

Transition to BS VI vehicle emissions and fuel quality standards in India

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Transition to Soot-free Heavy-duty Vehicles and Fuels:
Regional Workshop for Southeast Asia

August 25, 2021

India made tremendous progress on vehicular emissions front from 2000-2010, but fell behind after 2010.

- Vehicle emission standards and fuel quality standards (BS IV is 13 cities and BS III elsewhere) implemented more or less as per schedule
 - BS-IV fuel supply steadily increased – 50 additional cities covered by March 2015
- Use of CNG and LPG increased steadily, especially in city buses and autorickshaws

Pre-2015 fuel quality improvements 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 63 cities)
- Diesel: 10,000 ppm to 350 ppm (50 ppm in 63 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

2014 Auto Fuel Policy and Vision 2025 (Saumitra Chaudhuri committee) recommended a slower transition to BS VI

- Saumitra Chaudhari Committee recommendations:
 - 50 ppm sulfur fuels to be available by April 2017
 - 10 ppm sulfur fuels to be available by April 2020
 - BS IV in 2017, BS V in 2020, BS VI in 2024
- Weaknesses in the committee report
 - BS VI standards not fully defined
 - No firm date for adoption of World Light Duty Testing procedure ([WLTP](#))
 - Proposed durability for BS V standards (120,000km) is weaker than Euro 5 durability (160,000km)
 - Stage I and II vapor recovery systems not required for refueling stations
- National Transport Development Policy Committee (NTDPC known as the Rakesh Mohan Committee) recommended implementation of BS VI standards by 2020 (see page 23: http://planningcommission.nic.in/reports/genrep/NTDPC_Vol_01.pdf)

BS IV standards for new 2-wheelers effective April 2016 (all vehicles from April 2017)

- ☒ Adoption of the Worldwide Harmonized Motorcycle Test Cycle (WMTC)
- ☒ Introduction of evaporative emission standards
- ☒ Prohibition on crankcase emission
- ☒ Minor improvements in PUC requirements
- ☐ NOx standards much weaker than Euro 4; nearly a decade behind EU
- ☐ Durability of 30,000km is weaker than 50,000km required in Europe
- ☐ No on-board diagnostics (OBD) requirements

BS IV standards for 3-wheelers from April 2016

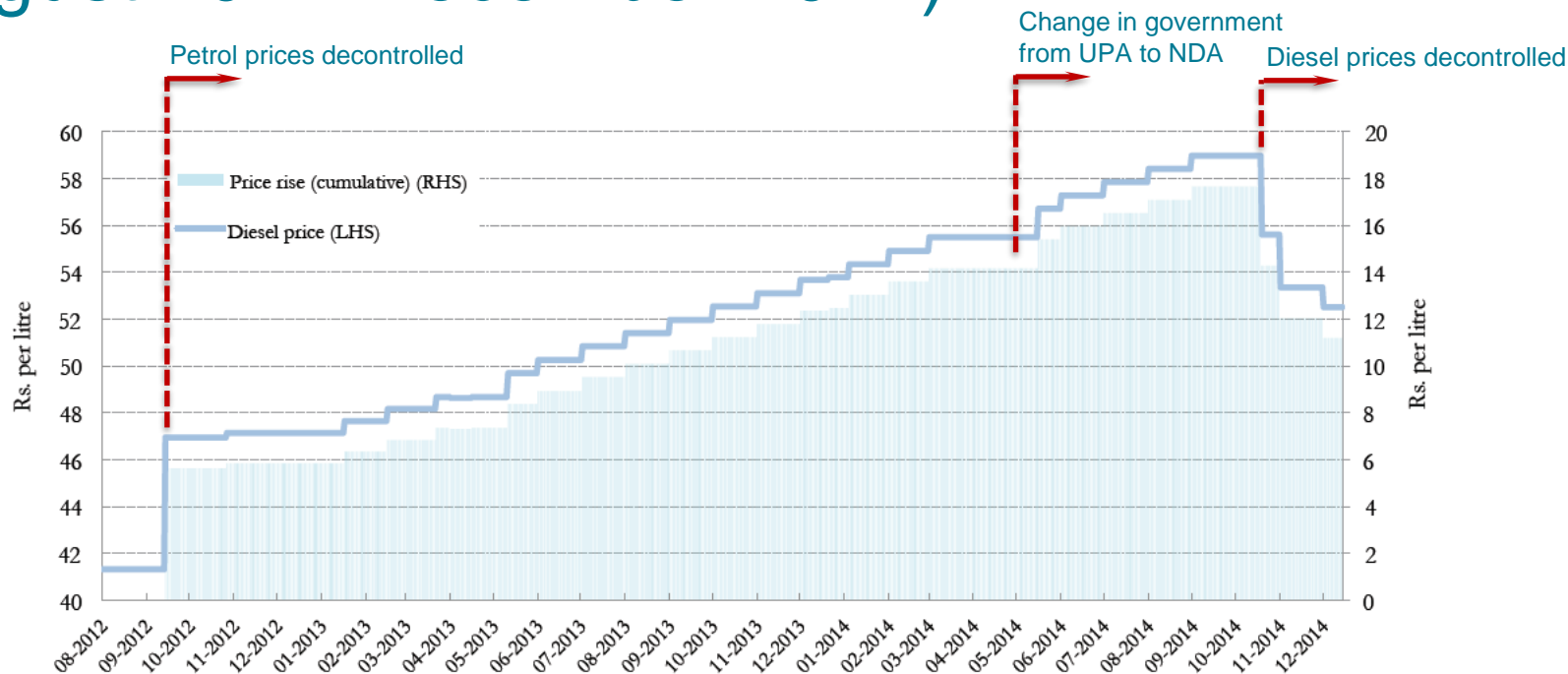
☑ 25% reduction in BS IV CO, and HC+NOx limit value compared with BS III

☑ Evaporative emission testing introduced

☐ only 15% reduction in PM emission limit for diesel 3-wheelers

- 20% reduction feasible (<http://www.theicct.org/two-and-three-wheelers-india-iyer-report>)

Diesel retail price and cumulative price increase (August 2012-December 2014)



2015.....One final attempt at BS VI leapfrog by 2020



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March 5, 2015

Shri Dharmendra Pradhan
Minister of State (Independent Charge)
Ministry of Petroleum and Natural Gas
Shastri Bhawan
New Delhi - 110011

SUB: Leapfrog to Bharat VI emission standards in Auto Fuel Policy

Dear Mr. Pradhan,

I am writing to express the strong support of the International Council on Clean Transportation (ICCT) for the Government of India's proposal to leapfrog to Bharat VI vehicle emission standards, and complementary fuel-quality standards, by 2020. The ICCT is an independent research organization that provides unbiased technical research and analysis to regulators focused on improving the environmental performance and energy efficiency of the transport sector. Our experience working on vehicular air pollution standards across the world, including in India, leads us to the conclusion that skipping Bharat V standards and going to Bharat VI standards in 2020 is the right strategy for India, as the air quality and public health benefits far exceed costs and fully justify the investment in producing ultra-low sulfur fuel.

The government's position to expedite progress to Bharat VI standards, which are based on the European Euro 6/VI standards, is supported by the following:

1. **Superior design of the Euro 6/VI emission standards.** Since India's Bharat emissions standards have been based on Europe's, as defined in a series of regulations that has now reached Euro 6/VI, the lessons learned in the European market should inform Indian policymaking. This means acknowledging both the successes of these policies in leading to highly efficient control technology, and some of the failings in intermediate policy stages. After the adoption of Euro 5/VI standards across the European Union, several shortcomings in the regulation were discovered. For heavy-duty vehicles, Euro V standards have not achieved hoped-for reductions in NOx emissions. While Euro 5 standards have resulted in dramatic reductions in PM emissions from light-duty diesels, real-world diesel NOx emissions have continued to far exceed certification limits. **Annexure - I** contains a briefing paper that describes the technical advantages Euro 6/VI standards over Euro 5/VI standards in detail. [Given the regulatory improvements](#)

➤ <https://theicct.org/events/auto-fuel-policy-roadmap-india-what-next>

Aftertreatment devices required to meet BS IV, V and VI emission norms

	BS IV	BS V	BS VI
Light-duty Gasoline (direct injection engines <u>only</u>)			Gasoline particulate filter <u>may</u> be required
Light-duty Diesel		Diesel particulate filter (DPF) <u>required</u>	Lean-NOx traps (LNT) for smaller engines, and Selective Catalytic Reduction (SCR) for bigger engines <u>required</u>
Heavy-duty Diesel	Selective Catalytic Reduction (SCR) preferred.	Selective Catalytic Reduction (SCR) <u>required for most engines.</u>	Diesel particulate filter (DPF) <u>required</u>

Advantages of Euro 6 over Euro 5

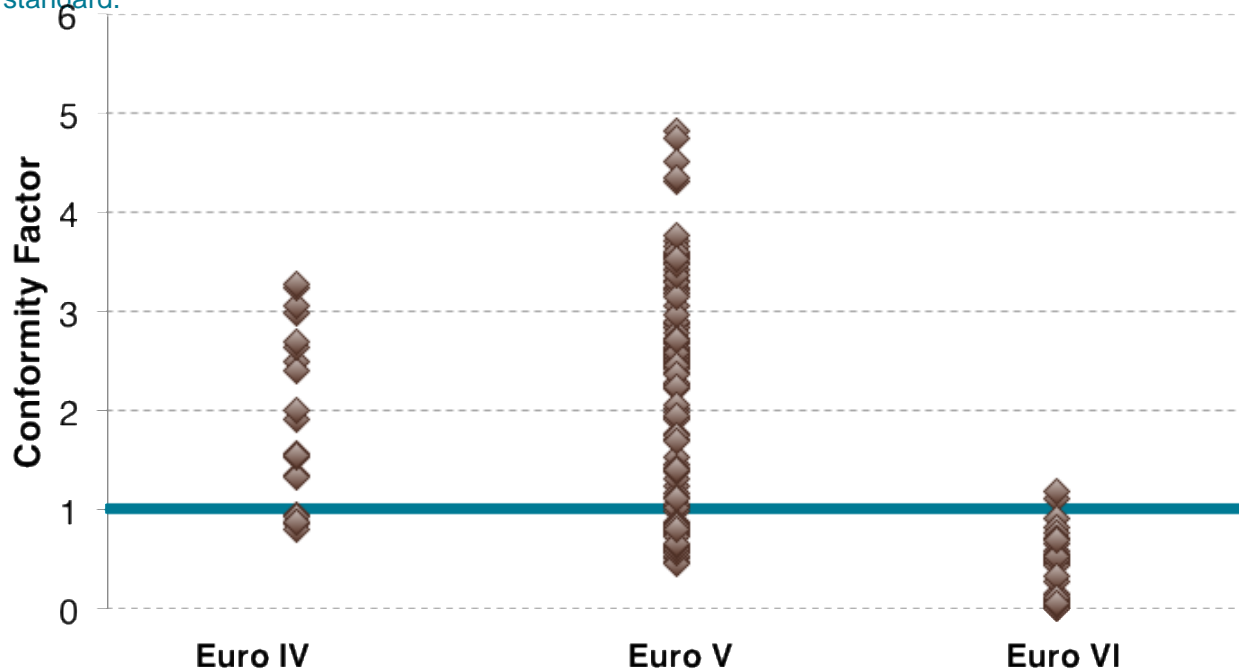
- Limits on particle number (PN) for all vehicle types
- Euro 6 narrows the gap between NOx (or HC+NOx) standards for diesel and gasoline
 - Ideally standards would be fuel neutral
- Portable Emission Measurement System (PEMS) based real driving emissions (RDE) testing
- On-Board Diagnostic (OBD) thresholds (OTLs) for Euro 6 are 70-75% lower than Euro 5 OTLs for NOX and PM
- Adoption of World Harmonized Light Vehicles Test Procedure (WLTP)

Advantages of Euro VI over Euro V

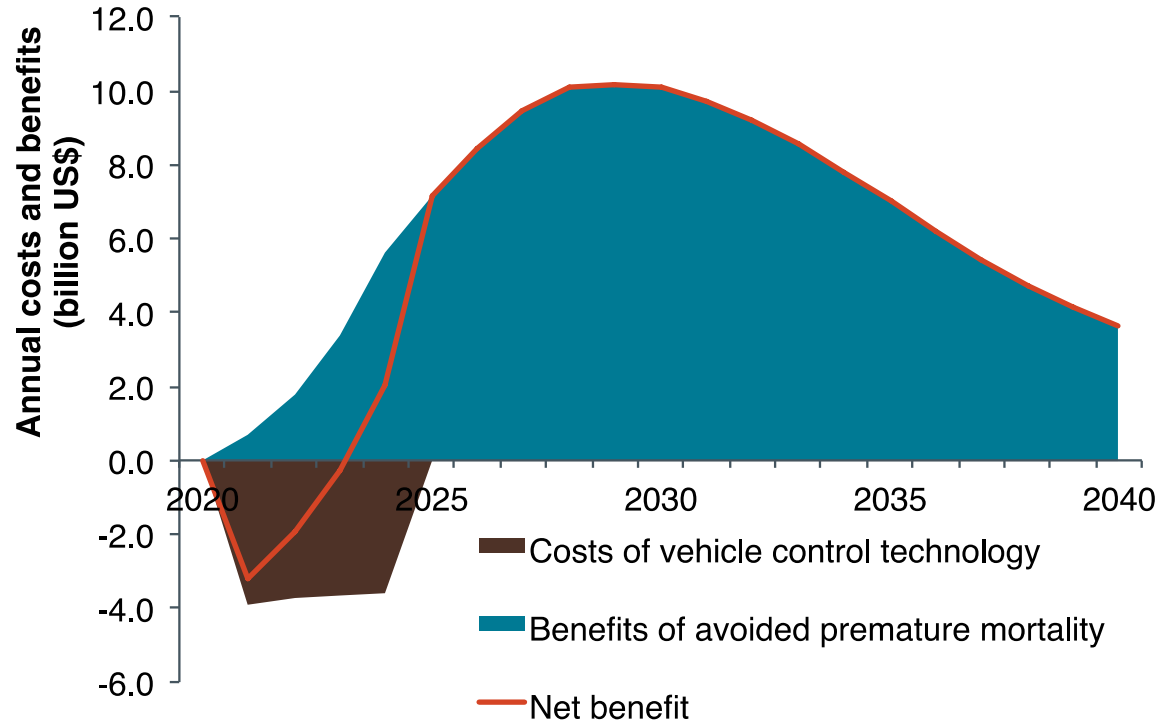
- Introduction of Diesel Particulate Filters (DPFs) on heavy vehicles
- Limits on particle number (PN)
- Adoption of World Harmonized Transient Cycle (WHTC) and Steady-State Cycle (WHSC)
- Introduction of in-service conformity (ISC) testing requirements using a Portable Emission Measurement System (PEMS)
- New limit on ammonia (NH₃) emissions
- Tighter methane limits for CNG vehicles by 50% and imposing the same limit on LPG vehicles
- Extended durability requirements
 - 160,000 km or 5 for small buses and pick-up trucks
 - 300,000 km or 6 years for mid-size trucks and buses
 - 700,000 km and 7 years for heavy trucks and buses
- Extensive improvements in OBD systems

Good news for heavy-duty vehicles: Euro VI real-world NO_x emissions are in line with emission limits

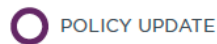
NO_x emissions conformity factors for all tests plotted vs. Euro level
Conformity factor of one indicates that vehicle emissions meet the corresponding Euro standard.



Advancing BS VI standards is cost-effective even with conservative assumptions



Unexpected win in 2016.... although lots of loose ends...



APRIL 2016

WORKING PAPER 2016-9



INDIA BHARAT STAGE VI EMISSION STANDARDS

ICCT POLICY UPDATES
SUMMARIZE
REGULATORY
AND OTHER
DEVELOPMENTS
RELATED TO CLEAN
TRANSPORTATION
WORLDWIDE.

On February 19, 2016, the Indian Ministry of Road Transport and Highways (MoRTH) issued a draft notification of Bharat Stage (BS) VI emission standards for all major on-road vehicle categories in India.¹ The standards apply to light- and heavy-duty vehicles, as well as two- and three-wheeled vehicles. As proposed, the BS VI standards will go into effect for all vehicles in these categories manufactured on or after April 1, 2020. The draft BS VI proposal specifies mass emission standards, type approval requirements, and on-board diagnostic (OBD) system and durability levels for each vehicle category and sub-classes therein. In addition, reference and commercial fuel specifications are included in the BS VI proposal. The adoption of the proposed BS VI emission standards will essentially bring Indian motor vehicle regulations into alignment with European Union regulations for light-duty passenger cars and commercial vehicles, heavy-duty trucks and buses, and two-wheeled vehicles. While not yet reaching European levels, more stringent emission standards are also set for three-wheeled vehicles.

With this proposal, the Indian Government has confirmed its intent to leapfrog BS V level emission standards and move directly to the more stringent and robust BS VI level. The proposed BS VI standards are far-reaching in scope and incorporate substantial changes to existing Bharat Stage III and IV emission standards. Of particular note is the tightening of particulate matter (PM) mass emission limits and the introduction of particle number (PN) limits for light- and heavy-duty vehicles (LDV, HDV) fitted with gasoline direct injection (GDI) and compression Ignition (CI), or diesel, engines. As evidenced by the adoption of nominally equivalent PM and PN standards in Europe, this step will likely lead to the near-universal application of diesel particulate filters (DPF) to control PM emissions from new diesel LDVs and HDVs.

Technical Background on India BS VI Fuel Specifications

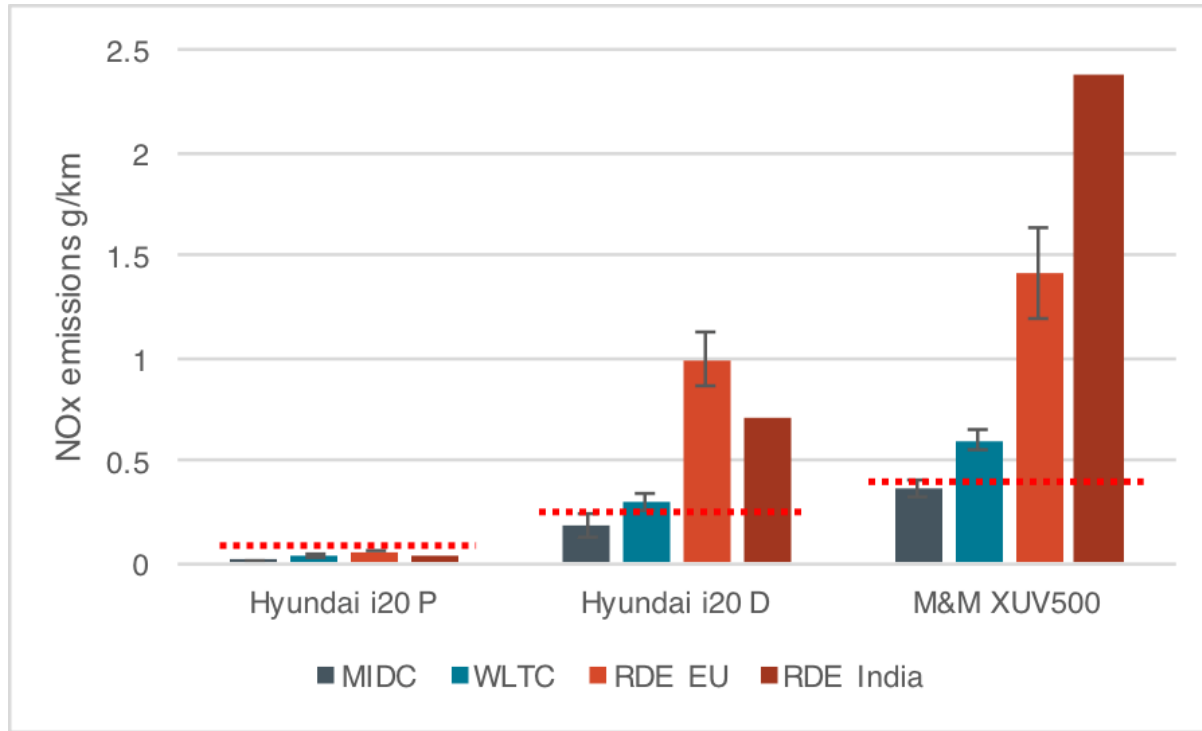
Background

On February 19, 2016 the Ministry of Road Transport and Highways (MoRTH) issued a draft notification of Bharat Stage (BS) VI emission standards for on-road vehicles in India.¹ In addition to emission standards for new vehicles, the proposed BS VI regulation contains specifications for reference and commercial gasoline and diesel fuels. These specifications define requirements for physical properties and chemical composition of the fuels, and are meant to ensure that commercial fuels are of sufficient quality and compatible with engine and emission control technologies that will be required to meet BS VI emission standards.

While proposed BS VI fuel specifications largely follow European regulations, proposed limits for several commercial gasoline and diesel fuel parameters in India differ from EU values. These parameters include octane number and olefin content for regular grade gasoline; and density, 95% distillation boiling point (T_{95}), and polycyclic aromatic hydrocarbon (PAH) content for diesel. This working paper details these differences in fuel specifications for commercial gasoline and diesel fuels in India and the EU, and assesses potential air pollutant emission impacts of these differences.

Gasoline Fuel Specifications

2017...Real Driving Emissions (RDE) accepted in India...



2018...but RDE is not a done deal!

 POSITION BRIEF


THE INTERNATIONAL COUNCIL
ON CLEAN TRANSPORTATION

MAY 31, 2018

TECHNICAL CONSIDERATIONS FOR IMPLEMENTING
A REAL DRIVING EMISSIONS TEST FOR PASSENGER
VEHICLES IN INDIA

F. POSADA, Y. BERNARD, L. YANG, AND A. BANDIVADEKAR.

2018... India adopts filter forcing regulation on non-road vehicles



POLICY UPDATE

JUNE 2018

INDIA BHARAT STAGE IV AND V NON-ROAD EMISSION STANDARDS

ICCT POLICY UPDATES

SUMMARIZE

REGULATORY

AND OTHER

DEVELOPMENTS

RELATED TO CLEAN

TRANSPORTATION

WORLDWIDE.

On March 5, 2018, India's Ministry of Road Transport and Highways released the final rule for non-road Bharat Stage (CEV/Trem) IV and V emission standards,¹ including stringent emission limits on particulate matter (PM), particulate number (PN) (BS V only), nitrogen oxide (NO_x), hydrocarbon (HC), and carbon monoxide (CO). This is the first time India has adopted one set of consistent standards regulating both agricultural and construction equipment. The BS (CEV/Trem) IV and V standards are in general alignment with the European Stage IV and V standards for diesel engines used in non-road mobile machinery. India has now become the first region outside of the European Union to adopt Stage V-equivalent emission standards, moving ahead of countries such as the United States, Japan and China in its control of emissions from new diesel powered non-road equipment.

The regulation applies to diesel engine equipment, including agricultural tractors, construction equipment vehicles, and combine harvesters. The BS (CEV/Trem) IV standards set requirements for diesel engines between 37 and 560 kW, starting October 1, 2020. The BS (CEV/Trem) V standards, starting from April 1, 2024, cover a wider range of engines, including those smaller than 8 kW and those larger than 560 kW, and introduce PN limits for those engines with rated power between 19 and 560 kW. The required emission limits (Table 1), durability periods deterioration factors, and test cycles are consistent with those in the European Stage IV and V standards. The stringent PM and PN limits are set at a level which will ensure diesel particulate filters, the key technology needed to effectively control particulate matter emissions from diesel engines, adopted as expected in the European Stage V standards. Engines equipped with selective catalytic reduction also must meet ammonia emission limits of 25 ppm for those less than 56 kW, and 10 ppm for those above 56 kW.

2019... preparing for the transition...informing various stakeholders...



FACT SHEET: I

OCTOBER 2019

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FACT SHEET: INDIA

OCTOBER 2019

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DRIVERS AND

WHAT

India will transition to Bharat Stage (BS) VI emissions standards. The new platform is compliant with the standard. Union in standard of nitrogen oxides (PM), will manufacture filter (D)



FACT SHEET: INDIA

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FLEET AND MAINTENANCE MANAGERS

WHAT TO EXPECT FROM BHARAT STAGE VI DIESEL VEHICLES?

UPDATING INSPECTION PROCEDURES FOR BHARAT STAGE VI COMMERCIAL DIESEL VEHICLES A GUIDE FOR RTOS AND TESTING CENTERS

India will transition to Bharat Stage (BS) VI emissions standards. In some cases, a third component, an ammonia

Refineries and Fuel Standards in India

★ BS IV standards (cities)
 BS IV standards (districts)
 BS V standards (districts)

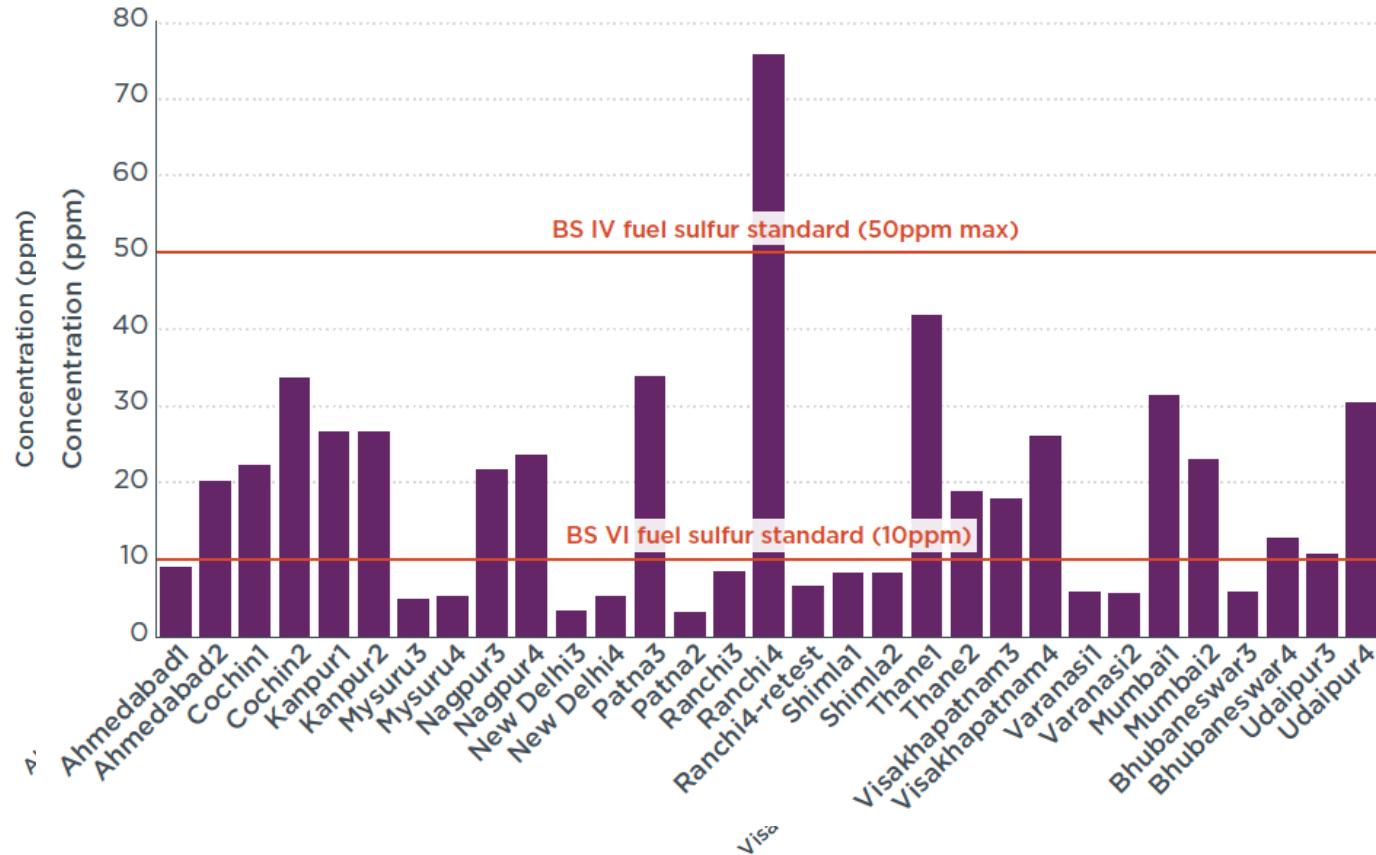
Refinery Capacity (MMTPA)

0.1
 1
 10

The National Capital Region (NCR) comprises four constituent sub-regions: the Haryana sub-region (Faridabad, Gurgaon, Mewat, Rohtak, Sonapat, Rewari, Jhajjar, Panipat and Palwal), the Uttar Pradesh sub-region (Meerut, Ghaziabad, Gautam Budha Nagar, Bulandshahr, and Baghpat), the Rajasthan sub-region (Alwar district), and the National Capital Territory (NCT) of Delhi.

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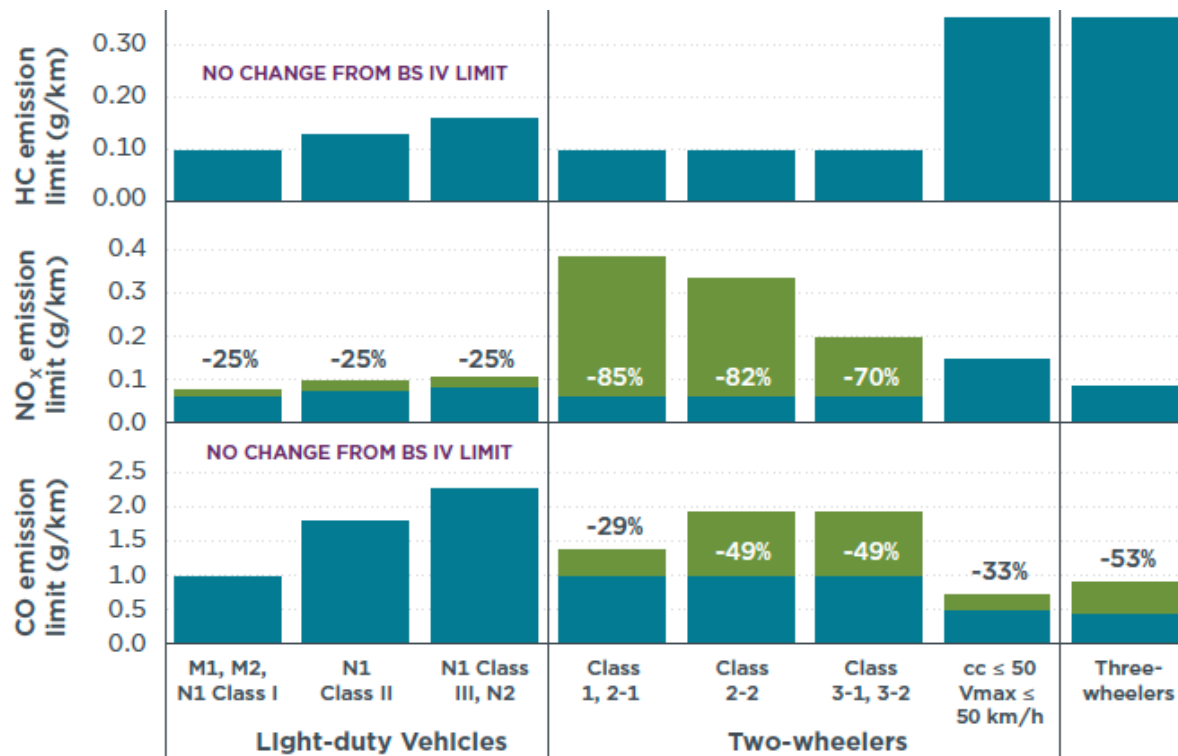
BS IV fuel quality testing showed readiness for BS VI (Dec2019/Jan2020)



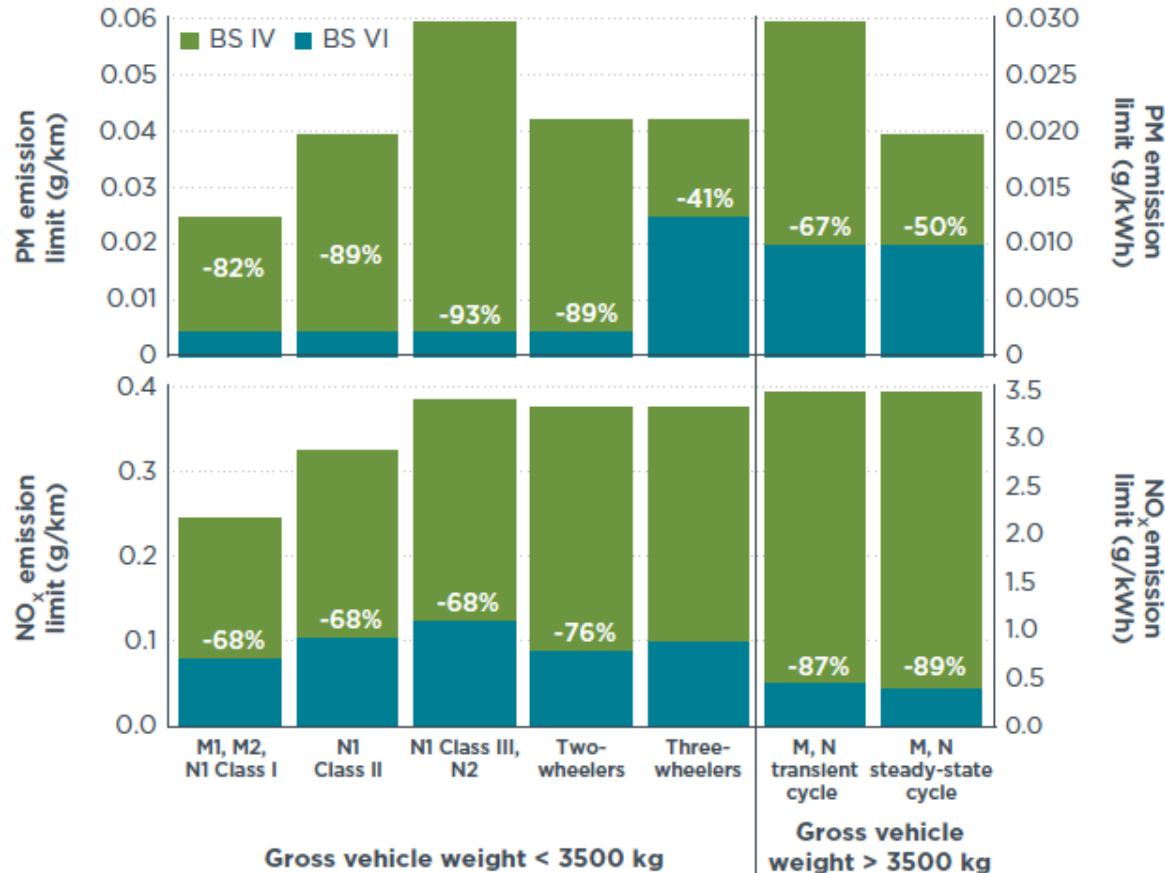
➤ <https://theicct.org/publications/gasoline-diesel-fuel-quality-survey-india-part-1-jul2020>

Bharat VI emission standards are bringing about
a major change in diesel emission controls

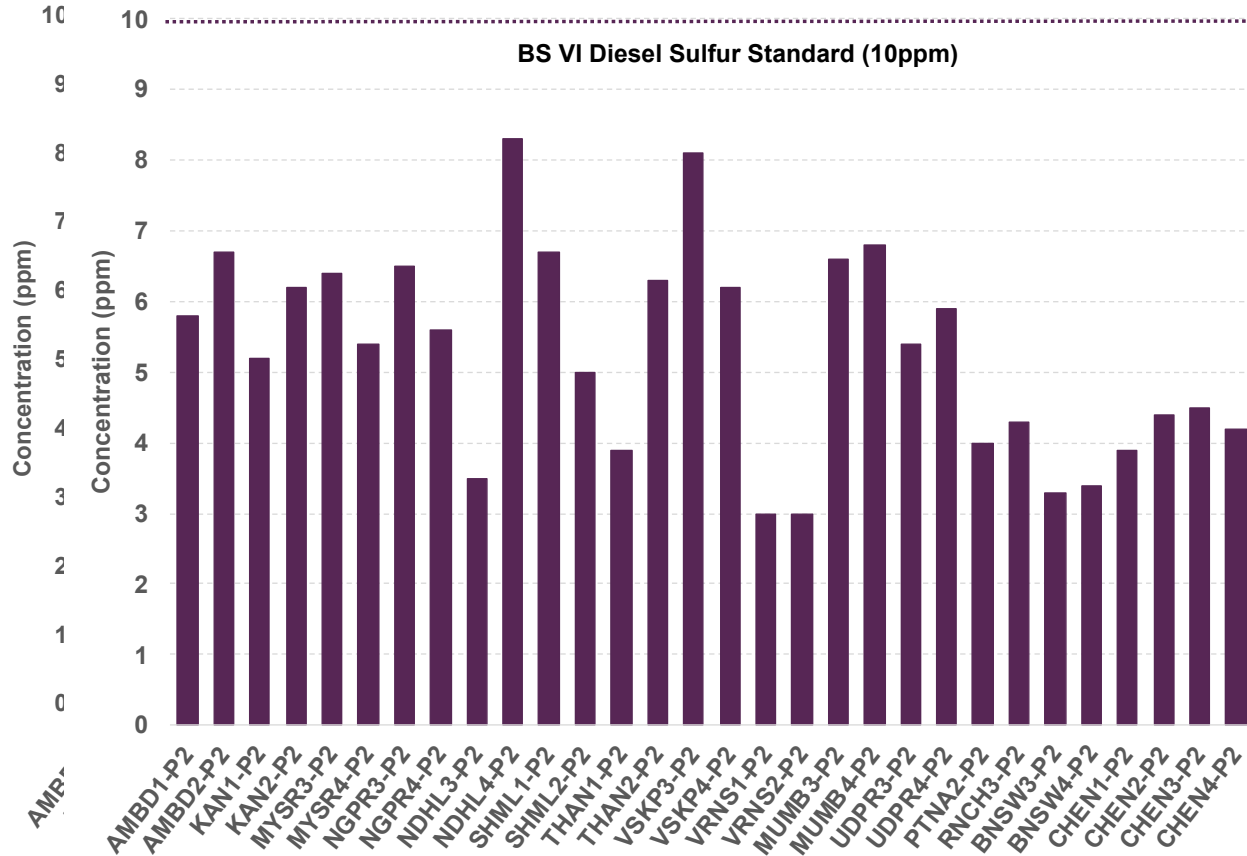
BS IV and VI emission limits for petrol/CNG vehicles



BS IV and VI emission limits for diesel vehicles



BS VI Fuel Quality Tests (June - November 2020) showed excellent sulfur content



➤ <https://theicct.org/publications/gasoline-diesel-fuel-quality-survey-india-part-2-apr2021>

Ongoing concerns about implementation of BSVI standards

- ❑ Consistent fuel quality across the country
- ❑ Robustness of aftertreatment systems
- ❑ On-board usage and maintenance of aftertreatment systems
- ❑ Nationwide distribution infrastructure & Standard grade Urea availability
- ❑ Tampering with aftertreatment systems and on-board diagnostics
- ❑ Driver/Cleaner/Owner Awareness
- ❑ Effectiveness of compliance and enforcement programs

Current BS VI \neq Final Euro 6/VI even after 2023

World Light-Duty Test Procedure (WLTP) not fully adopted

On-board fuel consumption meters not included

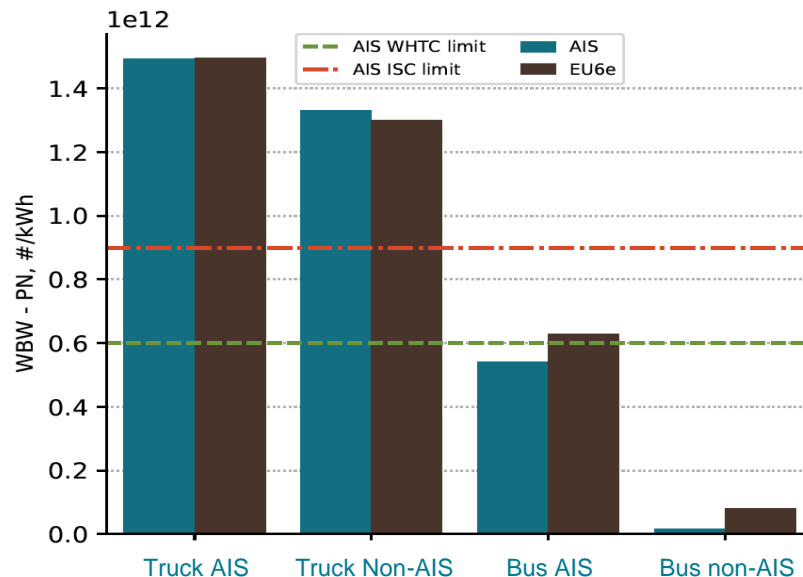
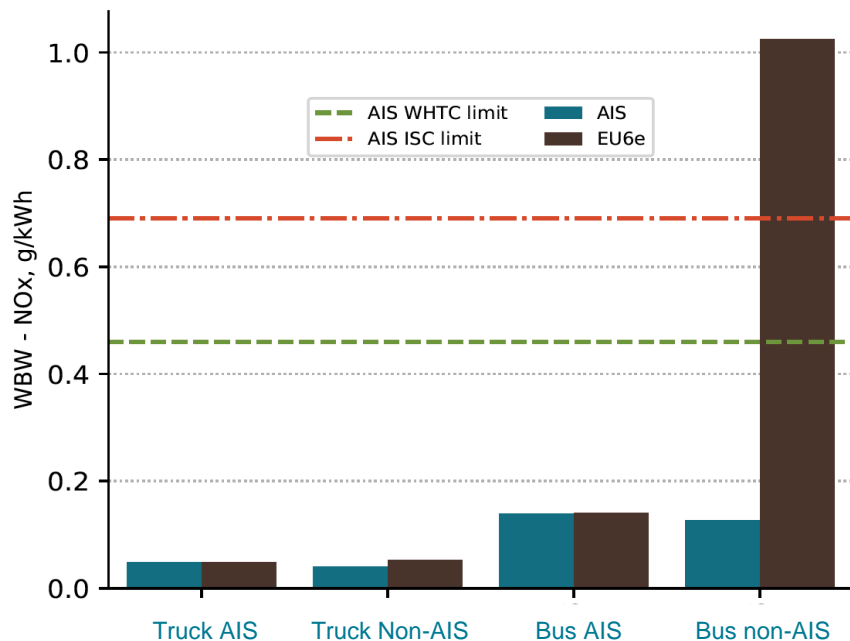
Real-driving emissions (RDE) proposal not consistent with Euro 6d

- Not clear if PN will be monitored only or confirmed
- Conformity factors not decided
- Cold start emissions not fully included
- Use of reference fuel, not market fuel for RDE testing
- No public dissemination of RDE data
- No in-service conformity using RDE

Euro VI D, and E provisions (Increased share of urban driving, cold start and PN testing during in-service conformity) not yet included fully

Relaxed emission limits for 3-wheeler NOx

BS VI on-road testing shows the need to adopt all Euro VIE, and in-service conformity provisions



Application of broader EU6e filters with coolant temp of 30C (replacing of 70c in AIS) and power threshold of 10% (replacing 20% P.T. in AIS) are applied, substantial differences are observed during certain test cycles, while the differences remain subtle in other tests. This shows how vehicle operation and route characteristics can have significant influence on the conformity factors.

BS VI is a major step forward, but World-class standards are 50-90% more stringent than BS VI !

ICCT India Initiative: <http://www.theicct.org/india>

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A combination of regulatory tools and incentives is necessary to reduce transport emissions

New Vehicle Policies

- ❑ **Stringent tailpipe emission standards**
 - ✓ BS VI for on-road vehicles
 - ✓ Stage IV and V for non-road vehicles
- ❑ Stringent evaporative emission standards
- ❑ Strong compliance and enforcement program
- ❑ Promotion of electric drive

Clean Fuel Policies

- ✓ **Ultra-low sulfur fuels**
- ❑ Stage I and II evaporative controls

In-use vehicle emission control

- ❑ On-board diagnostics (OBD) based inspection and maintenance program
- ❑ Remote sensing or other in-use emissions testing program
- ❑ Scrappage of old (especially diesel) vehicles
- ❑ Diesel particulate filter (DPF) retrofits for BS IV vehicles

Demand management

- ❑ Restrictions on use of older/more polluting vehicles
- ❑ Additional fees for older/more polluting vehicles
- ❑ Low Emission zones (LEZ)/Zero Emission Zones (ZEZs)

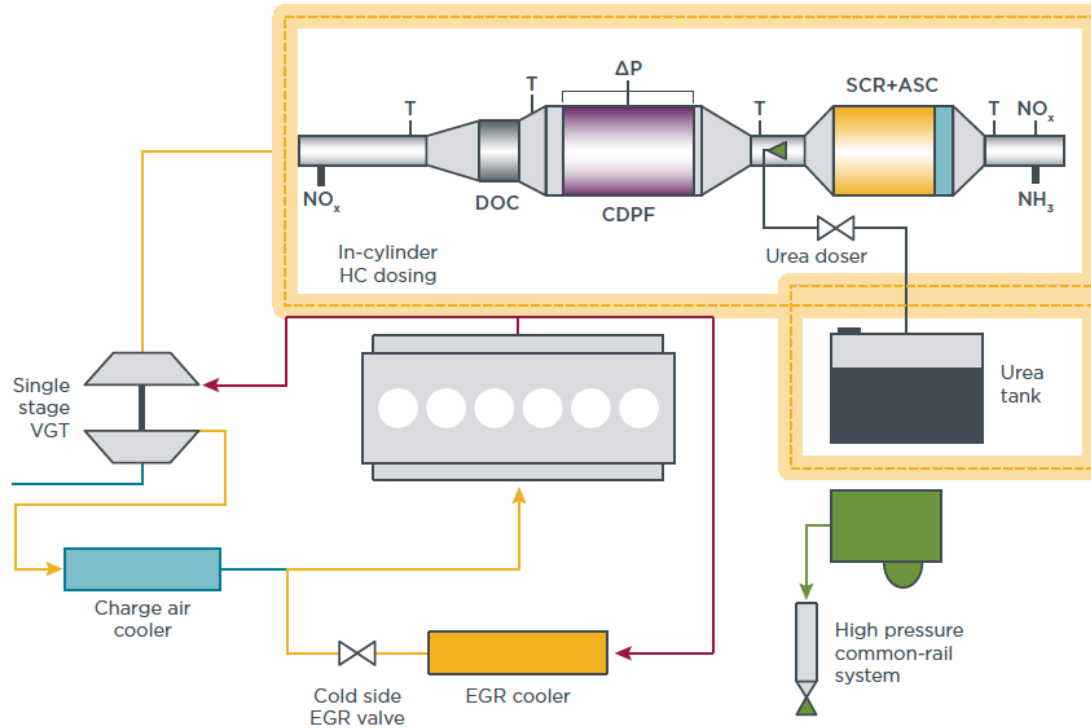
BS IV standards for new 2-wheelers effective April 2016 (all vehicles from April 2017)

Emission Standard for 2-W	Motorcycle Class	Emission Limits (g/km) ^[1]			
		CO	NO _x	HC+NO _x	
				If Evap. Test ≤ 2.0 g/test	If Evap. Test ≤ 6.0 g/test
Bharat III (2010) IDC	All 2-W	1.0	-	1.0	1.0
Bharat IV (2016 TA; 2017 AV)	Class 1 and Subclass 2-1	1.403	0.39	0.79	0.59
	Subclass 2-2	1.970	0.34	0.67	0.47
	Subclass 3-1 and 3-2	1.970	0.20	0.40	0.20
European Standards – WMTC testing					
Euro 3 (2006)	V _{max} < 130 km/h	2.62	0.17	0.92	0.92
	V _{max} ≥ 130 km/h	2.62	0.22	0.55	0.55
Euro 4 (2016 TA; 2017 AV)	V _{max} < 130 km/h	1.14	0.07	0.45	0.45
	V _{max} ≥ 130 km/h	1.14	0.09	0.26	0.26

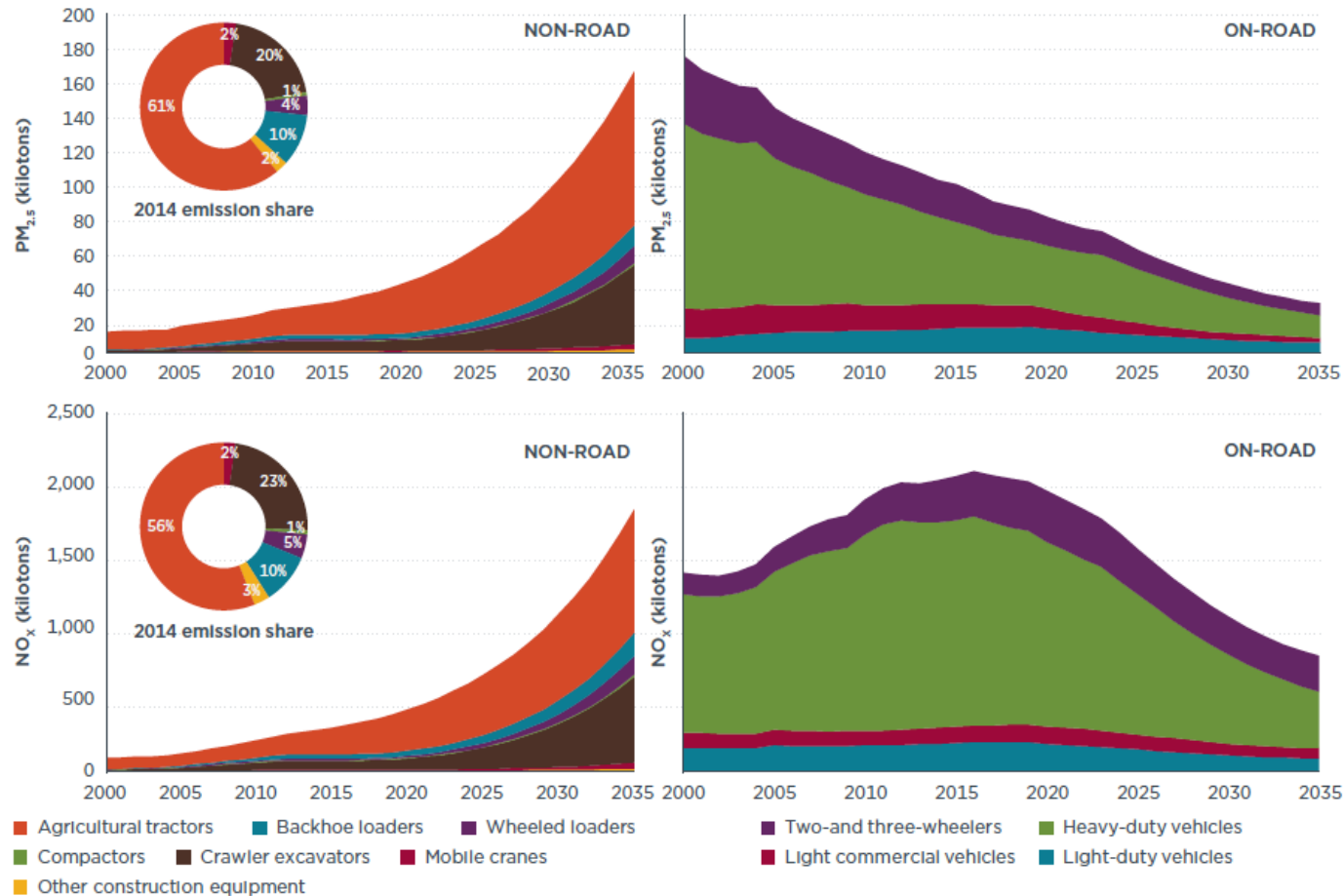
[1] Test procedure and driving cycles according to WMTC GTR-2 regulations, incorporating amendment 2, with preconditioning soaking and cold starts. Emission sampling starts at t=0 seconds.

➤ http://www.theicct.org/sites/default/files/publications/ICCTupdate_BSIV-motorcycles_aug2014.pdf

Typical BS VI aftertreatment systems for diesel buses/trucks



Importance of reducing non-road emissions in a post BS VI world



India Stage IV and V non-road emission standards

Category (kW)	Applicable with effect from	CO	HC	NO _x	PM	PN	Test cycle
		g/kWh				#/kWh	
Bharat Stage (CEV/Trem) IV							
37 ≤ P < 56	October 1, 2020 DELAYED by six months	5.0	4.7 (HC + NOx)		0.025	-	NRSC and NRTC
56 ≤ P < 130		5.0	0.19	0.4	0.025	-	
130 ≤ P <560		3.5	0.19	0.4	0.025	-	
Bharat Stage (CEV/Trem) V							
P < 8	April 1, 2024	8.0	7.5 (HC + NOx)		0.4	-	NRSC
8 ≤ P < 19		6.6	7.5 (HC + NOx)		0.4	-	
19 ≤ P <37		5.0	4.7 (HC + NOx)		0.015	1*10 ¹²	NRSC and NRTC
37 ≤ P < 56		5.0	4.7 (HC + NOx)		0.015	1*10 ¹²	
56 ≤ P < 130		5.0	0.19	0.4	0.015	1*10 ¹²	
130 ≤ P <560		3.5	0.19	0.4	0.015	1*10 ¹²	
P ≥ 560		3.5	0.19	3.5	0.015	-	NRSC

Making BS VI affordable....

