Improving Fuel Quality: Comparing India's program against global benchmarks

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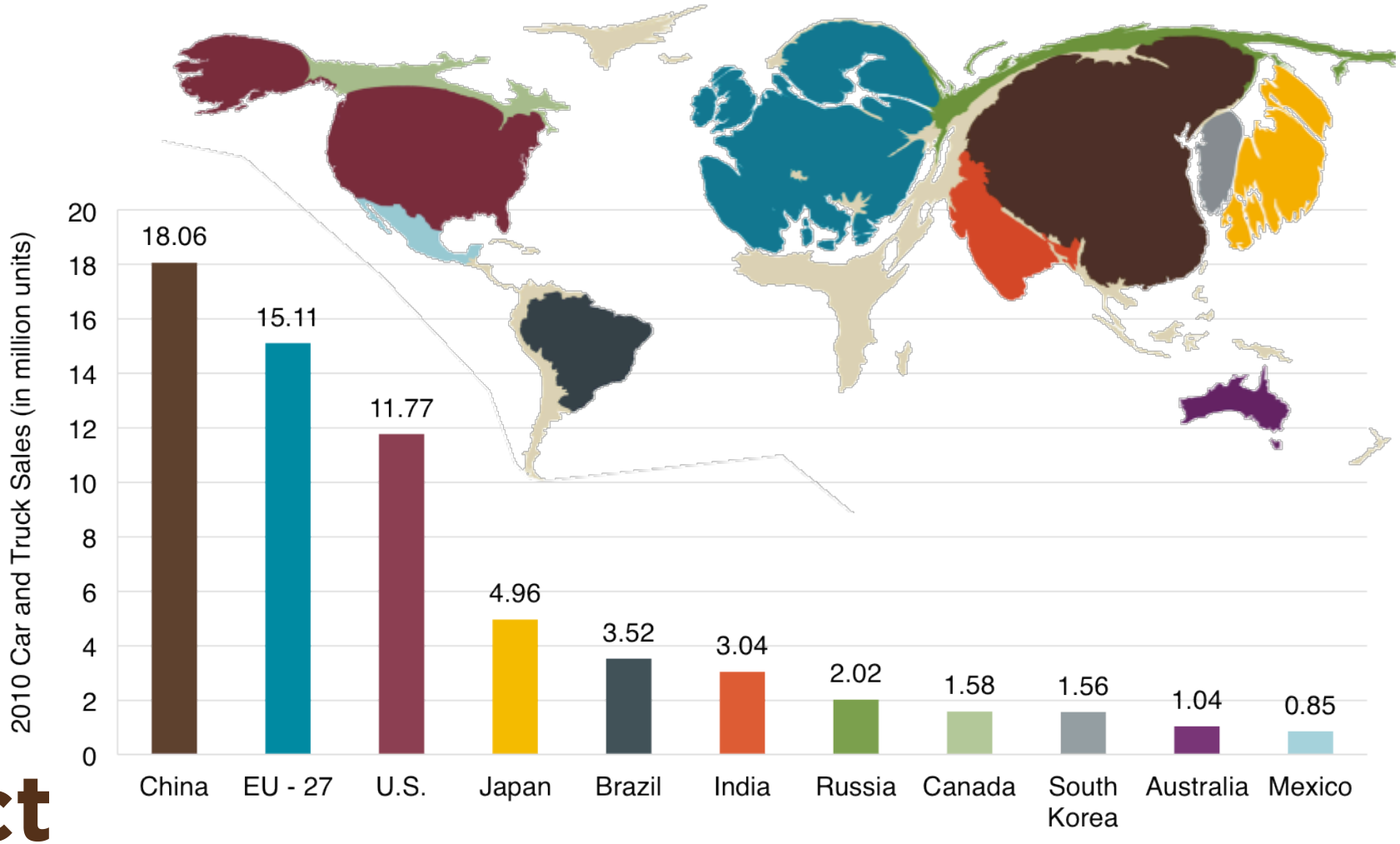
What is ICCT?

The mission of the ICCT is to dramatically improve the environmental performance and efficiency of cars, trucks, buses, and transportation systems in order to protect and improve public health, the environment, and quality of life.



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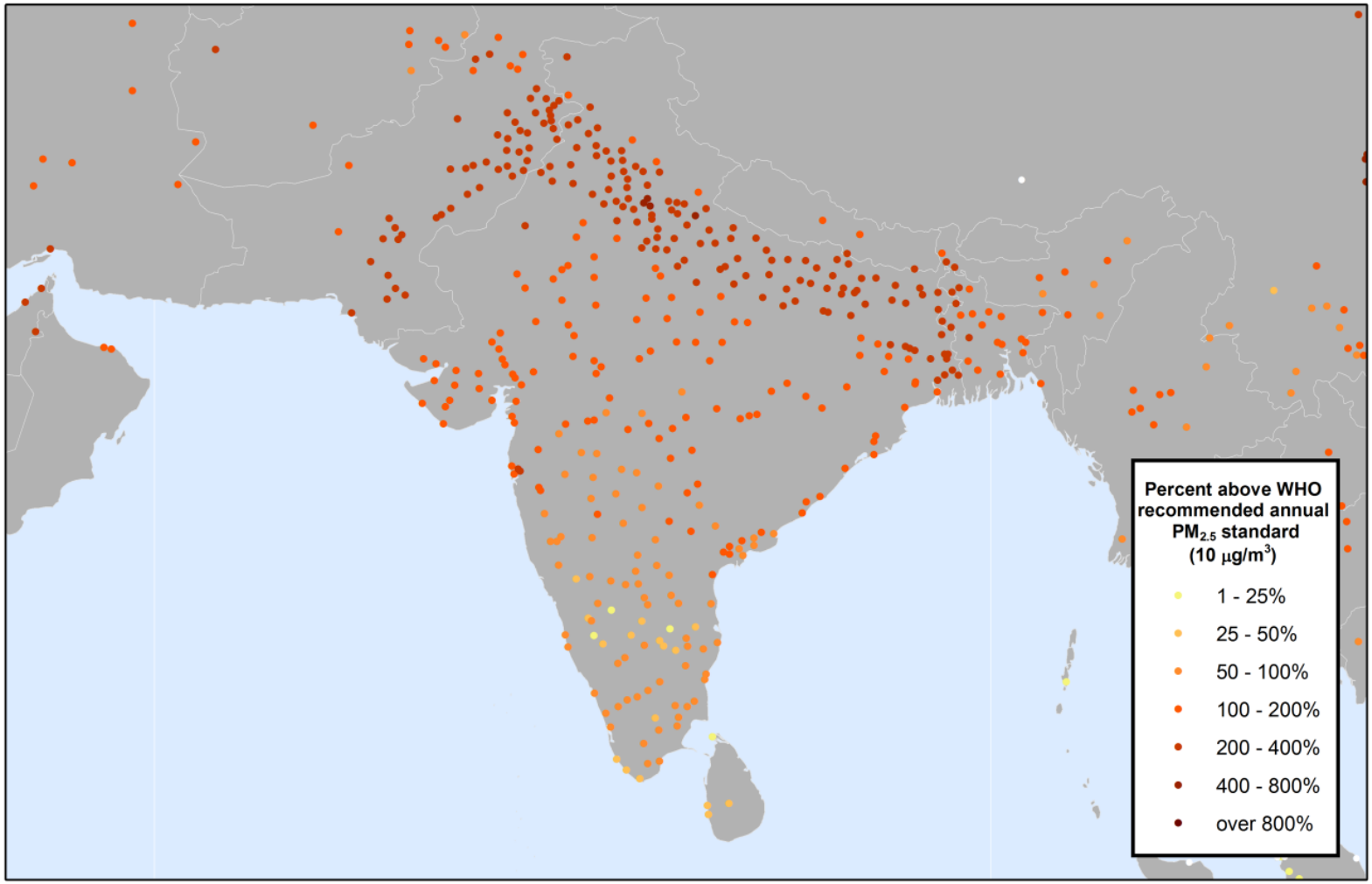
154,000 lives lost each year in India due to $PM_{2.5}$ alone…

2005 Annual Average $PM_{2.5}$ Concentrations Relative to WHO Air Quality Guidelines



Adapted from: **Exposure Assessment for Estimation of the Global Burden of Disease Attributable to Outdoor Air Pollution**
Michael Brauer, Markus Amann, Rick T. Burnett, Aaron Cohen, Frank Dentener, Majid Ezzati, Sarah B. Henderson, Michal Krzyzanowski, Randall V. Martin, Rita Van Dingenen, Aaron van Donkelaar, and George D. Thurston *Environmental Science & Technology* **2012** *46* (2), 652-660

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Purpose of this webinar series is to initiate a dialogue around Auto Fuel Policy in India.

ICCT is conducting a study to evaluate the past successes and future prospects of India's vehicular emissions control program

- New vehicle and engine emission standards
- Fuel quality standards
- Vehicle compliance and enforcement program
- Fuel inspection and compliance program
- Alternative fuels and new energy vehicle policies
- Fuel efficiency standards and labeling

Today's webinar focuses on the fuel quality standards and compliance program

- Compare and contrast India's program with that in US, EU, Japan and China
  - What's working
  - What's not working
  - What could be improved
  - Barriers to progress
  - Preliminary recommendations for discussion

- The first webinar (April 26) focused on vehicle emission standards and compliance programs, while the third webinar (June 28) will focus on evaluation of costs and benefits of cleaner vehicles and fuels in India

Gasoline quality effects on vehicle emissions

Gasoline	Euro 1	Euro 2	Euro 3	Euro 4	Euro 5/6
Lead ↑	CO, HC, NO_X ↑ as catalyst is destroyed				
Sulfur ↑	CO, HC, NO_X, SO_2, SO_3 ↑				
Olefins ↑	Increase in HC for Euro 3 and higher vehicles, and higher HC reactivity. NO_X ↑				
Aromatics ↑	Increased exhaust benzene				
	HC↑, NO_X↓, CO↑		HC, NO_X, CO ↑		
Benzene ↑	Increased exhaust and evaporative benzene				
Ethanol ↑ <3.5% O_2	Minimal effect with new vehicles equipped with oxygen sensors, adaptive learning systems				
MMT ↑			Catalyst Plugging		
RVP ↑	Increased evaporative and exhaust HC Emissions				
Deposit control additives ↑	Potential HC, NO_X emissions benefits				

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Diesel quality effects on vehicle emissions

Diesel	Euro 1	Euro 2	Euro 3	Euro 4	Euro 5/6
Sulfur ↑	SO_2, PM ↑	If oxidation catalyst is used, SO_3, SO_2, PM ↑		If DPF, LNT, SCR, 50 ppm needed, 10 ppm ideal	
Cetane ↑	Lower CO, HC, benzene, 1,3 butadiene, formaldehyde & acetaldehyde				
Density ↑	PM, HC, CO, formaldehyde, acetaldehyde & benzene ↓ , NO_X ↑				
Volatility ↑	NO_X, HC increase, PM, CO decrease				
Polyaromatics↑	NO_X, PM, formaldehyde & acetaldehyde ↓ but HC, benzene & CO ↑				

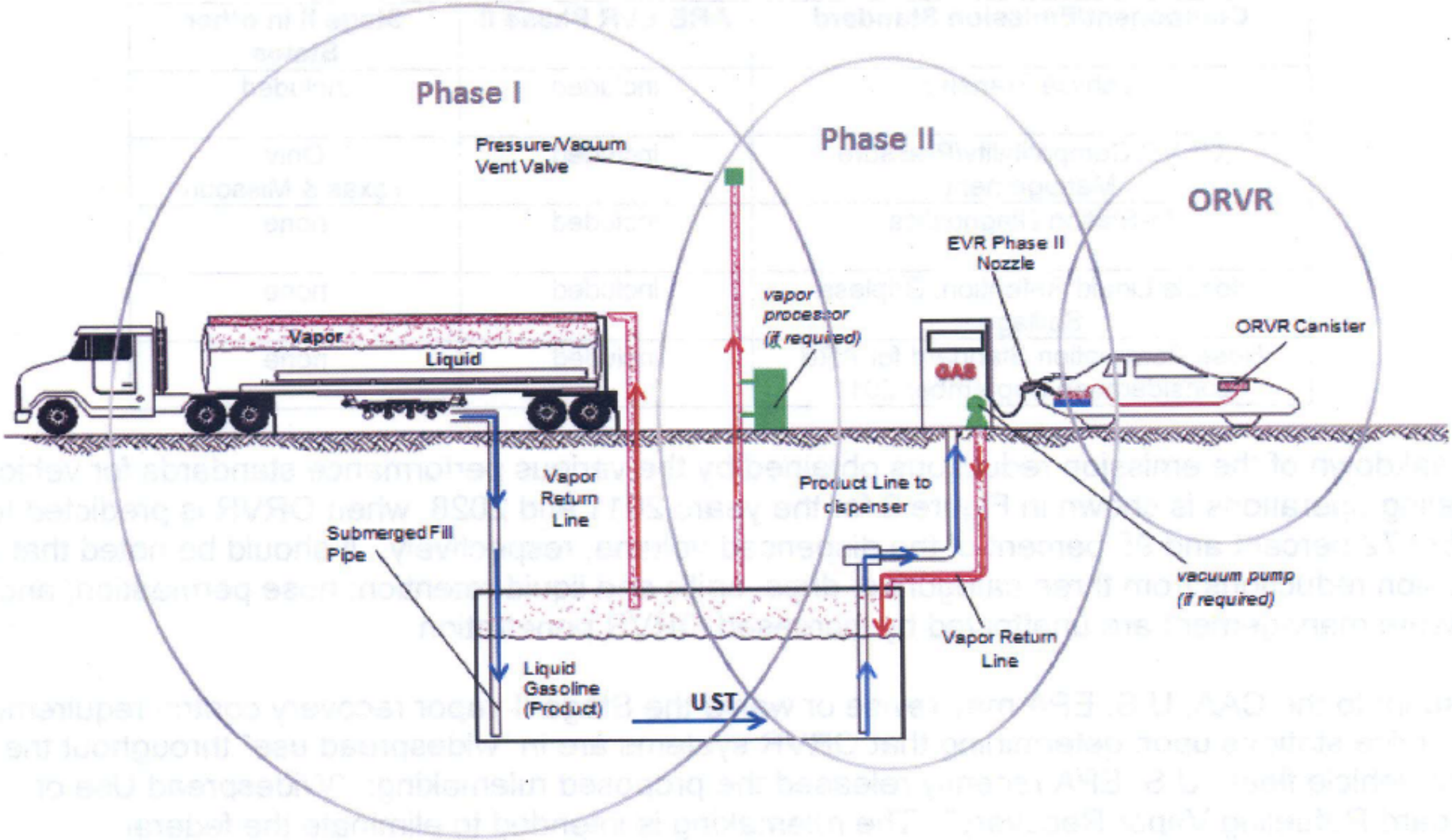
What has been accomplished in India

- Lead removed from all fuels by the year 2000
- Sulfur levels have fallen dramatically
  - Gasoline: 2000 ppm to 150 ppm (50 ppm in 20 cities)
  - Diesel: 10,000 ppm to 350 ppm (50 ppm in 20 cities)
- Octane number increased in gasoline
  - Regular: 88 to 91
  - Premium: 93 to 95
- Benzene levels reduced in gasoline
  - 3% to 1%
- Aromatic content reduced
  - No regulation to 35% maximum
- Use of sulfur-free CNG and LPG has increased, especially in city buses and autorikshaws

Compliance issues

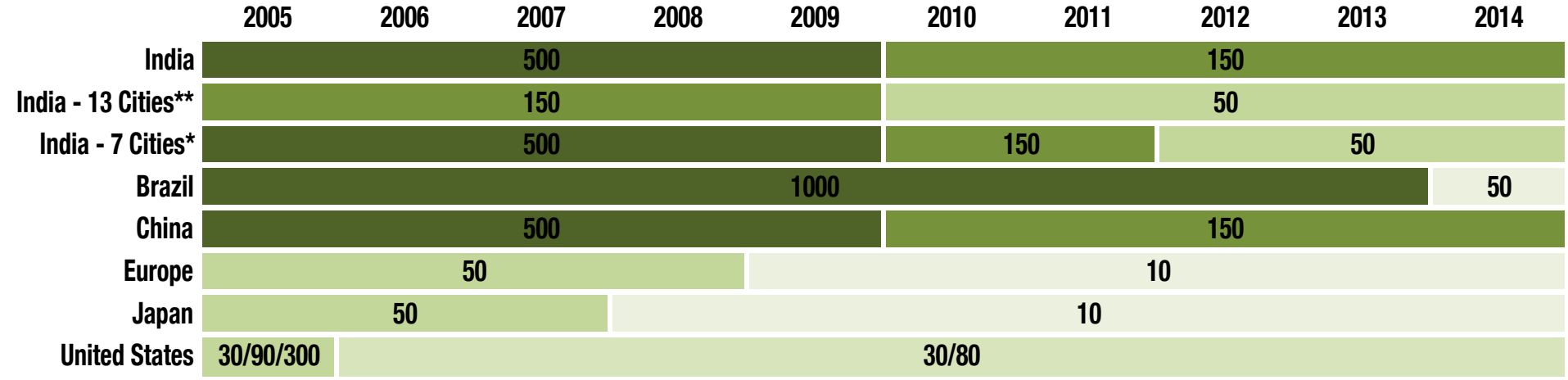
	India	US	Japan
Fuel Testing	Oil industry tests fuel; only one independent fuel testing lab	Oil industry tests every batch; EPA audits industry tests & contracts testing to multiple independent labs across the country	Oil industry testing before sale; METI tests all service stations annually at one of nine NPA labs
Presumptive Liability	Oil companies not responsible once fuel leaves their depots	All parties in fuel distribution system responsible	All parties in fuel distribution system responsible
Fuel Registration & Tracking	No centralized or computerized system	Computerized EPA Designate & Track system accounts for all fuel nationwide	All fuel and fuel handlers registered with METI
Penalties	None to date	Fines and criminal charges against violators	Fines and possible jail time; non-compliant service stations closed

Vapor Recovery Options: Stage I, Stage II controls/On-board Vapor Recovery (ORVR)



Indian fuel quality standards still 5-8 years behind

Gasoline Sulfur Content Schedule (ppm)



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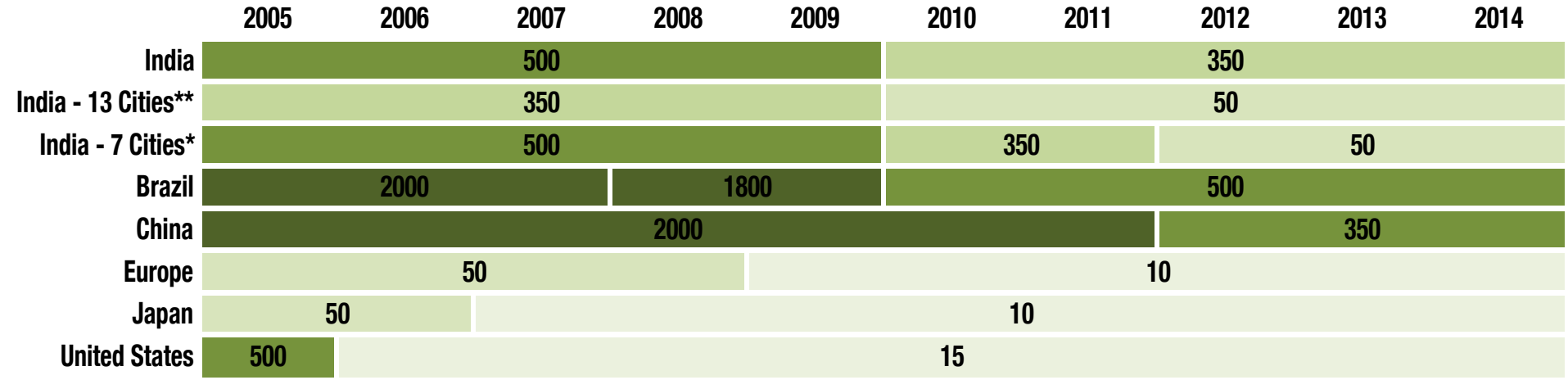

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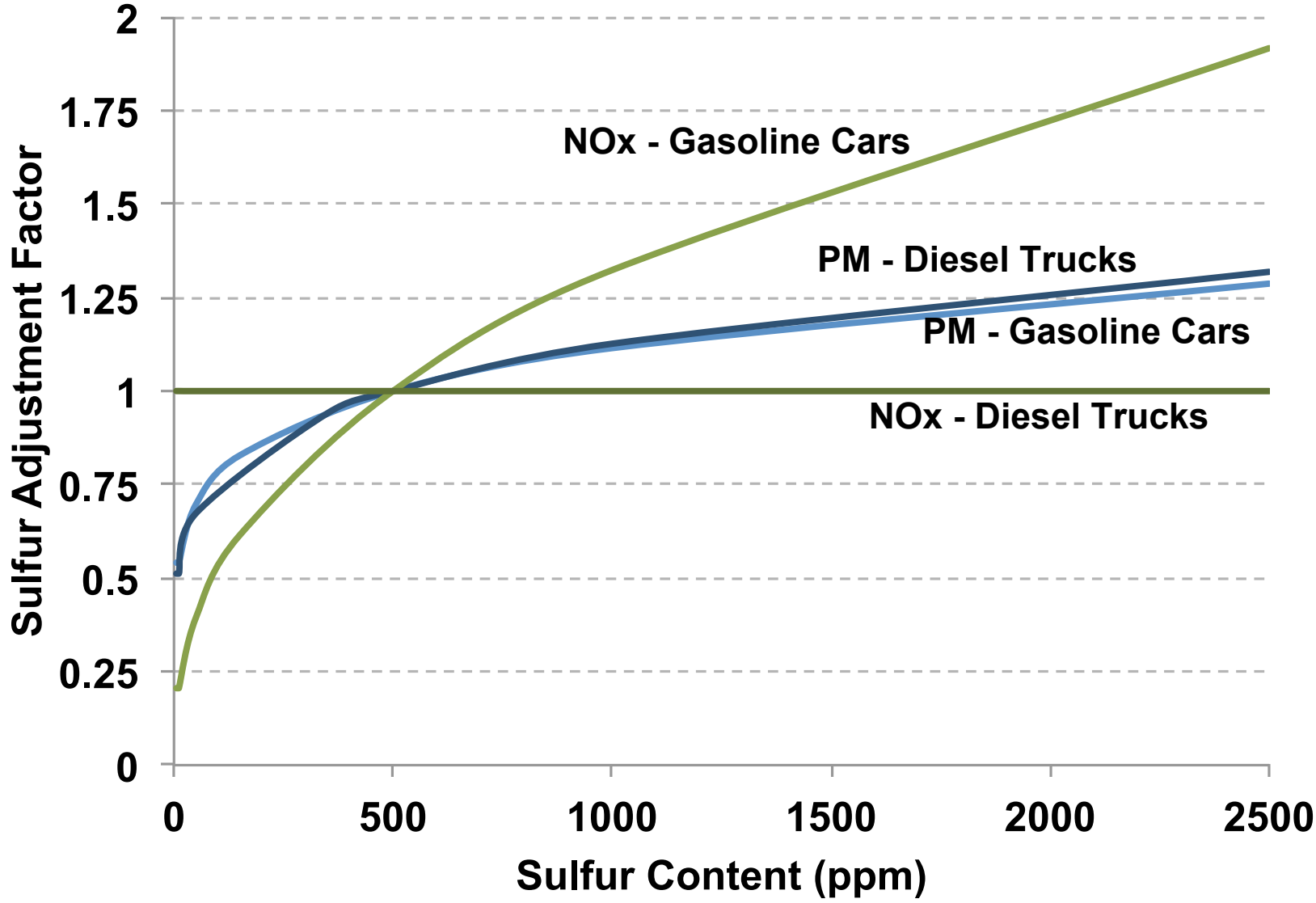
*Puducherry, Mathura, Vapi, Jamnagar, Ankleshwar, Hissar, Bharatpur

**Delhi, Mumbai, Kolkata, Chennai, Bangalore, Surat, Agra, Hyderabad, Pune, Ahmedabad, Kanpur, Lucknow, Solapur

Effect of fuel sulfur on vehicle emission factors



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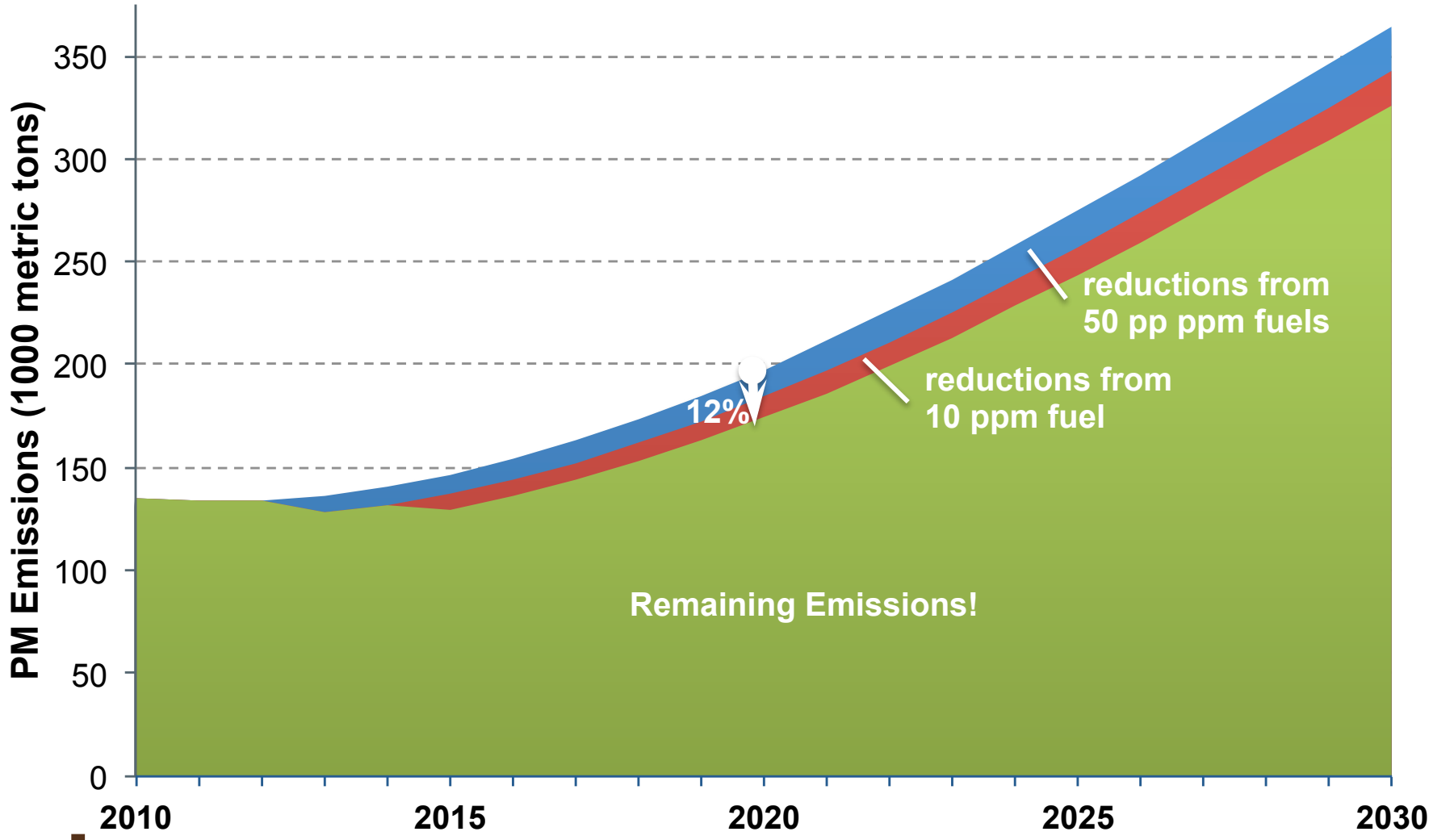
Annual PM Emissions (2000-2030) under low sulfur fuels



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Much cleaner diesel vehicles are possible, through stricter standards and/or retrofits.

No retrofit system **Uncontrolled Diesel Exhaust** (Level 1)	Retrofitted with **Diesel Oxidation Catalyst (DOC)** (Level 1)	Retrofitted with **Partial Filter** (Level 2)	Retrofitted with **Diesel Particulate Filter (DPF)** (Level 3)
Old technlogy Little black carbon removal Little ultrafine PM removal Does not remove lube oil ash	Old technlogy Little black carbon removal Little ultrafine PM removal Does not remove lube oil ash	Little black carbon removal Little ultrafine PM removal Does not remove lube oil ash	New Technology Used on all new trucks since 2007 >85% black carbon removal >85% ultrafine removal >85% lube oil ash removal

DPFs are typically installed on new diesel passenger vehicles with Euro V standards and on heavy duty vehicles with Euro VI standards, but can be retrofitted to older diesels provided <50 ppm sulfur fuel is available.

➢ Cleaire Advanced Emission Controls LLC

Low sulfur fuels enable stricter emission standards

SCENARIO	EMISSION STANDARDS	FUEL STANDARDS	ENFORCEMENT AND COMPLIANCE[1]	CHANGE IN FUEL TYPE[2]
World-Class	Bharat V (2013) countrywide and Bharat VI (2015) and "SULEV" (LD) and "Bharat VII" (HD) by 2020	Low sulfur fuel (50 ppm) by 2013 and ultra low sulfur fuel (10 PPM) by 2015	By 2020, only 3% of vehicle fleet are gross emitters	15% of LDV sales CNG and 10% LPG by 2030; 75% bus sales CNG by 2030; 50% of 3-wheeler sales CNG by 2030

1. Gross polluters are defined as vehicles where emission controls are non-functional.
2. LDV means PC only. Increases in CNG and LPG vehicle market share are assumed to happen at the expense of diesel market share.

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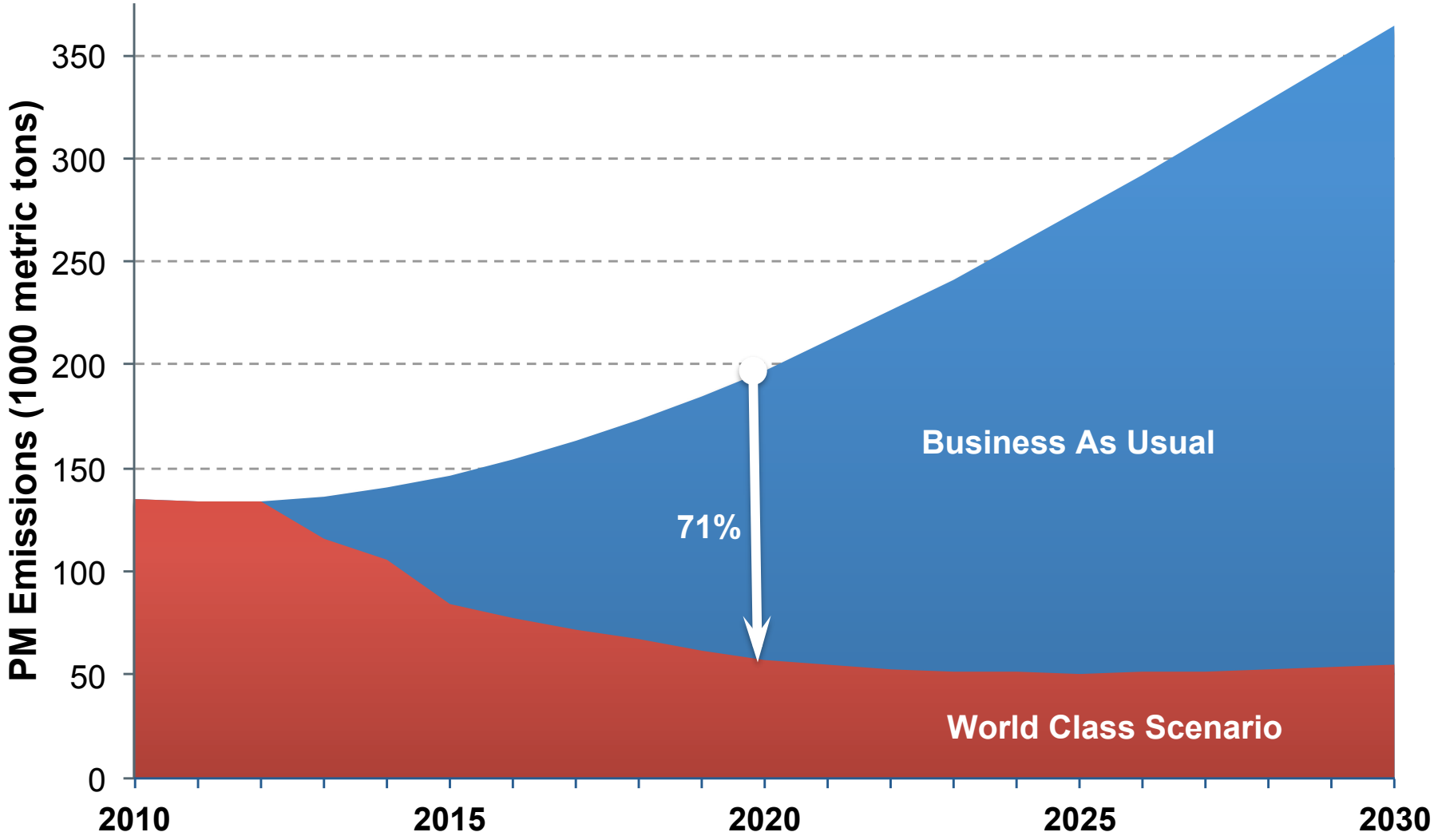
Annual PM Emissions (2000-2030) under low sulfur fuels enabled policies



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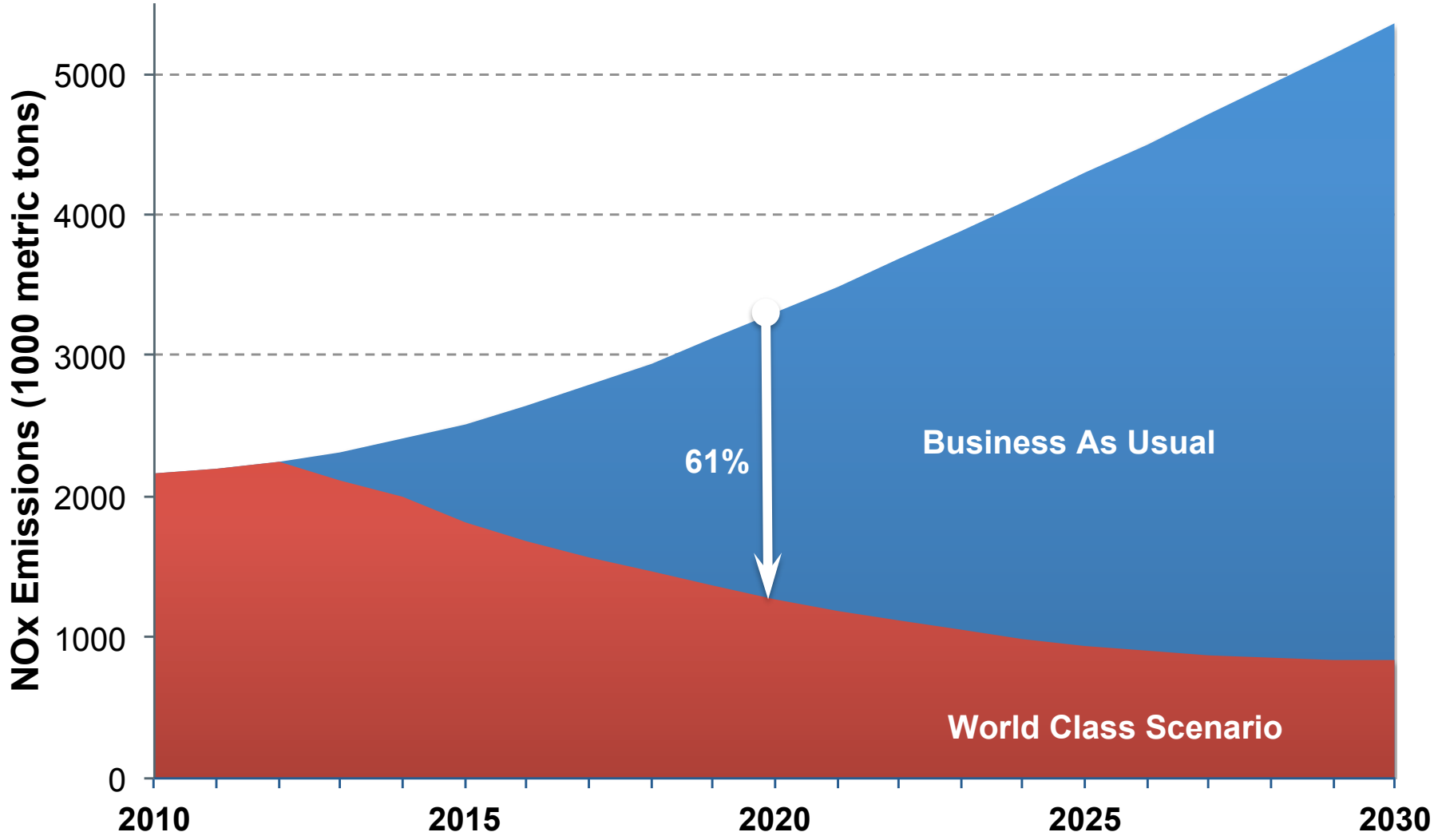
Annual NOx Emissions (2000-2030) under low sulfur fuels enabled policies



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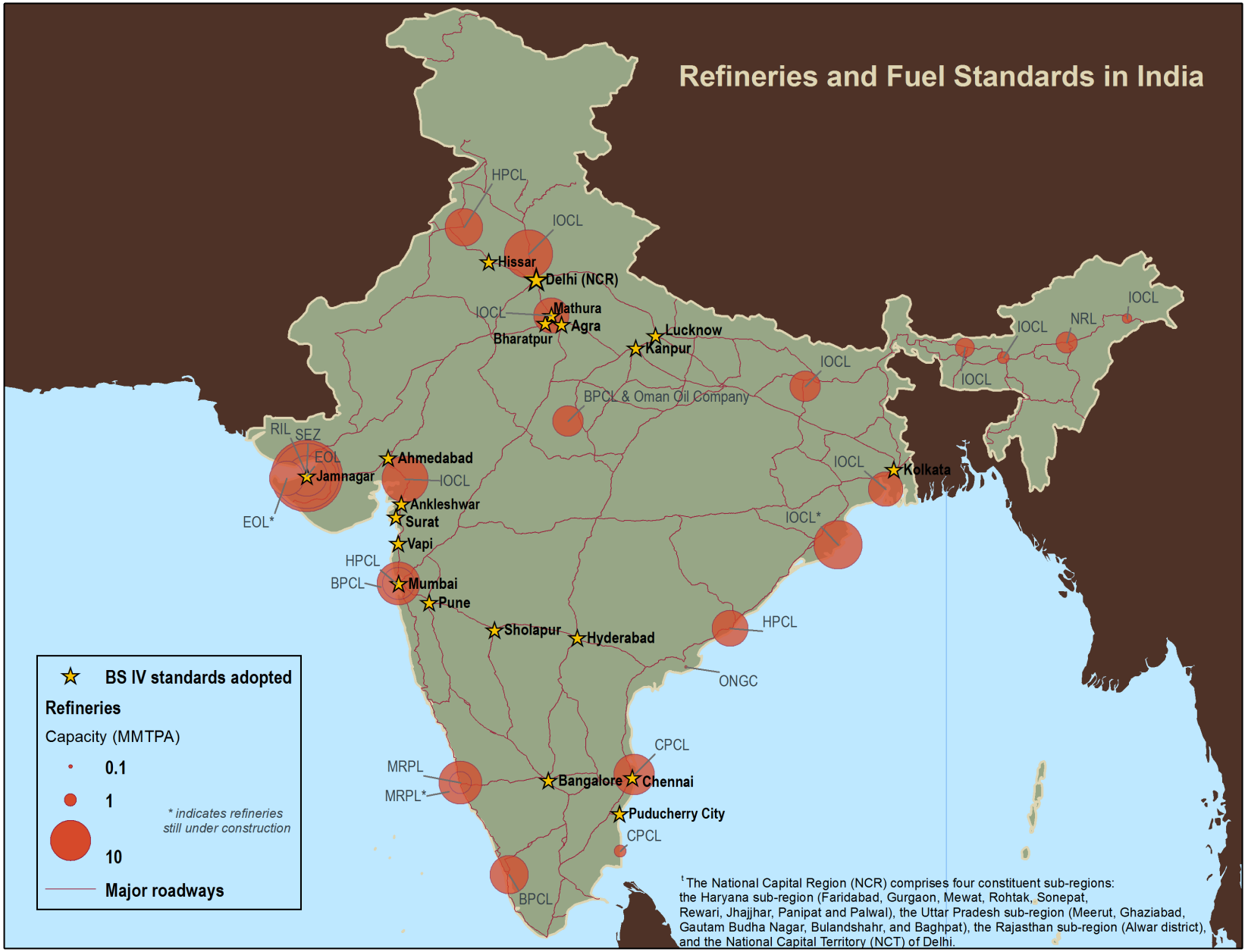
Bharat IV in 20 cities, but rest of India at BS III



Investing in ultra-low sulfur fuels is critical to the success of vehicular emission control program.

Hart Consulting/ MathPro conducting a study for ICCT to evaluate the cost of transition to ULSFs in India

- Additional refining costs associated with ULSFs
  - Capital charges associated with the investment in new or upgraded process capacity and support
  - Cost of additional hydrogen supply
  - Cost of replacing lost product yield
  - Cost of replacing lost gasoline octane

Exiting refinery groupings in India

Refinery Group	Count	Crude Capacity (K Bbl/day)		Crude Type	
		Total	Average	Low S	High S
A: Large Export	3	1520	506.7	4%	96%
B: High Distillate Conversion	6	1120	186.7	14%	86%
C: Small Sweet	4	98.6	24.7	100%	-
D: Medium Conversion	6	976.3	162.7	19%	81%
E: Transition Year Capacity	8	1234	154.2	40%	60%

Preliminary study results to be presented at the next webinar!

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What's inhibiting further progress for fuel quality in India?

- No Roadmap for future fuel quality in India
- Under-recoveries for diesel and kerosene
  - Diesel and kerosene much cheaper than gasoline
  - Incentivizes fuel adulteration
- No vapor recovery controls
- Only one independent fuel quality testing lab

Preliminary recommendations for discussion

- Move to low sulfur fuels
  - <50 ppm fuels nationwide immediately
  - <10 ppm fuels nationwide as soon as possible
- Stronger enforcement
  - Inspect fuel quality at service stations more frequently
  - Make all fuel handling parties responsible for fuel quality along the supply chain
  - Increase the number of independent fuel testing labs to at least one per region
- Mandate Stage I and Stage II vapor recovery controls
- Reform fuel pricing policies to allow diesel, kerosene, and other fuels to be sold at market value

For more information…

- ICCT India website: http://theicct.org/india
- First webinar on vehicular emissions in India: http://theicct.org/blogs/staff/reducing-vehicular-emissions-india-webinar-notes
- Briefing on the benefits of low sulfur fuels in India: http://theicct.org/benefits-low-sulphur-fuels-india
- Briefing on the potential of lower vehicle emission standards in Indian cities: http://theicct.org/potential-lower-vehicular-emissions-indian-cities
- Blog on dieselization in India: http://theicct.org/blogs/staff/harsh-calculus-dieselization-india
- Blog on vehicle and fuel taxes in India: http://theicct.org/blogs/staff/india-2012-budget

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