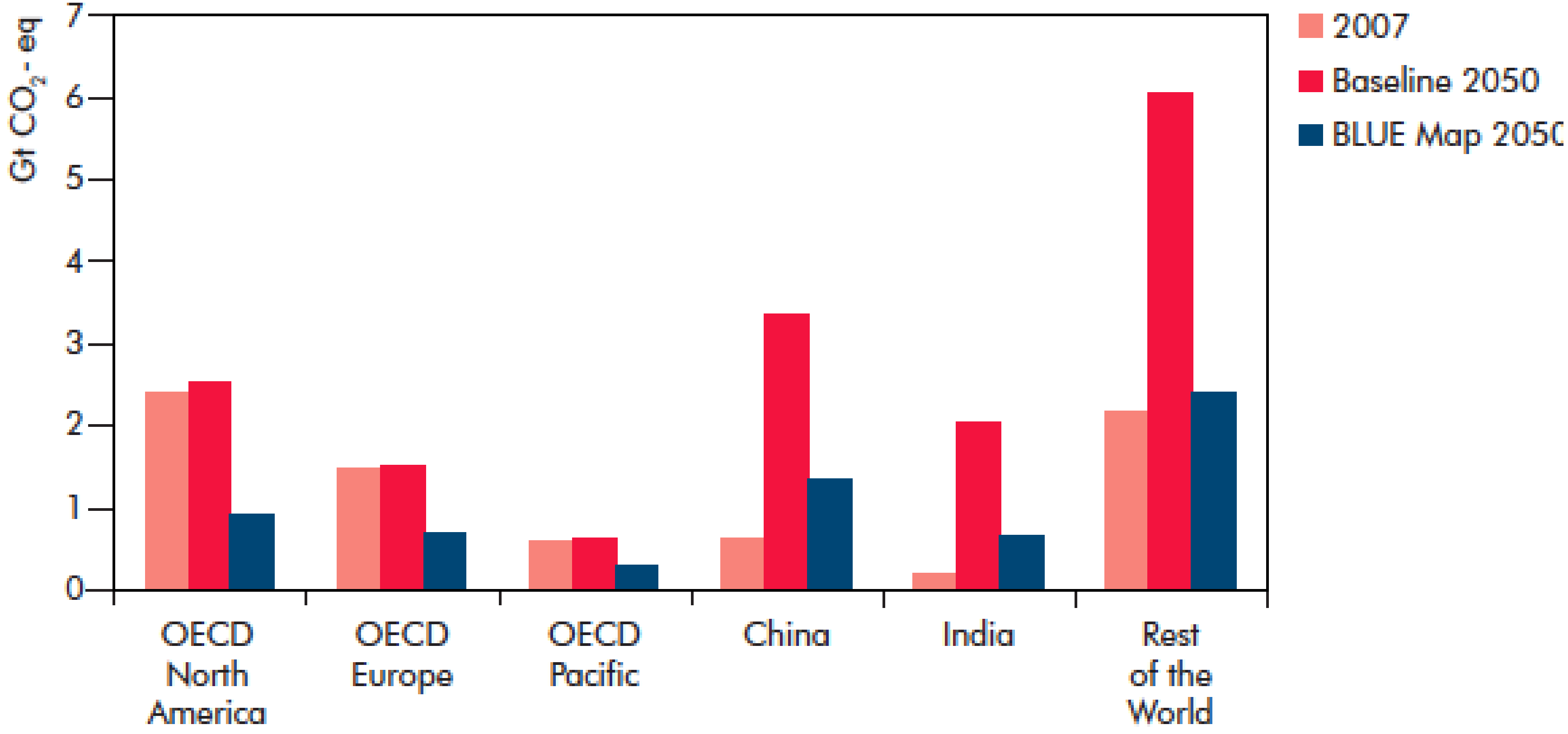
GHG emissions from the Transport Sector

- Worldwide:
  - 23% of all energy related CO2 emissions in 2007 (~8 Gt)
  - Expected to grow to 14 Gt (2050) in the baseline scenario of IEA
  - Blue Shift scenario saves 2 Gt by 2050 and Blue Map scenario saves 9 Gt by 2050. For the Blue Map scenario, 50% of the reduction is due to efficiency improvements and the rest through fuel shifts away from fossil fuels to biofuels, electricity and hydrogen.
- In India:
  - 7.5% of national overall GHG emissions in 2007 (~142 Gt)
  - Expected to grow >10X by 2050 in the baseline scenario
  - Expected to grow ~6X by 2050 even in the Blue Map scenario
  - Expected to grow ~8X by 2050 in the Blue Shift scenario

Source: IEA MoMo model – ETP 2011

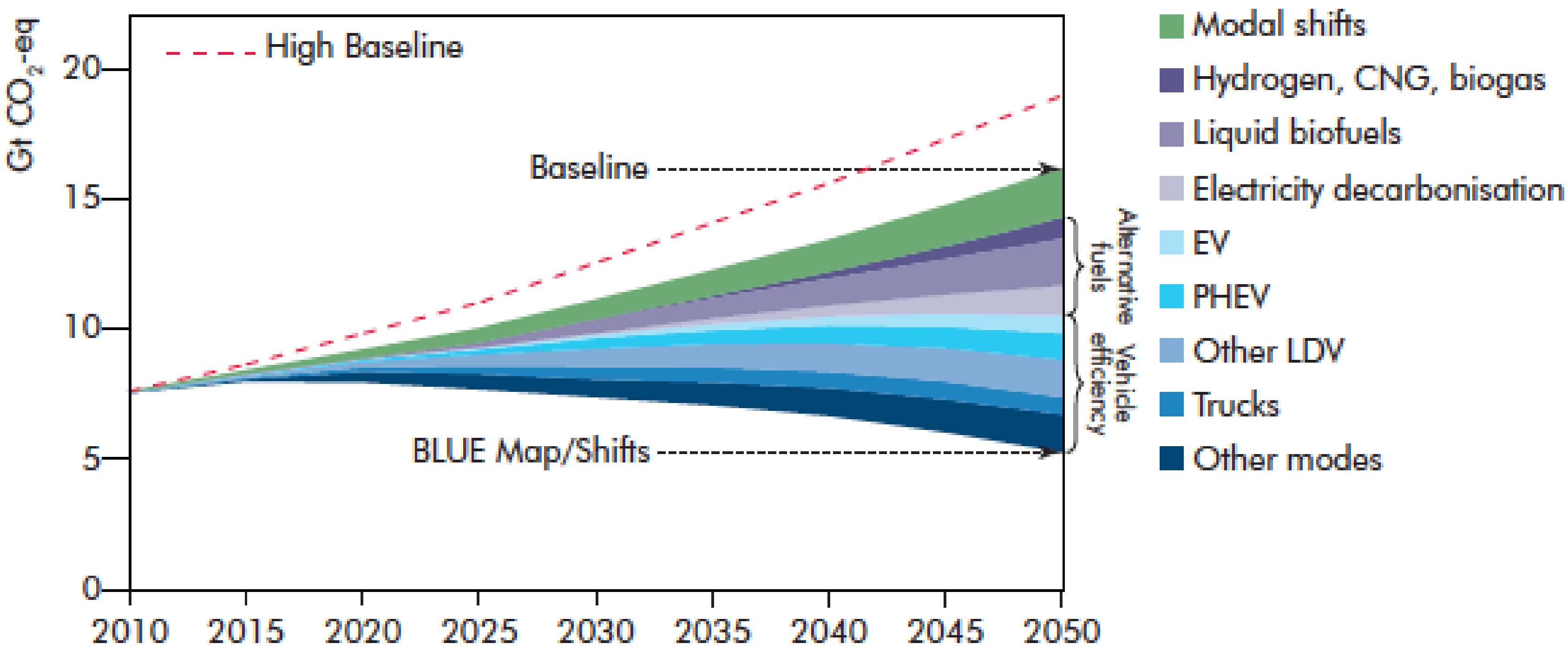
Figure 7.12 ▶ **Well-to-wheel transport CO_2-equivalent emissions by region and by scenario**



Source: IEA MoMo model – ETP 2011

Worldwide mitigation scenarios

Figure 7.11 ▶ Sources of greenhouse-gas emissions reduction, transport sector

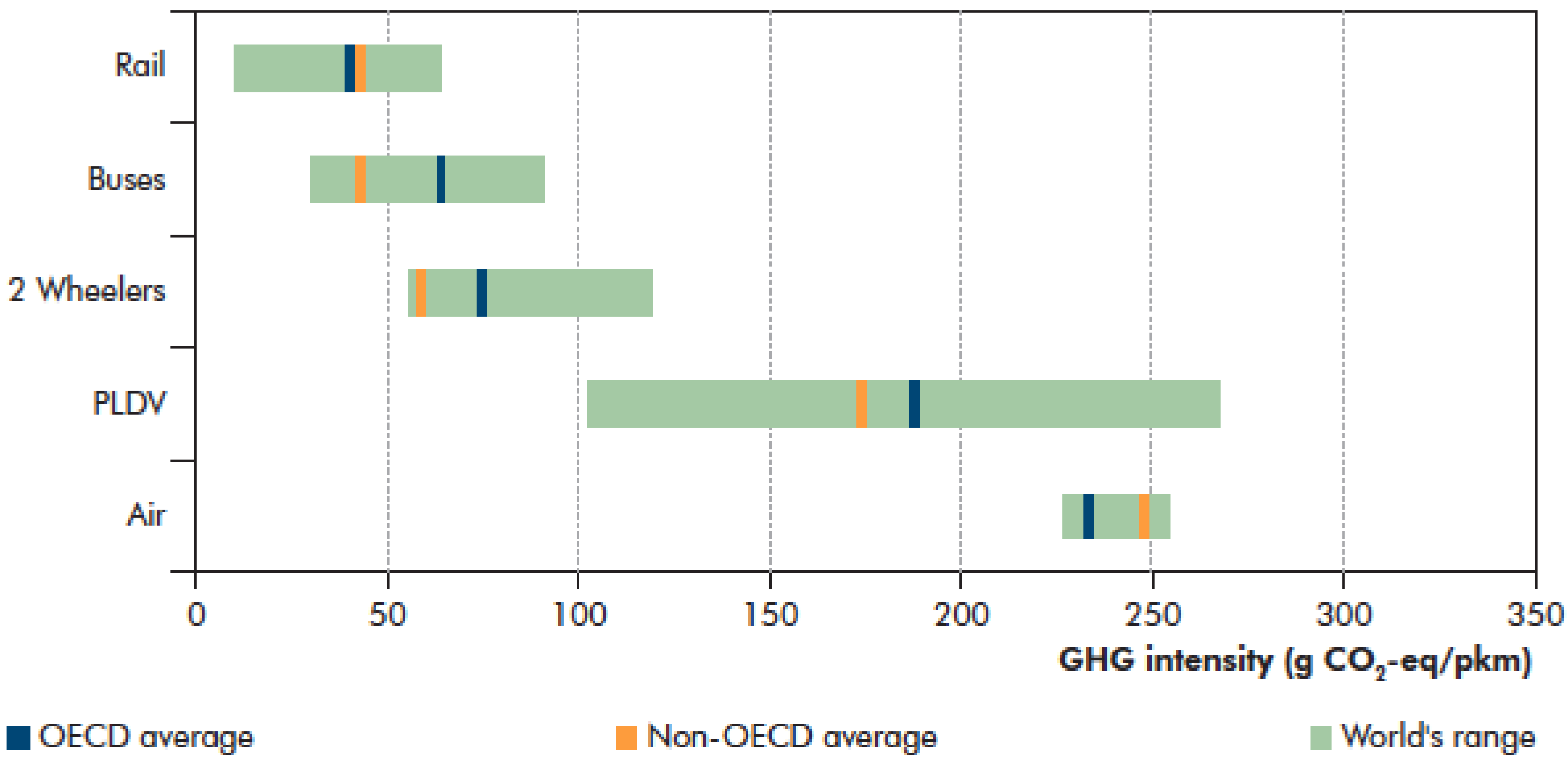


Source: IEA MoMo model

Options for Mitigation

- Avoid
- Shift
- Improve
  - Vehicle efficiency improvements
  - Advanced Vehicles and Fuels

World-wide vehicle efficiency variations



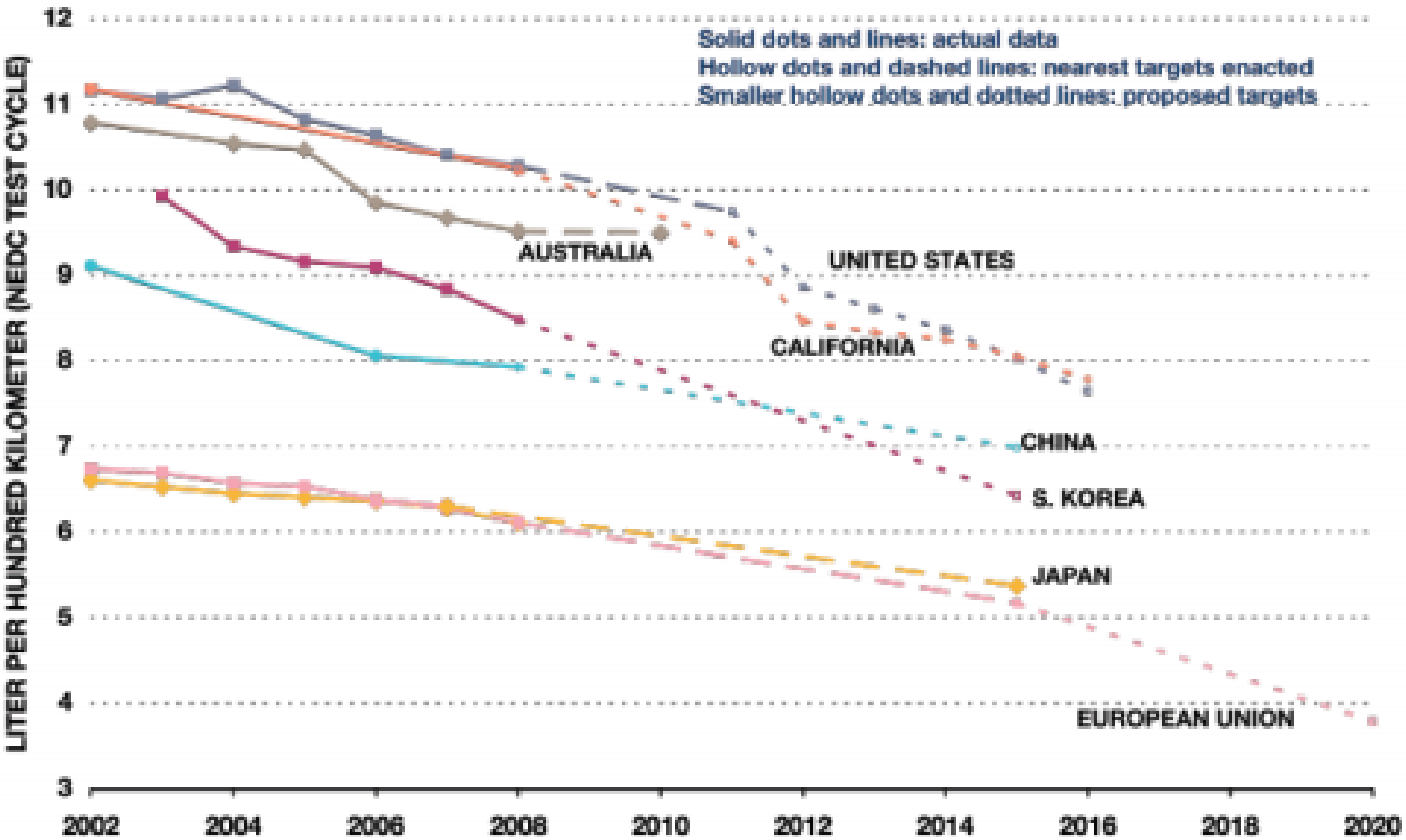
Sources: IEA MoMo database; Buhaug *et al.* (2008).

How are fuel consumption and CO_2 emissions related?

- A vehicle consuming 10 liters of gasoline for travelling 100 Kms is emitting ~230 gms of CO_2 per Km.
- At the moment, India seems to be well poised as far as CO_2 emissions per Km for cars are concerned (~6 liters/100 km).

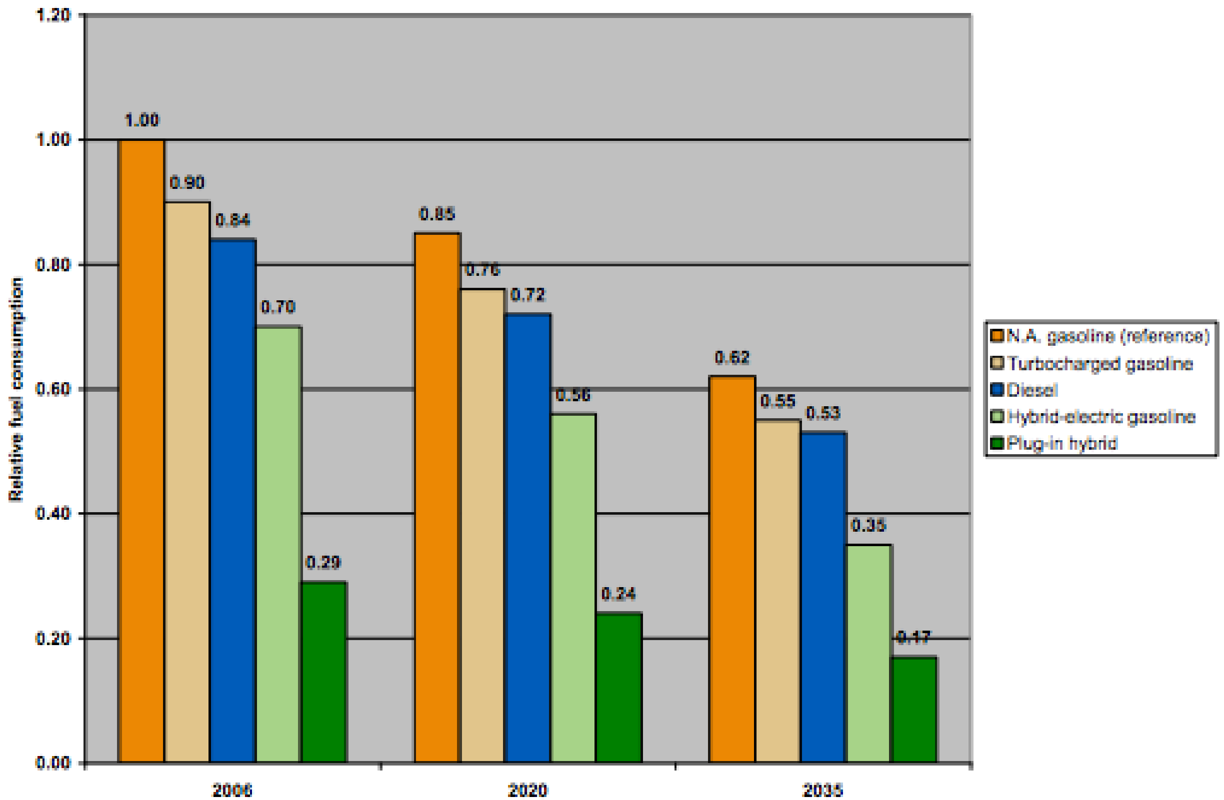
However, this is attributable to lower average vehicle weights in India.

Efficiency targets by some major vehicle producing regions



Technology Potentials

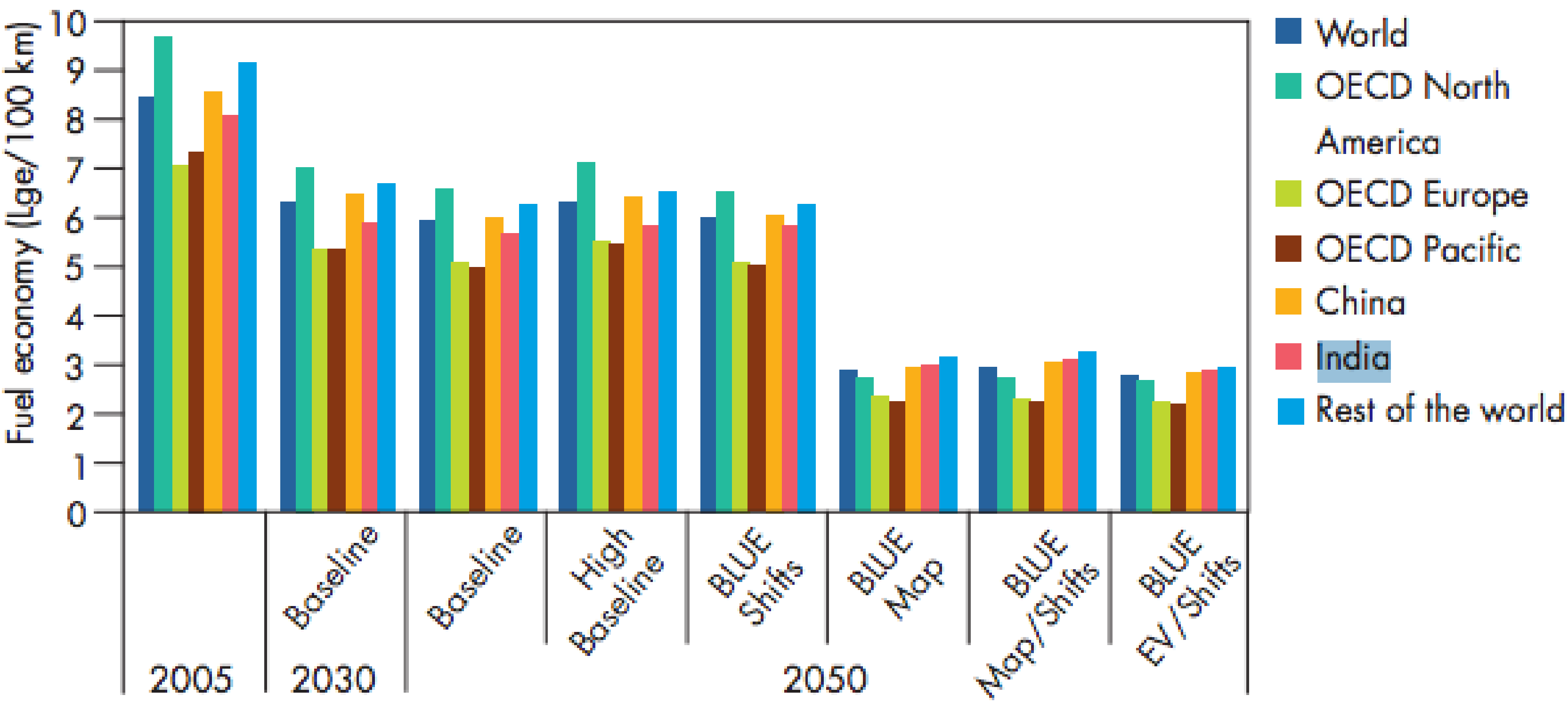
Figure 5. **Potential reduction in fuel consumption of new US LDVs by MY2020 and MY2035 relative to MY2006 using different powertrain types**



Source: Compiled from NRC, 2009

What does the future look like?

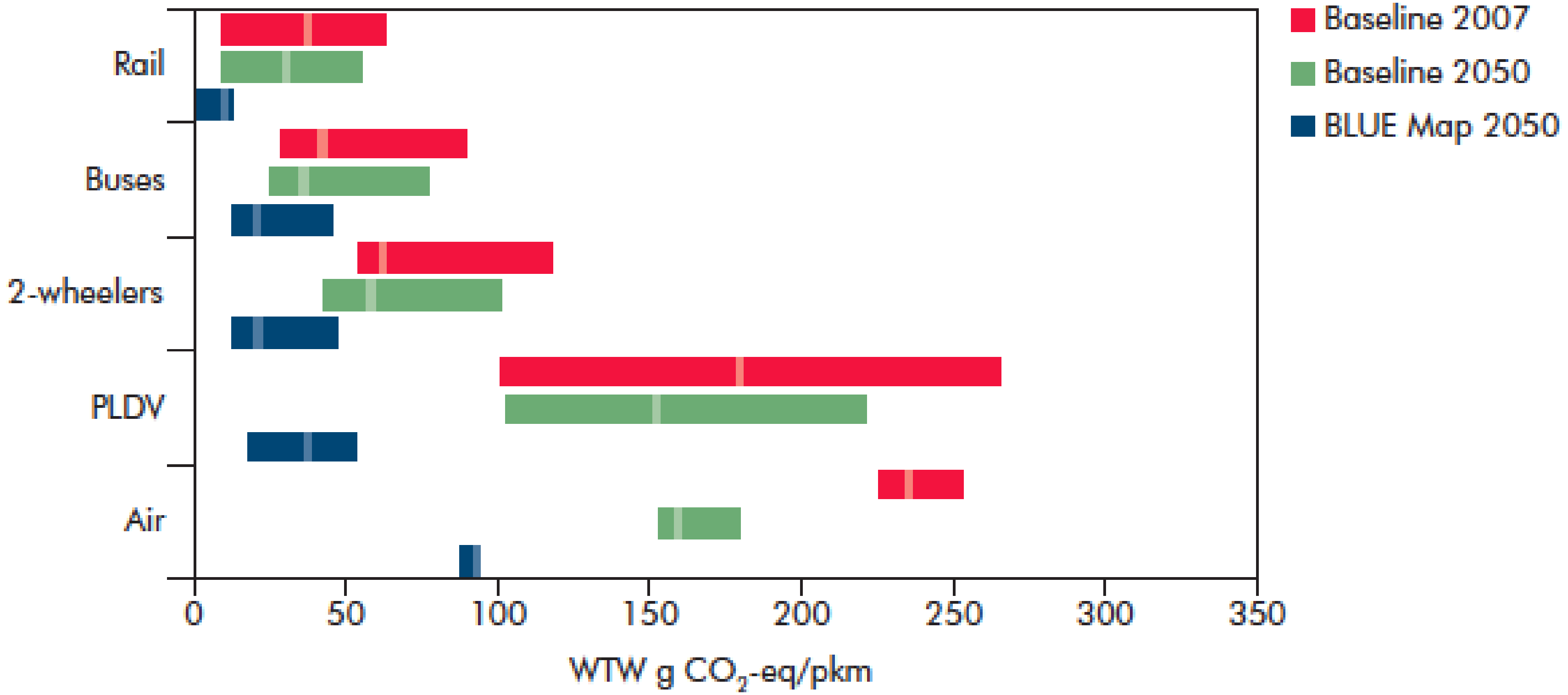
Figure 3.12 ▶ **New LDV tested fuel economy for selected regions, 2005-2050**



Source: IEA MoMo model – ETP 2011

What does the future look like?

Figure 7.17 ▶ Evolution of the greenhouse-gas intensity of passenger transport modes



Source: IEA MoMo model

India’s options and likely adoptions by 2030 (1)

- More efficient Internal Combustion Engines (ICEs)
  - For every gram of gasoline/diesel/CNG etc. that is burnt in the combustion chamber, there is 3.7 grams of CO_2 produced.
  - Improvements in Gasoline spark-ignition engines (turbocharging, down-sizing)
  - Improvements in Diesel compression-ignition engines (turbocharging)
  - Transmission improvements (more gears, better lubricants, hydraulics, CVTs)
  - Weight and Size reduction
  - Rolling resistance and air drag reduction

The driving factors

- Policy (Efficiency norms, Focused support)
- Fuel Prices
- Global technology improvements
- Global diffusion rates

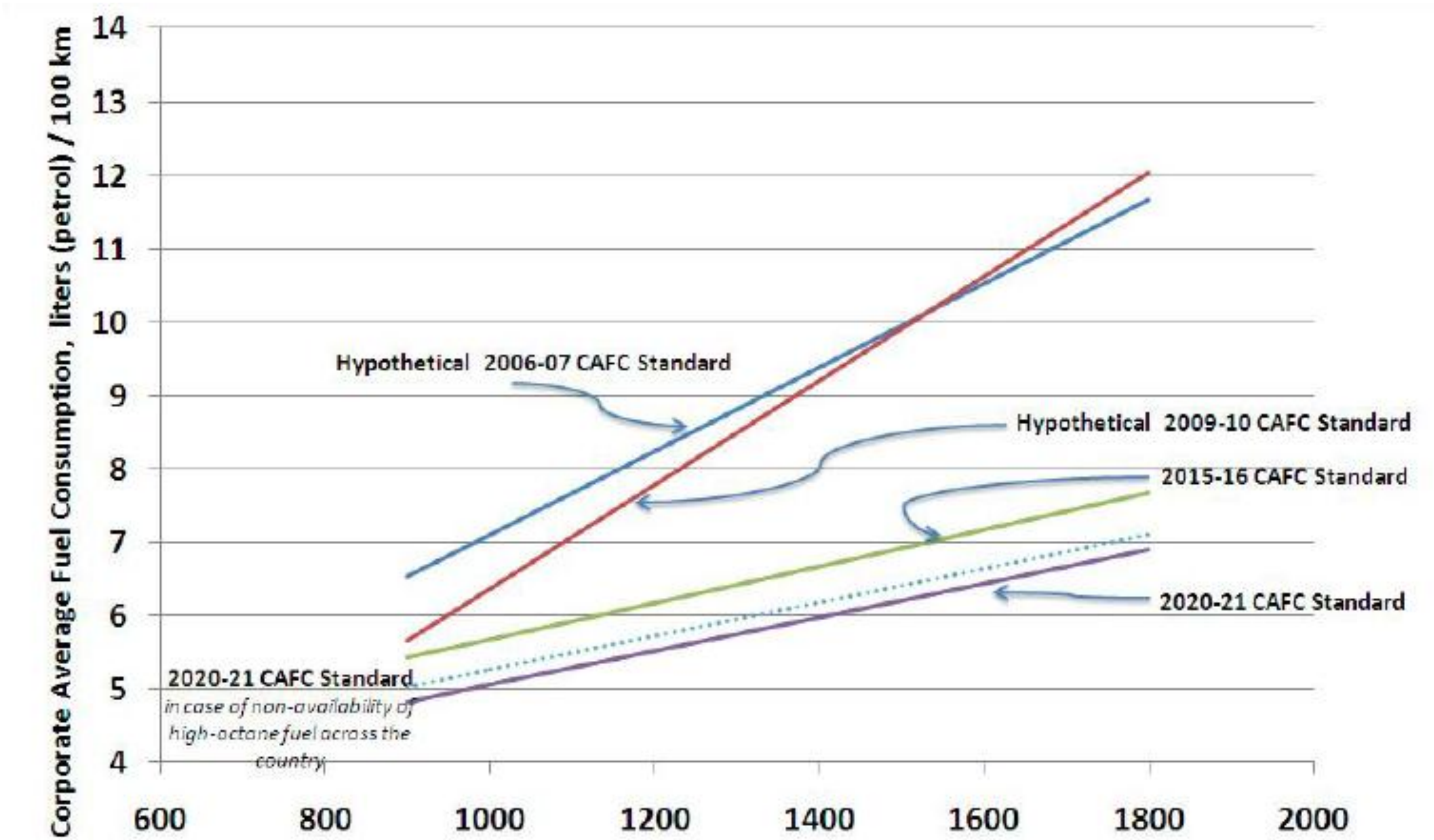
Fuel Economy Standards for India

- Between 2007 and 2010, the car industry has already improved its average fuel economy from 6.53 litre per 100 km to 6 litre per 100 km in 2010 – an improvement of 2.8 per cent a year (CSE assessments)
- BEE has released a consultation paper ‘Passenger Car Fuel Economy Labeling and Standards’ with economy standards for passenger cars

Standards and Labeling of Fuel Consumption in Cars (BEE draft)

- Medium and long term fuel consumption standards for new cars to provide a regulatory signal to manufacturers to continuously reduce the fuel consumption of cars sold by them over the next 10 year period
- Labeling of all new cars with labels providing information on fuel consumption and its relative fuel consumption relative to other models of the same weight class
- Each manufacturer would need to ensure that the Corporate Average Fuel Consumption (CAFC) of all cars sold by them is less than that specified by the CAFC standard corresponding to the average vehicle weight sold by them in that year.
- Consumption reduction envisaged as occurring through improvements to conventional technologies (not by xEVs)

BEE Consultation draft



Source: BEE consultation draft on 'Passenger Car Fuel Economy Labeling and Standards'

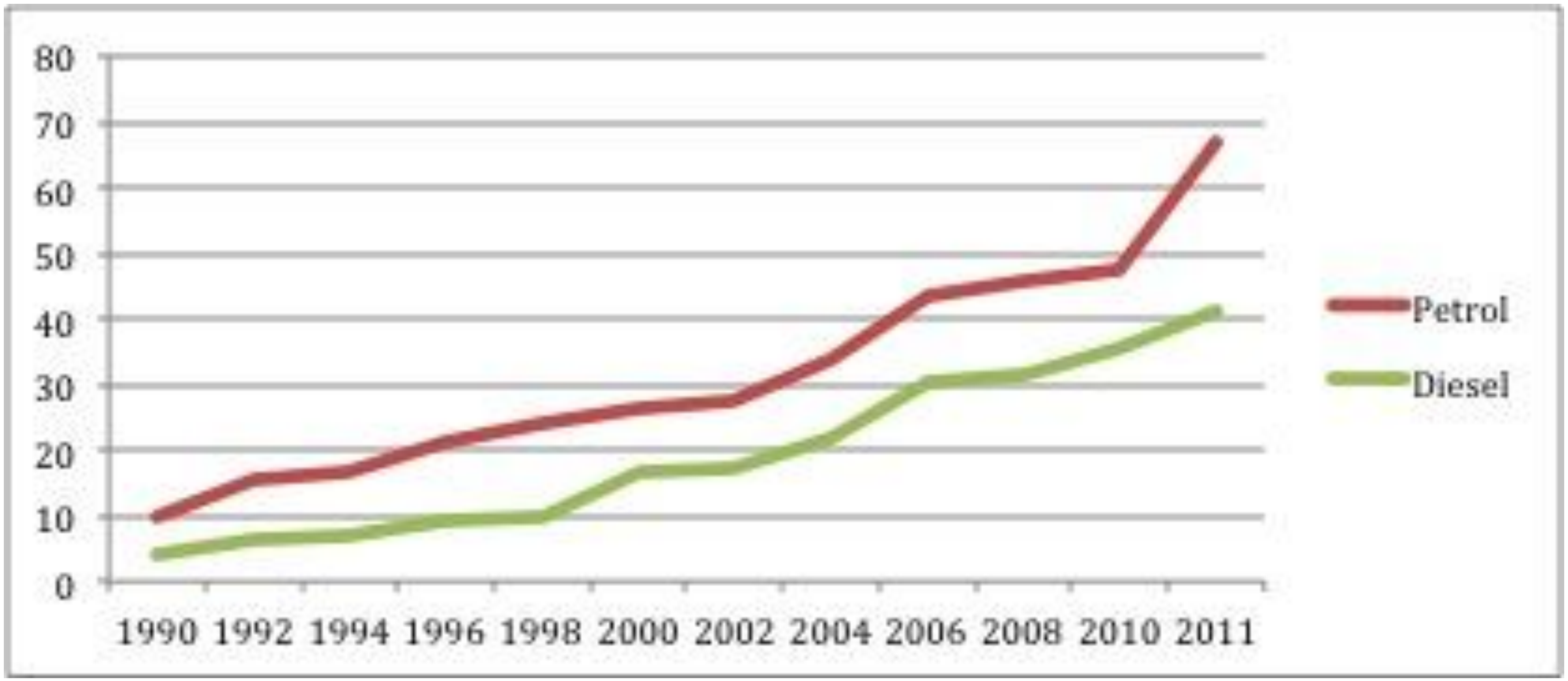
Comparison of emission (CO_2gm/km) target in key vehicle producing regions

- Improvements in fuel economy mandated by the standards are less stringent in the case of smaller cars (which comprise a bulk of Indian car sales)
- Some of the manufacturers are already above the proposed 2015 standards. Some criticism by NGOs for setting the bar low

Countries	2010	2020
EU	145	95
US	187	121
China	179	117
Japan	130	105
India	141	122 (?)

Source: http://www.downtoearth.org.in/content/fuel-economy-standards-non-starter

Fuel Prices (INR/Lt)



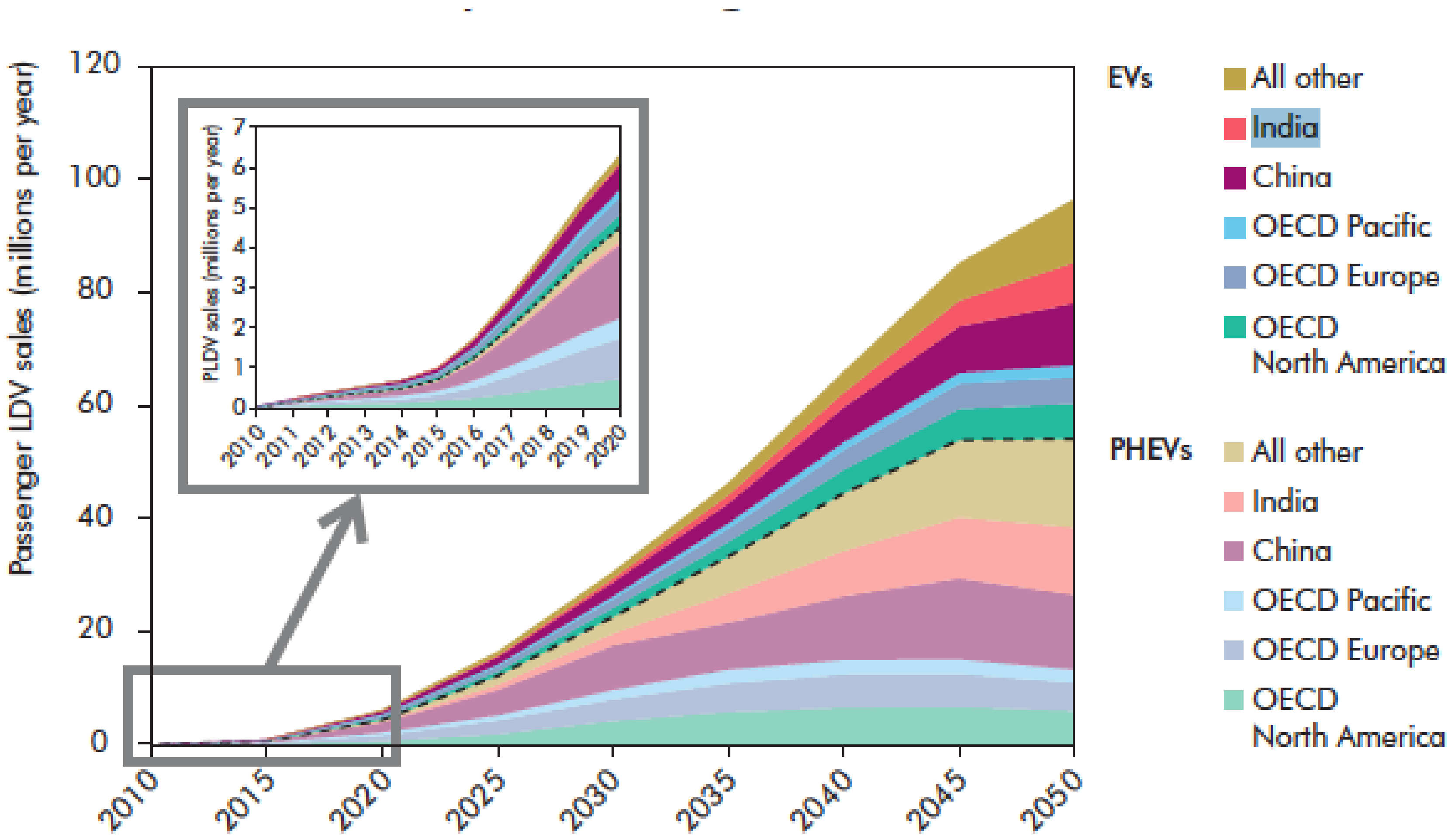
India vis-à-vis Developed countries

- On-set of advanced technologies experiences a time-lag in the Indian market (e.g. Hybrids started in US, Japan in early 2000 – still no market in India)
- The diffusion rates of technologies are slower (more so since some of the efficiency improvement technologies are rather expensive)
- Global diffusion rates and technology evolution would influence the Indian adoption.

India’s options and likely adoptions by 2030 (2)

- Advanced Vehicles and Fuels
  - Hybrid Gasoline
  - Hybrid Diesel
  - Plug-in Hybrid Gasoline
  - Plug-in Hybrid Diesel
  - CNG and LPG
  - Pure EV
  - Hydrogen Hybrid ICE
  - Hydrogen Fuel Cell

EVs and PHEVs



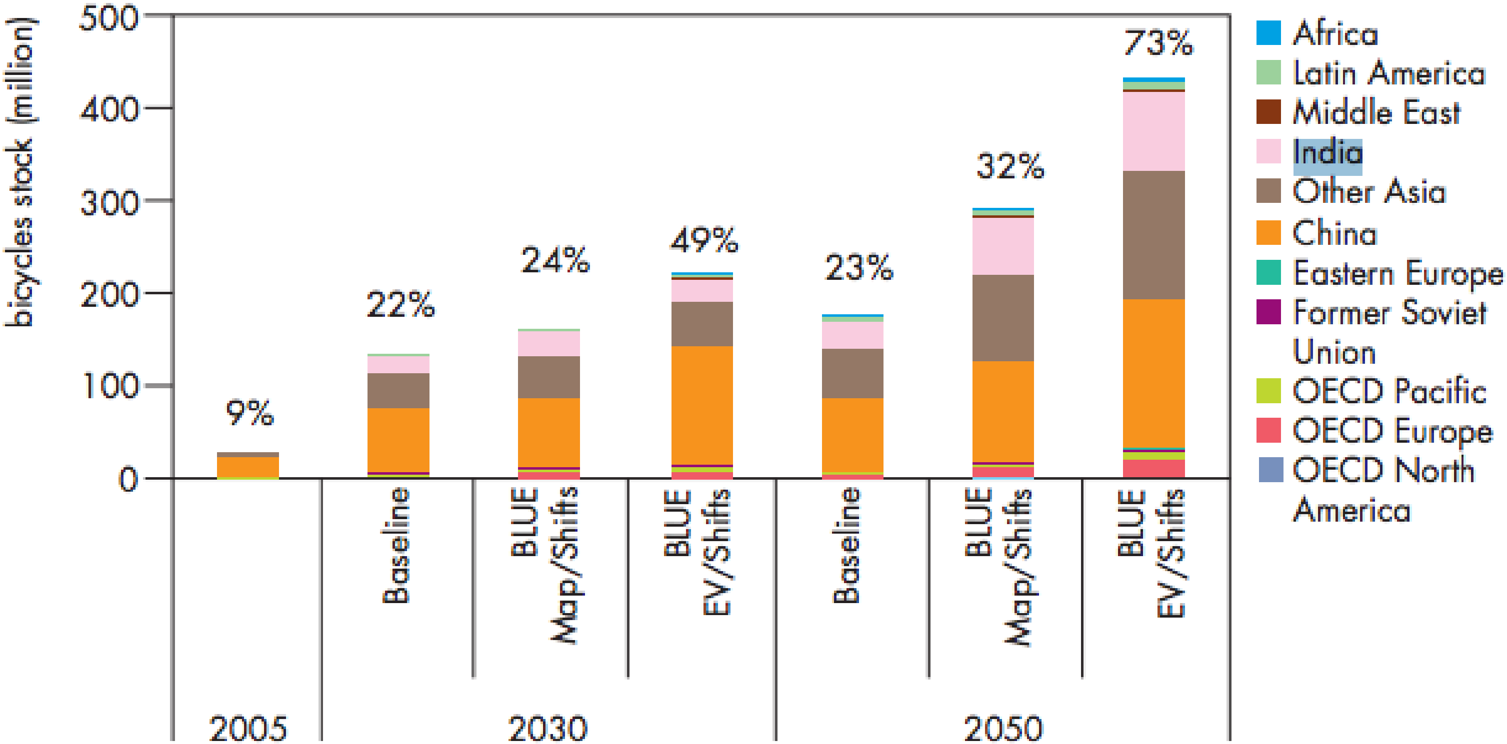
IEA MoMo model

Advanced Vehicles and Fuels (India)

- Hybrids (with stop-start, regenerative braking) begin to appear around 2015 with Plug-in hybrids not appearing anytime before 2020 on a significant scale.
- Significant penetration of pure EVs unlikely before 2030 (unless a technology breakthrough drastically improves battery performance and reduces cost)
- Hydrogen Fuel Cell vehicles very unlikely by 2030.

Two-wheelers

Figure 5.19 ▶ Electric two-wheelers stock evolution and share, by region



Source : IEA Mobility Model.

Technological Complexity and Battery Sizes

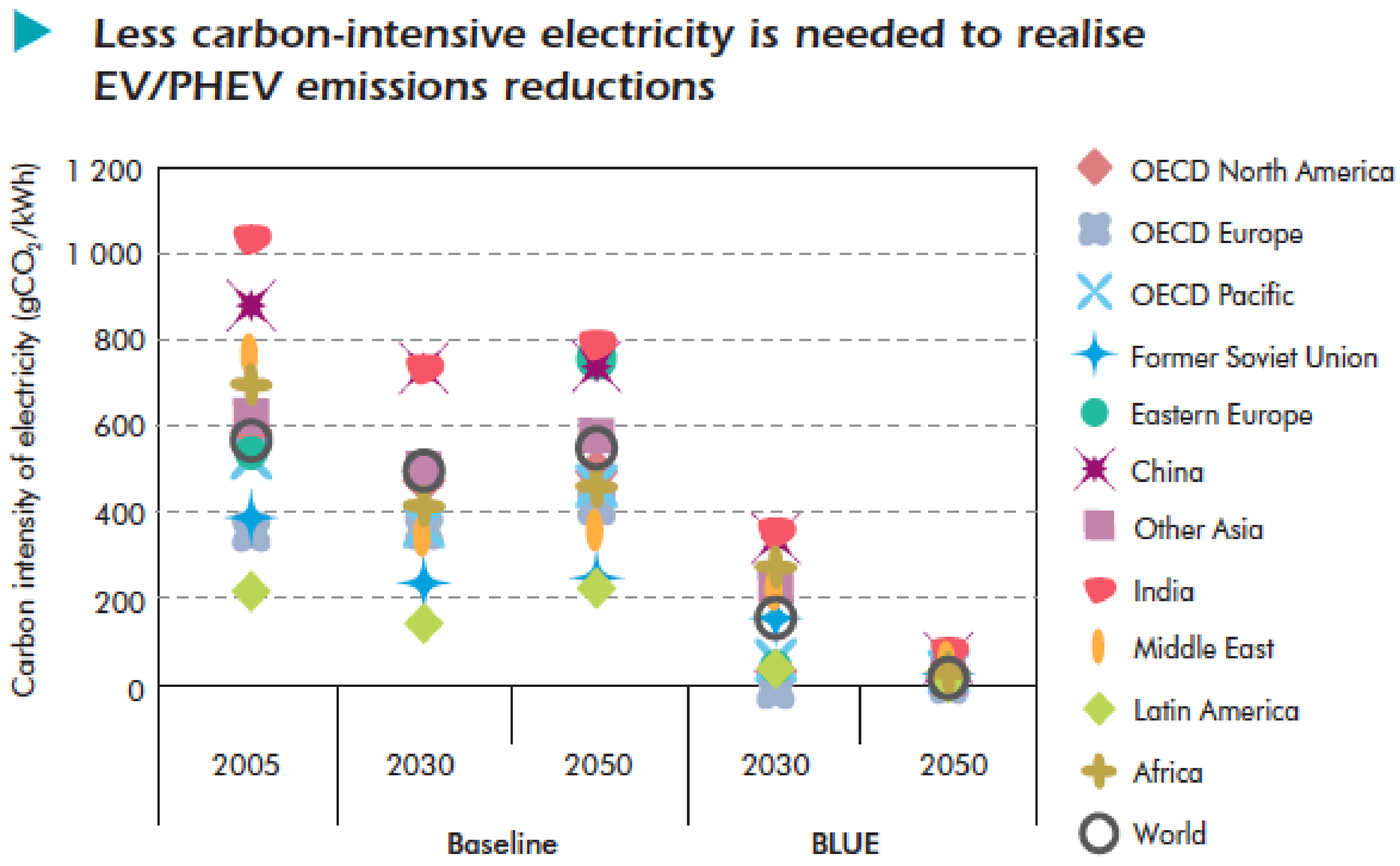
Bio-fuels

- Up to 30% blending in transport fuel by 2050 (IEA assumption) leading to a 4% reduction in India's overall GHG emissions (ETP 2010)
- McKinsey (2009) projects a 5% reduction in oil consumption by the Transport sector by 2030 due to biofuels mixing
- Biofuels blending is expected to mitigate 17 million tonnes of CO_2 by 2030

Significant GHG mitigation contributions (till 2030) by…

- Two wheeler xEVs
  - Hybrids up to 50% more efficient over baseline
  - EVs
- Mild-hybrids (through improved efficiency)
  - Efficiency improvement by 14%-18%
- Parallel full hybrids
  - Efficiency improvement by up to 30%
- Plug-in hybrids

However, an average Indian KWh is very carbon intensive



Source: ETP 2010

The electricity source conundrum

- Even if EVs and PHEVs were to be deployed in large numbers, would that really lead to GHG mitigation in India?
- Even in the most optimistic renewable deployment scenarios, Indian electricity is expected to remain significantly CO_2 intensive

CO_2 emissions intensity ($g\ CO_2$ /km) reduction by 2030 (%)

Technology mitigation option		**Average Penetration**	**Likely efficiency gain**	**Relevant factors**
Improvements to IC Engines		30%-50%	20%-25%	Global diffusion curves & technology evolution, Policy, Fuel prices
HEVs	Mild	10%	10%-15%	Global diffusion curves & technology evolution, Policy, Fuel prices
	Full	1%	20%-30%	Global diffusion curves & technology evolution, Technology breakthroughs, Policy, Fuel prices
Pure EV		~0%	~0%	Technology breakthroughs
Bio-Fuels		5% reduction in oil consumption		Policy

Source: Assessments based on global technology penetration projections and diffusion rates.

Questions?

Back-up slides

Baseline, Blue Map and Blue Shift scenarios of the IEA

- Baseline Scenario – assumes no new policies are implemented
- Blue Map scenario – assumes global energy related GHG emissions are reduced to half their 2005 levels by 2050 (optimistic about all technologies)
- Blue Shift scenario – assumes travel is shifted towards more efficient modes and a modest reduction in total travel growth.

Reduction Potential for interventions (Cars)

Intervention	Projected Improvements in the US (by 2030)	Applicability to India	Projected improvements in India (by 2030)	Fractional Applicability to Indian fleet	Realizable overall reduction in g CO2 emissions/km by 2030 over 2009-10 (Baseline – 140)
Improvements in Gasoline SI Engines	25%-35%	50%	15%	50% (70%)	10.5 (14.8)
Improvements in Diesel CI engines	20%-25%	50%	12.5%	50% (30%)	8.75 (5.3)
Gasoline and Diesel HEV interventions (start-stop/regenerative braking)	10%	30%	3%	100%	4.2
Transmission improvements	2%-9%	50%	3%	100%	4.2
Rolling Resistance, Drag reduction	3%-4%	50%	1.5%-2%	100%	2.5
Weight/Size reduction	5%-7%	50%	3%	100%	4.2

Total reduction: 35 (36) g CO_2/km

Source: Assessments based on global technology penetration projections and diffusion rates.

Reduction Potential for interventions (2Ws)

Intervention	Projected Improvements in the US (by 2030)	Applicability to India	Projected improvements in India (by 2030)	Fractional Applicability to Indian fleet	Realizable overall reduction in g CO2 emissions/km by 2030 over 2007 (Baseline – 25)
Improvements in Gasoline SI Engines	25%-35%	50%	15%	100%	3.75
Improvements in Diesel CI engines	20%-25%	50%	12.5%	0%	0
Gasoline and Diesel HEV interventions (start-stop/regenerative braking)	10%	20%	2%	100%	0.5
Transmission improvements	2%-9%	50%	3%	100%	0.75
Rolling Resistance, Drag reduction	3%-4%	50%	1.5%-2%	100%	0.5
Weight/Size reduction	5%-7%	50%	3%	100%	0.75

Total reduction: 6.25 g CO2/km

Source: Assessments based on global technology penetration projections and diffusion rates.

Reduction Potential for interventions (3Ws)

Intervention	Projected Improvements in the US (by 2030)	Applicability to India	Projected improvements in India (by 2030)	Fractional Applicability to Indian fleet	Realizable overall reduction in g CO2 emissions/km by 2030 over 2007 (Baseline – 65)
Improvements in Gasoline SI Engines	25%-35%	0%	0%	0%	0
Improvements in CNG/LPG engines	20%	75%	15%	100%	9.75
Gasoline and Diesel HEV interventions (start-stop/regenerative braking)	10%	30%	3%	100%	2
Transmission improvements	2%-9%	50%	3%	100%	2
Rolling Resistance, Drag reduction	3%-4%	50%	1.5%-2%	100%	1-1.2
Weight/Size reduction	5%-7%	50%	3%	100%	2

Total reduction: 16.75 g CO_2/km

Source: Assessments based on global technology penetration projections and diffusion rates.

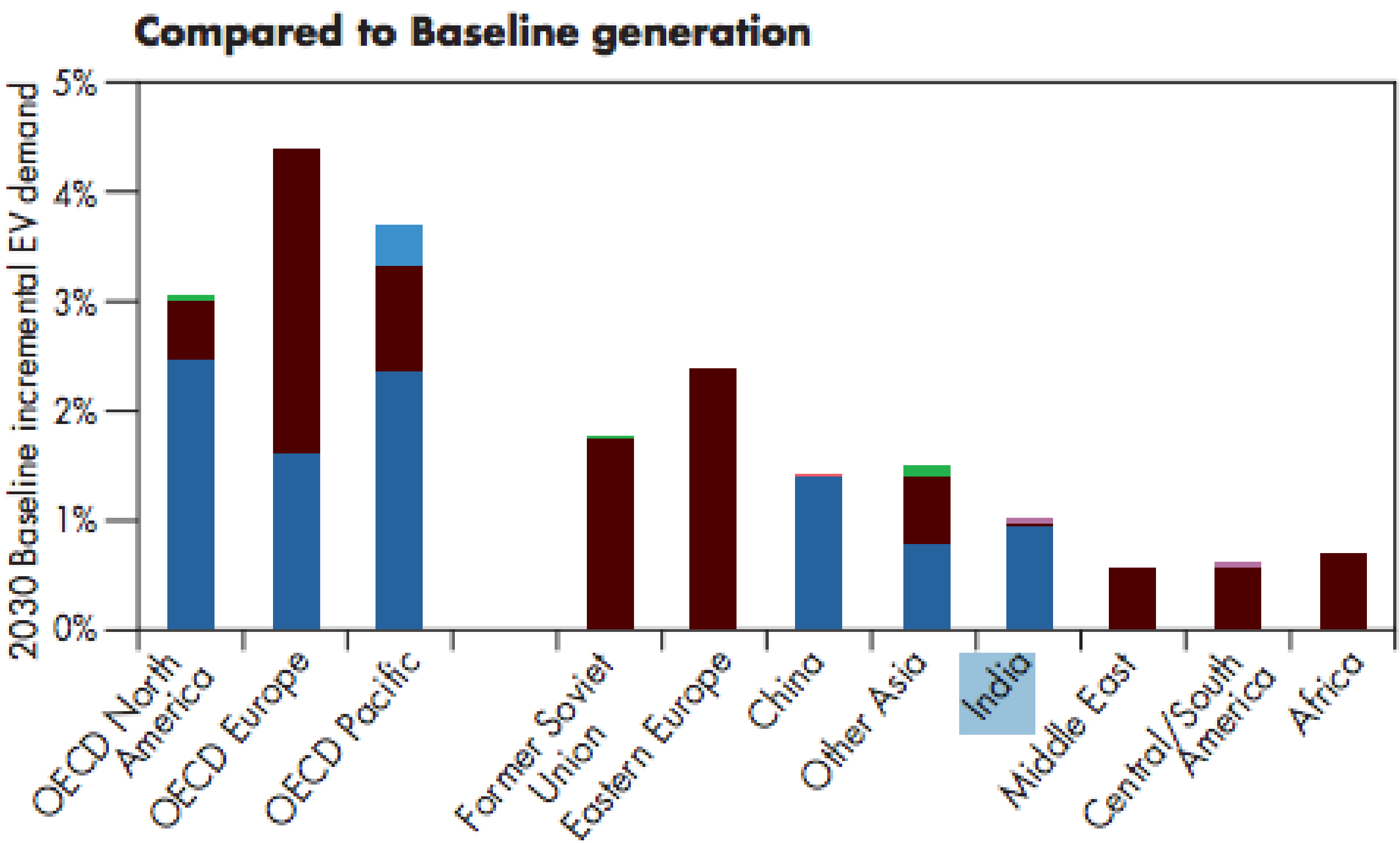
Reduction Potential for interventions (Public Transport)

Intervention	Projected Improvements in the US (by 2030)	Applicability to India	Projected improvements in India (by 2030)	Fractional Applicability to Indian fleet	Realizable overall reduction in g CO2 emissions/km by 2030 over 2007 (Baseline – 850)
Improvements in Gasoline SI Engines	25%-35%	70%	20%	0% (30%)	0 (51)
Improvements in Diesel CI engines	20%-25%	70%	15%	100% (70%)	127 (90)
Gasoline and Diesel HEV interventions (start-stop/regenerative braking)	10%	30%	3%	100%	25.5
Transmission improvements	2%-9%	50%	3%	100%	25.5
Rolling Resistance, Drag reduction	3%-4%	50%	1.5%-2%	100%	15
Weight/Size reduction	5%-7%	50%	3%	100%	25.5

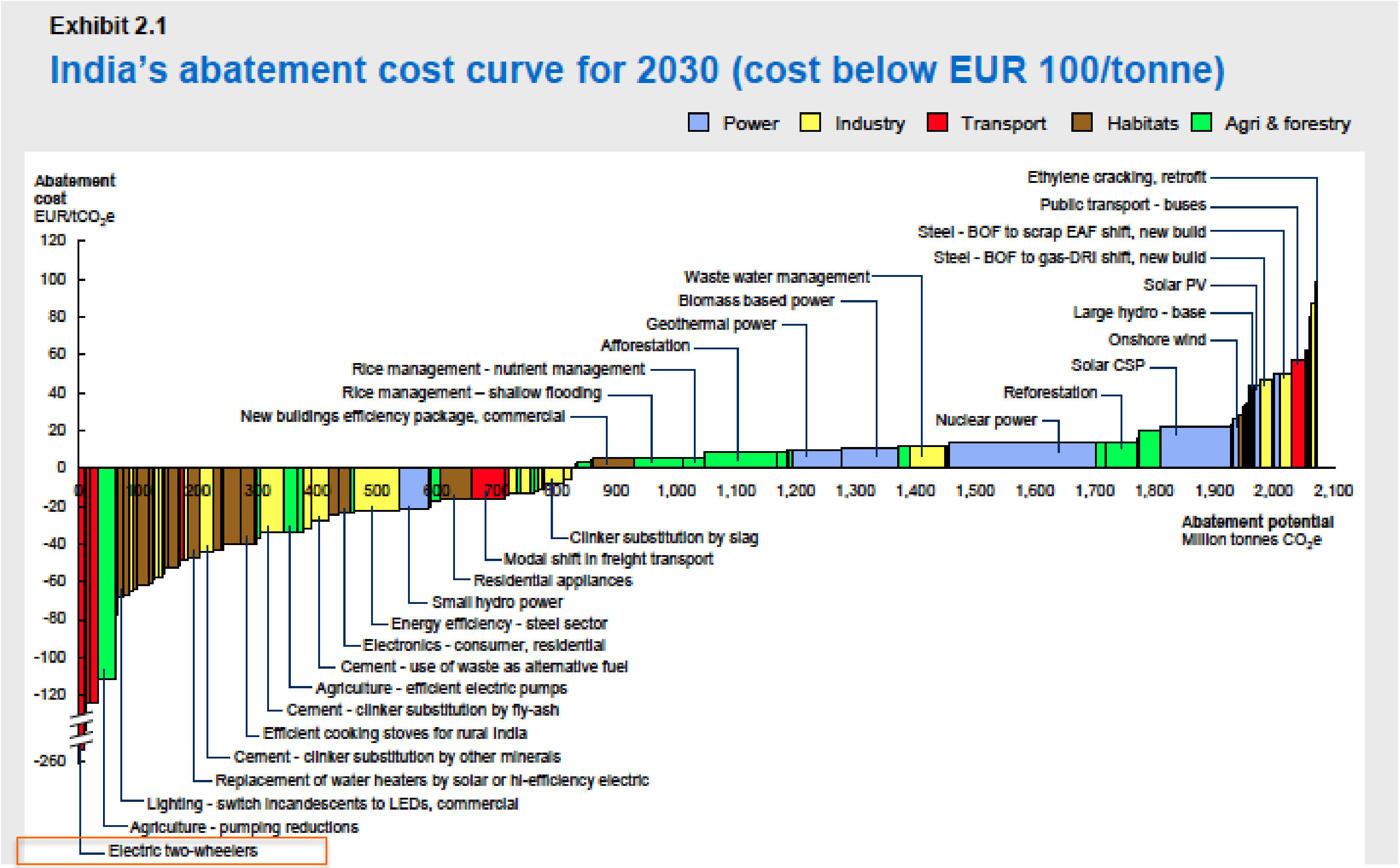
Total reduction: 218.5 (232.5) g CO2/km

Source: Assessments based on global technology penetration projections and diffusion rates.

The Electricity demand increase due to xEVs is ~1%



Two Wheeler EVs make economic sense as well



Source: McKinsey 2009

CO_2 emissions intensity ($g\ CO_2$ /km) reduction by 2030 (%)

- More efficient ICEs
  - Cars (25%)
  - 2Ws (25%)
  - 3Ws (27%)
  - Public Transport (25%-28%)
- Advanced Vehicles and Fuels (for the numbers deployed)
  - 2W Hybrids (50%)
  - 4 W hybrids (15%-30%)
  - Pure EVs (0 to limited gains) – *assuming India halves the carbon intensity of its electricity production by 2030 over 2009*.

Contingencies/Uncertainties:

- Efficiency norms
- xEV support program
- Diesel subsidy regime