POSITION PAPER

October 2016

The Energy and Resources Institute

Improving Inspection and Maintenance System for In-use Vehicles in India

CONTENTS

Authors (TERI)
Jai Kishan Malik, Arindam Dutta, C Sitalakshmi, Sumit Sharma

Authors (OKAPI)
Amber Luong, Ayushman Banerjee

Advisor
S Sundar, TERI

The Energy and Resources Institute
Darbari Seth Block, IHC Complex,
Lodhi Road, New Delhi- 110 003

Tel. 2468 2100 or 4150 4900
Fax. 2468 2144 or 2468 2145
India +91 Delhi (0) 11

www.teriin.org

Background

- Air pollution is emerging as an important concern in India. Levels of particulate matter (PM) are above the prescribed national standards in about 80% of Indian cities. Other than PM, gaseous pollutants like NOx and SO_2 are found to be high at specific locations. There is adequate evidence that air pollution has adverse effect on human health and agriculture in India.
- The transport sector is an important contributor to pollution in cities. The sector accounts for a significant contribution in $PM_{2.5}$ concentrations in most Indian cities. In Bengaluru, the sector accounts for almost 50% of $PM_{2.5}$ concentrations. Figure 1 shows the share of the transportation sector in the $PM_{2.5}$ levels in five major cities of India.

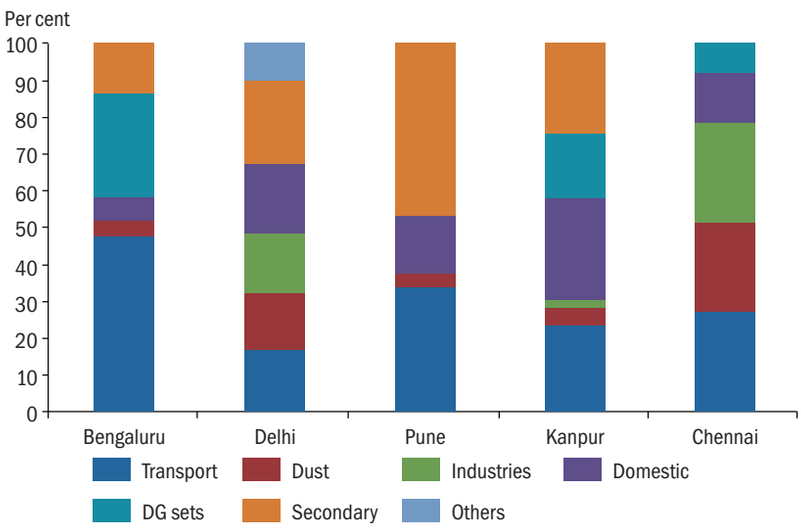

Figure 1: Source apportionment studies for $PM_{2.5}$ in five major cities of India

SHAKTI SUSTAINABLE ENERGY FOUNDATION

- Previous studies have shown that poorly maintained vehicles and older vehicles are responsible for a major share of pollution from the transport sector. While one of the studies suggests that about 60% of vehicular pollution in India can be attributed to about 20% of poorly maintained vehicles on the road; another study says that almost 60% of vehicular air pollution in India can be attributed to vehicles which are older than 10 years.
- A steep growth of vehicles is projected in the future and it is estimated that the on-road vehicular population in India would be 315 million by 2030. The emissions are expected to grow if not controlled in time. The best option to control emissions would be to reduce the number of vehicles on road. However, considering business as usual, the Government of India has recently announced the introduction of Bharat Stage (BS)-VI emission norms for control of emissions from new vehicles from 2020. Even with the tightening of the emission norms and introduction of cleaner fuel in the past, the expected results have not been observed in the air quality of Indian cities. In the absence of an effective inspection and maintenance (I&M) system, the on-road reduction in emissions cannot be ensured even with the introduction of cleaner fuels.
- Evidently, there is an urgent need to address the issue of I&M of the in-use vehicular fleet and this position paper not only highlights the issue but also suggests key strategies for improvement.

Current I&M System in India

- The gasoline/CNG/LPG vehicles are tested for CO and HC emissions, and lambda values and the diesel vehicles are tested for HSU emission. The standards for in-use vehicles in India were prescribed under Rule 115 (2) of Central Motor Vehicles Rules 1989, under the Motor Vehicles Act 1988. Revised PUC norms for in-use vehicles were notified by Ministry of Road Transport and Highways, Government of India, which were implemented across the country from October 1, 2004 (Tables 1, 2, and 3).

Table 1: PUC Norms for In-use Petrol/CNG/LPG-driven Vehicles

Vehicle Type	CO (%)	*HC (ppm)
Two- and three-wheelers (2/4 stroke) (vehicles manufactured before 31/3/2000)	4.5	9,000
Two- and three-wheelers (2- stroke) (vehicles manufactured after 31/3/2000)	3.5	6,000
Two- and three-wheelers (4 stroke) (vehicles manufactured after 31/3/2000)	3.5	4,500
BS-II compliant four-wheelers	0.5	750
Four wheelers other than BS-II compliant	3.0	1,500

*For CNG & LPG vehicles the measured Hydrocarbon value shall be converted using the following formula and then compared with the limits

- For CNG Vehicles- Non Methane Hydrocarbon, NMHC = 0.3 X HC
- For LPG Vehicles- Reactive Hydrocarbon, RHC = 0.5 X HC

Table 2: PUC norms for in-use CNG/LPG/petrol-driven four-wheeler manufactured as per BS-IV norms

S. No.	Vehicle type	Idle emission limits		High idle emission limits	
		CO (%)	HC (n-hexane equivalent) ppm	CO (%)	LAMBDA (RPM-2500±200)
1.	CNG/ LPG-driven four-wheelers as per BS-IV norms	0.3	200	-	-
2.	Petrol-driven four-wheelers as per BS-IV norms	0.3	200	0.2	1/±0.03 or as declared by vehicle manufacturer

Table 3: PUC norms for in-use diesel-driven vehicles

Method of test	Vehicle type	Maximum smoke density	
		Light absorption coefficient (1/metre)	Hartridge unit
Free Acceleration Test - for Turbo-charged engine and naturally aspirated engine method of test	Pre BS-IV	2.45	65
	BS-IV and above	1.62	50

- Gasoline/LPG/CNG vehicles are tested on idle speed testing mode and diesel vehicles are tested on free acceleration mode (FAS).
- It is mandatory for all the diesel vehicles manufactured post-April 2013 to be installed with OBD (on-board diagnostic system). Important functions like the performance of engines, fuel delivery system, and emission control devices are managed by electronic control units in modern vehicles. The potential areas in a vehicle which can influence the emissions of pollutants from the vehicle are monitored by the OBD each time the engine is started. A malfunction light starts glowing in the dashboard in case vehicle components, monitored by the OBD, are not functioning adequately. A fault code is also generated and stored in the OBD. The fault code records the information regarding the vehicle component which is malfunctioning at that moment. At present, OBD is not a part of formal PUC testing in India. The vehicles manufactured in future will have higher dependence on electrical equipment making OBD all the more useful. A more sophisticated version of OBD is expected to be introduced in 2020 along with BS-VI vehicles.
- To enforce the PUC regulations, a number of fuel-filling stations and some garages — known as PUC check centres — have been authorized to carry out these checks and the vehicles have to get the PUC check done periodically. Figure 2 shows the existing I&M system in India.

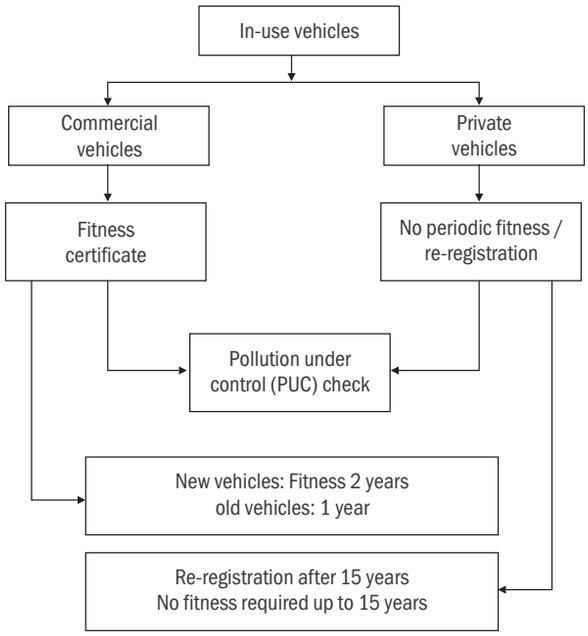

Figure 2: Existing I&M system in India

- The I&M programme in India consists of mandatory periodic PUC certifications for all types of vehicles and annual fitness certifications for commercial vehicles. The frequency of mandatory PUC checks varies from one to four times a year, depending on the state government's policies. According to the Central Motor Rules 1989, every motor vehicle is mandated to carry a valid PUC certificate after one year from the date of first registration.
- A central inspection and certification centre has been established in Nasik, Maharashtra (another such centre is also established in Burari) in June 2015. The vehicles are tested for PUC along with other safety parameters like brakes, headlights, speed, etc. The process of establishing such centres is also being initiated in other cities.

Limitations in the Current I&M System

- Some of the testing parameters like hartridge smoke unit (HSU) are quite dated and need to be changed. HSU has been used in PUC centres as a proxy for PM measurements. Newer engines emitting a lesser mass of PM in comparison to older ones, will call for newer technologies for accurate measurement of PM. Some parameters like NO_x, another major pollutant of concern from diesel vehicles, are not yet measured during PUC testing.

- The idle speed testing mode and FAS are not the best testing modes for inspection of in-use vehicles. These tests were chosen in the absence of more sophisticated methodologies at the time of introduction of PUC system in India to serve the purpose of inspection of vehicles. In addition to this, studies conducted by The Energy and Resources Institute (TERI) have shown that even the driving cycles adopted in the type approval (TA) of vehicles do not represent real world driving cycle. Currently, there is no effective mechanism in India to ensure that vehicles comply with their original mass emission standards (Type Approval norms) during the useful life. The absence of a mechanism which ensures that in-use vehicles comply with TA norms (subject to deterioration factors) could lead to a situation where the introduction of better technology will not lead to expected results in real world emissions.
- OBD can be a game changer for inspection and maintenance of in-use vehicles in India; however, it is still not a part of the formal PUC system. At present, there are no standards and guidelines for reading the codes generated by OBD. OBD only glows the malfunctioning indication light (MIL) in the dashboard. Since, there were no campaigns to inform vehicle owners about OBD or to train personnel at local workshops; it is unlikely that the OBD serves any useful purpose for emission control at the moment.
- Despite a provision of heavy penalties, merely 21% of vehicles in 2014 appeared for PUC testing in Delhi. Recent study by TERI showed that 13% and 10% of total registered vehicles turn up for PUC testing in Bengaluru and Mysore, respectively, in the year 2015/16. These low compliance rates indicate that I&M system only captures a small proportion of in-use vehicles, and most of the vehicles are running without a PUC certificate, possibly with higher emissions than the prescribed standards.
- Those vehicles which appear for testing also do not ensure compliance to the prescribed norm due to issues of manual interference, tampering, and manipulation with the datasets. This could lead to lesser failure rates as reported by the PUC centres, despite higher emissions in reality.
- The PUC data collected by the RTOs in the cities is not analysed comprehensively anywhere. In some cities like Delhi and Bengaluru, the PUC centres are connected to an online network. The data collected from these PUC testing is sent to a central database. In many other cities, these data are not networked to any central location and remain with local PUC centres. Nonetheless, the data collected by this process can provide useful insights in carving out city-specific policies for improving pollution load from vehicle fleet in the city. Box1 lists out the findings from the analysis of the data collected by the RTOs in Bengaluru and Mysore in the year 2015/16.

Box 1: PUC data analysis can provide insights for framing policies (case study of Bengaluru and Mysore)

- PUC datasets were collected for the two cities of Bengaluru and Mysore for all types of vehicles from AVL technologies. The data was analysed for the year 2015/16 for key parameters, such as vehicle types, age, fuel used, emission norms—BS-II, BS-IV, engine types, tail pipe emissions (CO, HC, NOx, CO_2, HSU) tested under the PUC programme. The datasets of 16 lakh and 1.3 lakh vehicles, were used for carrying out analysis for Bengaluru and Mysore, respectively.
- The PUC data analysis suggests that less than 1% diesel vehicles were found to fail in the two cities. In case of diesel vehicles, the highest failure rate was observed in the category of buses in Bengaluru, whereas in Mysore, the highest failure rate was observed in four-wheeler SUVs.
- In the case of gasoline/CNG/LPG vehicles, the failure rates varied from 1%–5% for different categories of vehicles, highest observed in 3-wheelers. Failure rates were higher in Mysore as compared to Bengaluru, possibly due to poor maintenance of vehicles or better enforcement of I&M testing laws.
- An analysis was carried out to assess the contributing factors (age, engine type, and fuel) in defining the emissions of a vehicle. In the category of non-diesel vehicles (gasoline/CNG/LPG), among the three variables discussed above, the fuel type emerged out as the major contributor to the emissions from vehicles tested under the PUC programme. The other two factors, i.e. vehicle age and engine type, also contribute significantly.
- In case of diesel vehicles, it was observed that both HSU readings (soot emissions) increased in both BS-IV and pre-BS-IV vehicles with age. However, the rate of increase in the emissions with age in case of BS-IV vehicles was higher in comparison to the pre BS-IV vehicles. This requires immediate attention and further investigation. One probable reason could be that low sulphur fuel required for BS-IV vehicles is not available countrywide. Usage of poor quality fuel when moving out of the city limits could be one of the reasons for higher deterioration of emission control devices in these engines.

Solutions to Improve In-use Vehicle Management in India

There are a number of issues that need to be resolved to improve the in-use vehicle management system in the country as discussed in the following points.

- The vehicles which do not have OBDs installed should be tested at the existing PUC facilities. However, the current HSU-based testing of diesel vehicles is based on the principle of absorption of light, which is not adequate to measure finer PM particles as present in the exhausts of new vehicles. This can be improved with LLSP (Laser-Light Scattering Photometry) systems which measure PM through scattering of light. With an ultimate motive to measure NOx from the tail pipe emissions of the diesel vehicles, the possibility of incorporating Non-Dispersive Ultraviolet (NDUV) absorption spectroscopy in the PUC testing system should be explored. NDUV works on the principle that NOx absorbs certain wavelength in the ultraviolet spectrum and transmits the rest. The PUC standards recommended for inspection and maintenance should also be tightened. There is a need to improve capacity of existing PUC centres over time to become a part of an enhanced overall I&M system; centres that do not meet more stringent requirements over time may be phased out, ultimately resulting in fewer PUC centres that will be easier to audit and verify.
- We recommend that OBD systems should be made mandatory for all vehicles by 2020. The standards to assess the OBD datasets for desired performance of the vehicles need to be developed. Some of the existing PUC centres should be equipped with the capacity to collect and analyse OBD datasets. All the vehicles equipped with OBD should be tested at these centres. Vehicles failing the OBD tests should be tested at accredited centres as discussed below. A pilot of OBD-based I&M programme should be implemented in Delhi. This pilot program can test the vehicles which already have OBD installed in them.
- **Accredited inspection systems:** The present initiatives taken by the government, i.e., introduction of centres, like in Nasik, serve the purpose of testing the vehicles for road worthiness (PUC + testing for road safety). If such centres are to be deployed for a city like Delhi with almost 8 million vehicles, then almost 125 centres would be needed to test all these vehicles on an annual basis. More importantly, it would be a challenge for the state governments to allot land for so many centres. Therefore it needs to be considered whether fewer centres can be set up only to test vehicles (only for emissions) which have failed OBD test. Hence, lesser amount of land would be required in each city. These centres would be equipped with facilities to test the vehicles on the rigorous loaded mode tests. Moreover, being few in number, these centres can be properly maintained and audited regularly. It could also be considered whether these facilities could be established and managed by automobile manufacturers who could take responsibility of the integrity of these tests. Possibility of introducing a policy where the government offers testing franchises on a minimum subsidy bidding basis can also be explored. These facilities should be regularly monitored by the respective state pollution control boards (SPCBs).
- Vehicles found with deranged parameters in OBD systems will be asked to carry out further loaded mode testing using advanced technologies like OHMS (On-road Heavy Duty Vehicle Emission Monitoring Systems) or Lug down testing for diesel vehicles. Gasoline vehicles, if found to be deranged as per the OBD standards, will need to go for advanced loaded mode testing, based on advanced testing procedure like ASM (Acceleration Simulation mode). Selecting a specific and suitable loaded mode test for vehicles requires further investigation. A list of technologies, deployed in other countries, is discussed in Annexure I.
- To summarize, cities in India would have three kinds of testing centres – traditional testing centres for vehicles without OBD, OBD testing centres for vehicles equipped with OBD, and accredited testing centres for vehicles failing the OBD tests. At present, only diesel vehicles manufactured post-April 2013 will have OBDs installed. By 2020, there would be minimal representation of vehicles with OBD in the total vehicular fleet. This number would then be expected to rise, assuming that all vehicles manufactured after 2020 will have OBDs installed. By 2035, vehicles without OBDs in the

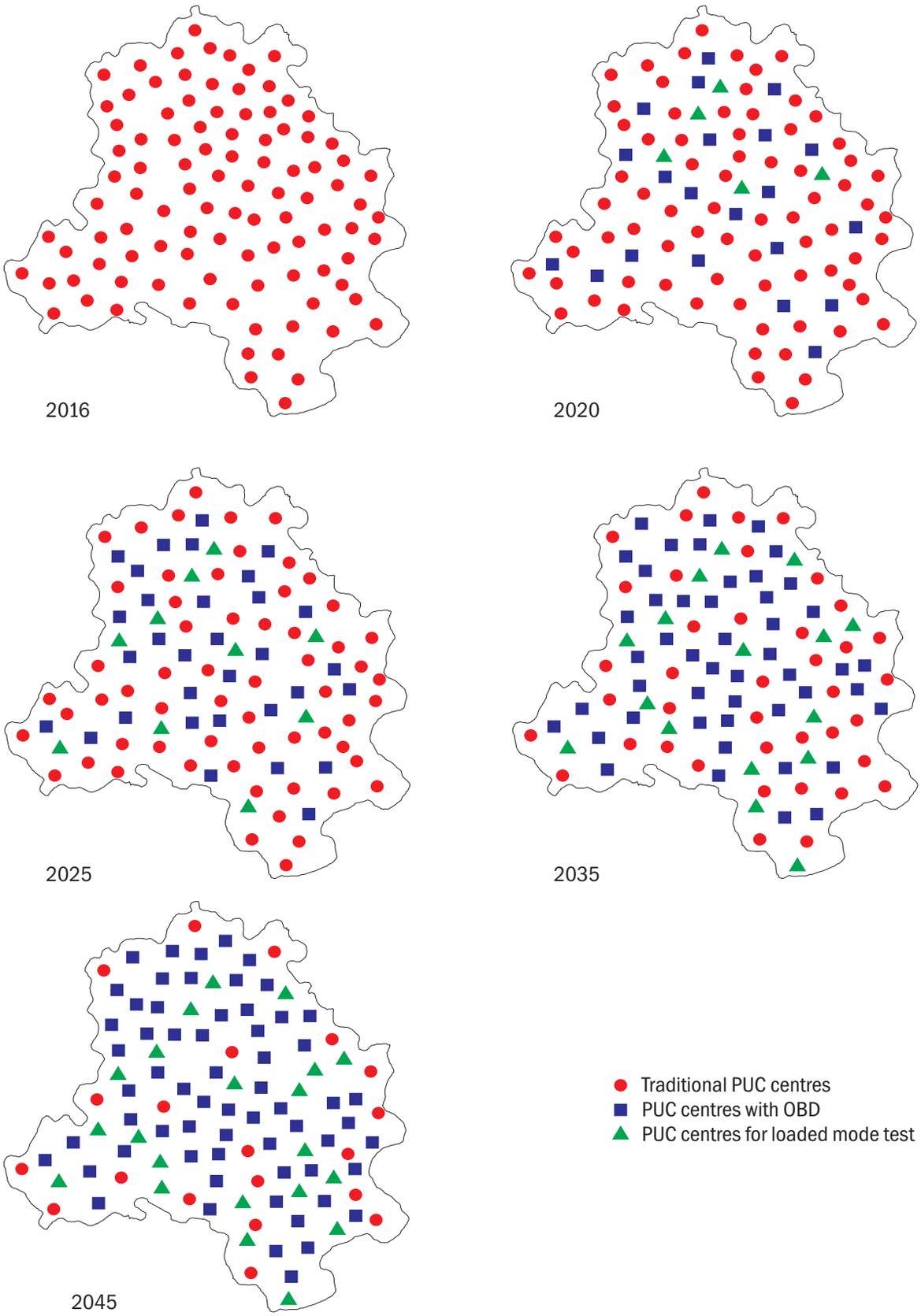

Figure 3: Expected changes in the percentage distribution of PUC testing centres in a typical Indian city

Indian vehicular fleet would start retiring and the need for OBD and accredited centres would rise and the number of traditional PUC testing centres would start decreasing. Figure 3 represents how the percentage distribution of traditional, OBD, and accredited testing centres are expected to change in a typical Indian city if the suggested recommendations are implemented.

- To assess the performance of the I&M programme in a city, remote sensing techniques need to be employed as a check. These tests can be carried out on selected roads where a significant number of vehicles are passing through and their emission signals are detected remotely by the device. The percentage of vehicles complying with the prescribed emission standards as detected by the remote sensing device can be compared with the data from I&M centres. If a wide variation is discovered, the I&M centres need to be strengthened further.
- **PUC integration with insurance:** In many countries, integrating both vehicle insurance and vehicle inspection has worked effectively in curbing emissions from in-use vehicles, such as in Costa Rica, the EU, and many states of US.
- **Quality assurance:** Periodic audits and quality checks must be a built-in component of the overall I&M programme to ensure effective implementation and positive results. Not even the most robust I&M mechanism can prove useful, unless frauds and manual tampering is completely avoided.
- It is suggested that all cities in India move to computerized testing centres. The test data collected in each of these centres is submitted on a real-time basis to a centralized location managed by the state transport department. This data is the key to understanding the vehicular fleet in each city; and hence, the results from analysis of this data can provide insights which can be used to frame city-specific policies for better inspection and maintenance of vehicles. This will result in introducing cost-effective and city-specific measures to identify high emitters. This can also act as input information for selecting models to be tested under the in-use vehicle compliance programme (IVCP), as discussed later.
- **Testing frequency**: It is recommended to conduct annual testing of vehicles across India rather than quarterly or biannual PUC checks. Annual checks (rather than quarterly or biennial checks) can ensure that higher percentage of the vehicular fleet actually appear for inspections.
- **Visible stickers**: It should be mandatory for all vehicles to carry a visible I&M sticker at all times, with validity period clearly mentioned on them to make it easier for the traffic cops to spot defaulting vehicles.
- **In-use Vehicle Compliance Programme (IVCP):** The goal of this programme would be to ensure that vehicles actually comply with their original emission standards (Type Approval standards) throughout their useful life after applying deteroiration factor. Presently, there are no tests or screening done in India to check whether the vehicles are actually meeting their Type Approval standards throughout their useful life, provided the vehicle is maintained optimally. This can be initiated by the Standing Committee on Implementation of Emissions Legislation (SCOE), which could initially target one vehicle model from all different automobile manufacturing companies operating in India. Two vehicles representing each model at two stages of their life-cycles (one new vehicle and one old vehicle) can be recruited for in-use compliance testing. Suitable vehicles would need to be recruited directly from consumers and the Regional Transport Office (RTO) database can play an important role for screening the on-road vehicles and pick out possible candidates. Models found to be emitting greater than their stipulated norms as per the Type Approval standards, would go in for more comprehensive testing at the expense of the manufacturer. For the comprehensive tests, a new set of samples could be recruited from the in-use fleet, which should be tested after adequate maintenance and servicing. Manufacturers usually claim that vehicles perform inadequately in the real world due to poor maintenance. Thus, for the purpose of IVCP, it is important that adequately maintained vehicles are selected for testing purposes. If those vehicles are also found to be failing the norms, the manufacturer should be given time to look into the possible cause and submit a detailed report to SCOE. The SCOE will look into the matter and

decide on further actions deemed necessary, which may ultimately lead to recall. For testing of vehicles under the IVCP, it is suggested that the R&D centres which have come up under the National Automotive Testing and R&D Infrastructure Project (NATRIP) could be roped in. A pilot programme for PEMS (portable emission measurement system)-based in-use testing on a few high volume vehicles should be taken up. Even if testing agencies like ICAT/ARAI test 8–10 cars and 8–10 trucks/buses each year in lab and on road, it will reveal a lot in terms of the state of compliance with the standards.

- Durability (deterioration) factors, presently prescribed in TA norms, are also questionable and need to be developed for local conditions in India, based on scientific assessments. Mass emission testing has to be carried out when the durability mileage claimed by the manufacturer is exhausted. Necessary correction in the durability factor should be made, based on the evaluation carried out.

- Undertaking these activities will require coordination at three levels:
  - Central (amongst the relevant Ministries, research institutes, and industry associations), possibly through existing committees such as the SCOE
  - Centre–State (with designated pilot state[s]) in order to facilitate information sharing and to feed implementation experience into the notified guidelines
  - Within State (amongst Transport Department, all RTOs, PUCs, accredited I&M centres, and traffic police)
- Therefore, it is also recommended that appropriate structures be put in place, either through public or private resources, to drive successful collaboration through the duration of these piloting and implementation activities.

Bibliography

Central Pollution Control Board (CPCB). 2015. National Ambient Air Quality Status and Trends in India – 2012, New Delhi.

Central Pollution Control Board (CPCB). 2011. Source Apportionment Study for Six Cities, Central Pollution Control Board, New Delhi.

Central Pollution Control Board (CPCB). 2010. Status of the Vehicular Pollution Control Program in India, PROBES/136/2010. Central Pollution Control Board (CPCB), Ministry of Environment, Forest and Climate Change (MoEFCC).

Indian Institute of Technology Kanpur (IITK). 2015. Comprehensive Study on Air Pollution and Green House Gases (GHGs) in Delhi. Indian Institute of Technology Kanpur.

International Council for Clean Technology (ICCT). 2016. On-Board Diagnostic (OBD) Checks for Inspection and Maintenance in India, International Council for Clean Technology.

Ministry of Road Transport & Highways (MoRTH). 2010. Document on test method, testing equipment and related procedures for testing type approval and conformity of production (COP) of vehicles for emission as per CMV Rules 115, 116 and 126, MoRTH/CMVR/TAP-115/116, Issue No. 4, Ministry of Road Transport & Highways, Government of India.

Ministry of Road Transport & Highways (MoRTH). MoRTH/CMVR/TAP-115/116 document (Issue 4), Chapter 8. ARAI India [online] , Ministry of Road Transport & Highways, Available at <https://www.araiindia.com/CMVR_TAP_Documents/Part-15/Part-15_Chapter08.pdf> [accessed 11 December 2013].

Ministry of Road Transport & Highways (MoRTH) MoRTH/CMVR/ TAP-115/116, Issue no.4, Volume II, standards for petrol and diesel engine vehicles, Ministry of Road Transport & Highways, Government of India.

Mysore City Police. 2016.Number of registered motor vehicles in Mysore. Available at http://mysorecitypolice.gov.in/contentpage.aspx?id=53.

National Transport Development Policy Committee (NTDPC). 2014. India Transport Report: Moving to 2032. New Delhi. Routledge.

Posada F, Yang Z, Muncrief. 2015. Review of Current Practices and New Developments in Heavy-Duty Vehicle Inspection and Maintenance Programs, International Council for Clean Technology.

Pundir B P. 2001. 'Vehicular Air Pollution in India: Recent Control Measures and Related Issues', in India Infrastructure Report 2001. New Delhi: Oxford University Press.

Sharma Sumit, Goel Anju, Suresh R, Sitalakshmi C, Mhatta Richa, Sundar S, Bansal Gaurav, German John, Posada Francisco, Franco Vicente. 2013. Assessment of emission test driving cycles in India: A case for improving compliance. The Energy and Resources Institute and ICCT.

Sitalakshmi C, Sharma Sumit, Sundar S, and Bhanot B. 2014. 'Establishing a National In-use Vehicle Testing Programme in India'. Shakti Sustainable Energy Foundation. Available at <shaktifoundation.in/wp-content/uploads/2014/02/National-in-use-vehicle-testing-programme-in-India.pdf>.

Acknowledgements

We thank Shakti Sustainable Energy Foundation for providing financial support for this work. We also thank all the reviewers, and partners especially, The International Council on Clean Transportation (US), and Okapi.

Annexure 1

Technology	Type	Expected improvement as compared to current technology in India	Deployment in other countries	Comments
ASM	Testing mode (loaded)	The vehicle is accelerated with load applied on it (usually tested on a dynamometer). Higher accuracy than 'unloaded' test in India.	Beijing, Ohio, British Columbia, Georgia	ASM requires the vehicle to be placed on a chassis dynamometer. Application of ASM in the current (decentralized) I&M system would be challenging.
IMxxx	Testing mode (loaded)	Further improvement over ASM. Instead, of just acceleration, the vehicle follows a test cycle on chassis dynamometer.	Wisconsin, Vancouver (Canada)	Chassis dynamometer of IMxxx is much complicated and expensive than the one used for ASM.
Lug down test	Testing mode (loaded)	A loaded mode test for Diesel vehicles. Better accuracy as compared to free acceleration test mode currently used in India.	Singapore, Hong Kong, Colorado, Beijing	Requires a chassis dynamometer for testing.
DT80	Testing mode (loaded)	One of the most rigorous loaded mode tests for diesel vehicles. Results show closer correlation with on-road testing.	Australia	The vehicle is tested on a pre-defined test cycle on a chassis dynamometer. Making it expensive.
LLSP	Estimation of PM particles in exhaust from diesel vehicles	Higher accuracy as compared to opacimeters used in India. Suitable for BSIV and beyond vehicles.	-	The cost of equipment as comparable with opacimeters.
NDUV	Estimation of NOx in exhaust from diesel vehicles	NOx is currently not measured in diesel exhaust.	-	Higher accuracy in NOx measurement as compared with other technologies like NDIR and FTIR
Electrochemical cells	Estimation of NOx in exhaust from diesel vehicles	NOx is currently not measured in diesel exhaust.	-	Accurate results but different principle of operation from NDUV. Used as NOx sensors in some OBDs
OBD	Records data and alerts driver of the malfunction of emission control devices	Will play an important role both from inspection and maintenance perspective. Less time consuming and more cost effective. Records the performance of the vehicles in on-road conditions.	Mandatory use in Europe, USA, South Korea	BS-IV vehicles in India are installed with OBD. More improvements in technology are expected with introduction of BS-VI vehicles.
Remote sensing	Estimation of pollutants (HC, CO, NOx, opacity) while it is running on-road.	Possibly best technology available to evaluate the on-road performance of the vehicles. Could be used along with I&M system. Cannot be used as a standalone measure.	RS campaign carried out in China, Hong Kong, Taiwan, EU and USA	Expensive equipment. Pre-requisites like single flow traffic, horizontal tail pipe needed.
OHMS	Estimation of PM and NOx in exhaust of diesel vehicles.	High accuracy.	-	Can be implemented only if India has centralized inspection centres.

Abbreviations

- ARAI: Automotive Research Association of India
- ASM: Acceleration Simulation mode
- BS: Bharat Stage
- CNG: Compressed Natural Gas
- CO: Carbon Monoxide
- HC: Hydrocarbon
- HSU: Hartridge Smoke Unit
- I&M: Inspection and Maintenance
- IVCP: In-use Vehicle Compliance
- LLSP: Laser-Light Scattering Photometry
- LPG: Liquefied Petroleum Gas
- NATRIP: National Automotive Testing and R&D Infrastructure Project
- NDUV: Non- Dispersive Ultraviolet
- NMHC: Non-Methane Hydrocarbon
- NOx: Oxides of Nitrogen
- OBD: On-board Diagnostic System
- OHMS: On-road Heavy Duty Vehicle Emission Monitoring Systems
- PEMS: Portable Emission Measurement System
- PM: Particulate Matter
- PUC: Pollution Under Control
- R&D: Research and Development
- RHC: Reactive Hydrocarbon
- RTO: Regional Transport Office
- SCOE: Standing Committee on Implementation of Emissions Legislation
- SPCB: State Pollution Control Board
- SUV: Sports Utility Vehicle
- TA: Type Approval
- TERI: The Energy and Resources Institute

About TERI

The Energy and Resources Institute

A dynamic and flexible organization with a global vision and a local focus, TERI was established in 1974, with initial focus on documentation and information dissemination. Research activities, initiated towards the end of 1982, were rooted in TERI's firm conviction that efficient utilization of energy and sustainable use of natural resources would propel the process of development.

All activities in TERI, the largest developing-country institution working towards sustainability, move from formulating local and national-level strategies to shaping global solutions to critical issues. Buoyed by more than 30 years of excellence in research and innovation, TERI is now poised for future growth, driven by a global vision and outreach, with a philosophy that assigns primacy to enterprise in government, industry, and individual actions.

About SHAKTI SUSTAINABLE ENERGY FOUNDATION

SHAKTI
SUSTAINABLE ENERGY
FOUNDATION

Shakti Sustainable Energy Foundation works to strengthen the energy security of India by aiding the design and implementation of policies that support energy efficiency and renewable energy.

For more information, contact:

Sumit Sharma

The Energy and Resources Institute (TERI)
Darbari Seth Block,
IHC Complex, Lodhi Road,
New Delhi- 110003

Tel: 24682100 or 41504900
Fax: 24682144 or 24682145
Web: www.teriin.org
E-mail: sumits@teri.res.in

The Energy and Resources Institute

SHAKTI
SUSTAINABLE ENERGY
FOUNDATION