

# Policy Brief

# BS VI READINESS AND ROADMAP IN INDIA



Centre for Science and Environment



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## BS VI readiness and roadmap in India

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**India will leapfrog to BS VI emissions standards in 2020 to cut emissions by 80-90 per cent from new vehicles. But real emissions and health benefits are possible only if these advanced technologies are properly operated and maintained and requirements for real world emissions tests are made tighter with strong deterrence for tampering.**

### **This is the only way to prevent another dieselgate. Is India prepared?**

Exactly a year from now, India, the only vehicle producing country in the world, will leapfrog directly from Bharat Stage IV emissions standards (BSIV) to Bharat Stage VI. This nation-wide leapfrog in 2020 will cut emissions by as much as 80-90 per cent from new vehicles. But this proactive move can deliver the real benefits only if immediate attention is paid to BS VI readiness. Cities will have to upgrade their on-road surveillance (much beyond the current PUC), bus and truck operators need sensitization on handling of the advance and complex emissions control technologies, and efforts are needed to prevent influx of cheating devices to defeat the stringent operational requirements.

This discussion is needed immediately to speed up readiness in our cities by 2020 and also to inform and influence next round of revision of BS VI regulations in 2023 for tighter real world emissions and in-service compliance requirements for vehicles sold. To kick-start this discussion Centre for Science and Environment has carried out a rapid review of the available information on the post Euro-VI reforms that have been initiated in Europe as well as carried out a stakeholder consultation in India to identify the gaps in the current regulations on BS VI emissions standards and test procedures and to chart the roadmap to inform the post-2023 reforms of the BS VI regulations. This stakeholder consultation has tapped into a diverse set of stakeholders including vehicle policy makers, vehicle testing agencies including Automotive Research Association of India and ICAT, automobile industry covering key vehicle segments, emissions component manufacturer, oil companies, bus corporations, truck operators and international technical bodies like International Council on Clean Transportation.

## What is at stake?

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India has come a long way to improve tailpipe emissions from vehicles since the nation-wide introduction of Bharat Stage I (BSI) emissions standards in 2000. For a considerable length of time the vehicle technology levels had languished at a lower level of technology ladder. There was not only considerable time lag with Europe, the roadmap also moved slower due to stepped introduction of standards within India. The major cities got the improved emissions standards first while the rest of the country followed nearly five years later. This time lag would have continued and spilled over much beyond these two decades if this proactive move was not made to shorten the fuse to leapfrog directly from BSIV standards to BS VI standards in 2020. Already BS VI 10 ppm sulphur fuels have arrived in Delhi and parts of NCR.

There is much reason to rejoice this leapfrog decision. India is in grip of explosive motorization and choking haze of pollution. More than 70 per cent of Indian cities are classified as critically polluted and vehicles are among the highest source of exposure. In cities like Delhi vehicles contribute upto 40 per cent of the particulate pollution load. Yet the motorization is at its fastest today. It just took close to 60 years to get the first 105,000 million vehicles and another 8 years to get next 105,000 vehicles.

India has also witnessed massive dieselization – during early part of this decade diesel cars were close to half of the new car sales. This only brings out the significance of the leapfrog decision. As vehicles lock in pollution for at least 12 to 15 years on roads, committing new vehicle stocks to clean emissions benchmark becomes necessary. Dieseltailgate has shook the world and India. Rapid dieselization and excessive realworld emissions cannot be tolerated anymore. Already a new study from International Council on Clean Transportation has shown that exhaust from only on-road diesel vehicles is responsible for nearly half of the premature deaths worldwide. And two-third of this is in India, France, Germany, and Italy. Among the 100 major urban centres assessed for transport sector related deaths, Delhi ranks sixth. India needs to tame dieselisation and ensure very stringent monitoring of real world emissions and in-service compliance. With tightening of regulatory benchmarks for diesel that includes leapfrog to BS VI emissions standards at the national level and pollution charges on diesel trucks and big cars, and ban on 10-year old diesel cars in Delhi and the national capital region in Delhi has shaken the diesel market. According to the available information dieselisation has dropped from 47 per cent of new sales in 2012 to 19 per cent in 2018. Major car maker Maruti Suzuki has even announced stopping diesel car production immediately after enforcement of BS VI emissions standards.

There is global learning curve post diesel-gate. Even after meeting Euro VI standards, Europe experienced excessive emissions from on-road diesel cars compared to their certification level. India cannot allow repeat of such episodes of dieseltailgate and high real world emissions negating the value of big investments in expensive emissions control systems and approaches. Already Volkswagen case has signaled the shadow of the dubious track.

## What makes BS VI a leapfrog strategy?

BS VI in 2020 is leapfrog not just because India is skipping BSV standards. It is leapfrog because of several fundamental shifts in approaches to emissions control, monitoring and compliance that are becoming possible for real cuts in emissions. Broadly in the time horizon of 2020-2023 several parameters will be phased in.

**India comes close to fuel neutral standards** as the difference between petrol and diesel emissions will narrow down substantially. Until now the emissions standards in India – as patterned along the lines of European standards – have allowed diesel light duty vehicles to emit several times higher nitrogen oxides and particulate matter – 3-5 times higher - compared to petrol vehicles. Particulate matter is not regulated in petrol vehicles, as it is very negligible. These are the pollutants of concern in India. Under BS VI the gap will be narrower. In fact, to address this China has adopted a mix and match approach in which they have taken the best of Euro VI and California standards to make China VI fully fuel neutral.

**Not only the total mass of PM emissions from diesel vehicles will be weighed and regulated but also particle numbers to be counted:** Under the new standards particle numbers from tailpipe will be counted to ensure effective emissions control devices or particulate traps are adopted – to atleast eliminate 95 per cent of the particles.

**Vehicles will be tested for real world emissions and in-service compliance:** This is a paradigm shift to monitor real world emissions from vehicles with portable emissions monitors over the driving pattern of vehicles on the road. Even as vehicles are moving in the real world emissions are monitored from full range of driving conditions. This is a more effective way to monitor to check deviation from the certification level of emissions and ensure life-time performance of emissions control systems.

**Two wheeler standards will become significantly more stringent. For the first time NOx and hydrocarbon will be regulated separately:** BS VI norms align with Euro 5 that is significantly tighter. By setting independent emission standards for HC and NOX, (that was combined earlier) BS VI emission standards will help to ensure that emission control strategies do not reduce emissions of one pollutant at the expense of the other. All petrol vehicle models are required to meet a 1.5 g/test evaporative emissions limit, and no flexibility provisions are included for meeting tailpipe and evaporative emission limits. Even two wheelers will have OBD system specifications. This will open up opportunity for more advanced technologies and electronics.

**Health benefits of BS VI emissions standards:** It has been estimated that health benefits of this move is expected to be much higher than the actual costs of the make over. According to an assessment by the US based International Council on Clean Transportation (ICCT), this leapfrog to BS VI and fuel and emissions standards roadmap will help to avoid 280,000 cumulative avoidable deaths by 2030. While the actual cost of the make over will be USD 10 billion the health benefit will amount to USD 90 billion – nine times higher.

## Why do we still need a conversation on BS VI emissions standards?

Emissions standards are not just about the norm values but also the testing requirements that decide the level of effectiveness of the standards and lifetime performance of vehicles. Getting the template right early is important as vehicles once out on the road lock in enormous pollution for considerable period of time. While several key changes will happen in 2020, there are still some critical parameters that need quick phase in to ensure real-world emissions performance. While the new BS VI emissions standards with some critical parameters will come into force in April 2020, the standard code 137 that governs the testing parameter for vehicles will introduce several new changes related to real world emissions and in-service compliance in the 2023 time frame. Therefore, informing that process has become so important based on the global review.

These changes need to align with the new packages of reforms of Euro VI regulations in Europe that followed after the Volkswagen emissions scandal. That had rocked the world and had also exposed more widespread dieselgate in Europe when large number of diesel cars were found to be emitting significantly higher nitrogen oxides (NOx) than the requirement. An assessment of emissions test results by the ICCT in Europe found that real world emissions from as much as 90 per cent of Euro VI cars exceeded standards by up to 12 times. This had triggered more systematic testing of dominant car models by the governments that revealed large-scale violation of standards on road. Dieselgate has put diesel car market at serious risk. This triggered decisions across European cities including Paris, London, Madrid, cities of Nethrland and more to phase out diesel cars.

Diesel-gate exposed that there is a gaping gap between emissions measured from cars at the type approval level in the laboratories that is done with predefined testing protocol reflecting some part of driving pattern and the real world emissions from actual driving pattern on roads. This posed a serious regulatory challenge.

This exposed that the existing regulatory and testing protocol for Euro V and Euro VI vehicles could not address the problem of real world emissions on roads. ICCT has cited instances in France, when regulatory protocol for testing of type approval of Euro VI vehicles – as defined by the official test cycle (NEDC) on a road instead of in a laboratory— was carried out on road, a large difference in emissions (more than 5 times) were noticed compared with the regulatory limit for Euro VI vehicles. This shows there are many boundary layers of driving conditions that are not included in the test cycle to check emissions.

## RDE legislative packages



This led to a spate of new regulatory reforms in Europe to tighten the nuts and bolts of the BS VI regulations and real world testing requirements for light duty vehicles. Since the introduction of the Euro VI regulations in Europe therefore, four reform packages of additional testing requirements have been introduced. All of them were related to the real world emissions from vehicles. The first two packages of RDE legislation were published in 2016 as regulations. The third legislative package was adopted in 2016 and published in 2017.

## What are these packages of reforms in Europe?

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Based on the information available from the European Commission, individual European countries like Germany and an exhaustive review of regulatory reforms in Europe carried out by the ICCT, as well as the ICCT review of A137 document, it is possible to outline the key features of the successive reform packages for Euro VI norms in Europe that needs to inform the post-2020 reform process in India.

Europe has initiated 4 packages of reforms.

**Package one: RDE Act 1, 2016:** The first step was to define the actual test procedure for basic features of the Real world Driving Emissions (RDE) test for monitoring. This includes several parameters like characterization of the RDE trip on roads for real measurements, the vehicle family concept, a description of the data evaluation tools, the technical requirements of the Portable Emissions Measurement Systems (PEMS) equipment to be used for realworld emissions monitoring, and reporting obligations. The RDE testing was done only for monitoring purposes, without an impact on the actual type approval, which continued to be based on laboratory measurements. It looked at the boundary Conditions and data evaluation methods.

**Package 2: RDE Act 2 – September 2017:** The second step determined the phasing in of RDE testing for type approvals of vehicles that are issued by national authorities. RDE measurements of NO<sub>x</sub> was made compulsory for new car models from September 2017, and for all new vehicles from September 2019. It further introduced conformity factor for NO<sub>x</sub> with additional boundary conditions of driving to ensure emissions do not deteriorate from the certified level beyond a specified margin. From September 2017, the real driving emissions (RDE) test procedure is a mandatory part of the type-approval procedure for new passenger cars and light-commercial vehicles in the EU.

**Package 3 - RDE Act 3:** RDE testing was extended to cover particle number (PN) emissions for all new vehicle types by September 2017 and for all new vehicles by September 2018. The testing methods included short city trips starting with a cold engine and hot engine starts. This reform Act also mandates that the real-world emission performance of a car should be clearly stated by the manufacturer in the certificate of conformity of each vehicle, that it is transparent and available for all citizens and public authorities. This includes the introduction of a not-to-exceed (NTE) limit for particulate number, the addition of a cold start element to the test procedure, specific provisions for testing hybrid-electric vehicles, as well as a calculation procedure for taking into account regeneration events, such as for diesel particulate filters. This included PEMS test procedure and test equipment for particle number and Conformity Factor for particle number.

**Package 4 - RDE Act 4 - 2020:** This reform package ensures transparent and independent control of emissions of vehicles during their lifetime. Type approval authorities will have to check each year the emissions of vehicles already in circulation (“in-service conformity” testing). Authorities and independent parties will be able to perform officially recognised tests through accredited testing centres. The 4th Act introduces a reduction of conformity factor in RDE measurements, from 1.50 to 1.43. The conformity factor for nitrogen oxide (NO<sub>x</sub>) is slightly lower—1.50 instead of 1.43—as a result of a revision of the

PEMS measurement uncertainty. Research results by the EC have shown that the conformity factor could be as low as 1.24 for a NOX limit of 80 mg/km. This means efforts have been made to reduce the margin for deterioration on road.

The Commission will continue reviewing the conformity factor with the aim of bringing it down to 1 as soon as possible and at the latest by 2023. The next reduction is scheduled for 2019. The emissions of a valid RDE test are compliant with the regulation if the reported distance-specific mass of emissions is below the corresponding No to Exceed Emission Limit (NTE) limit. The NTE limit, the product of the Euro 6 laboratory emission limit times the conformity factor of the corresponding pollutant, is valid both for the total trip and its urban section. As a result, an RDE test will only be passed successfully if the NOX emissions are below a “Euro 6d” threshold of 114 mg/km for diesel cars and 86 mg/km for gasoline cars.

The Euro VI d version: Euro 6d will thus be required from January 2020 onwards for newly developed models—and from January 2021 onwards for all new vehicles. The temporary, “Euro 6d-TEMP” conformity factor for NOX remains unchanged at 2.1 until the end of 2019 for new types of vehicles and until the end of 2020 for all new vehicles, but manufacturers can choose to type-approve their cars to the final, Euro 6d limits today. The conformity factor for particulate number (PN) emissions also remains at 1.50, as defined in the third package of the RDE regulation. Carbon monoxides (CO) are included in the RDE measurements but remain excluded from any NTE limit. The on-road RDE test complements the laboratory test and is intended to ensure that the emission levels of vehicles under real-world driving conditions stay low.

## The key features of 2020 reforms in Europe

**New type approval:** A new type approval scheme rules will be enforced from 1 September 2020 onwards. Each member state will retain its own type approval authority, and mutual recognition of type-approval certificates issued by the different national authorities will still apply. Nevertheless, the European Commission (EC) will play a stronger role than today, as in the future it will have the power to carry out its own verification testing and to initiate and monitor vehicle recalls. The regulation will also allow the EC to impose fines of up to 30,000 EUR per noncompliant vehicle on manufacturers, but only in cases where a penalty has not been previously issued by a member state.

**Independent market surveillance:** The new regulation will introduce independent market surveillance. This is different from the current EU type-approval scheme, which relies only on the pre-production type-approval tests and verification tests performed by the manufacturers on in-production vehicles. From September 2020 onwards, EU member states—and the European Commission—will be required to perform tests on vehicles already in the market, in order to ensure that vehicles in use still meet their emission limits.

For this purpose, each member state will install a market surveillance authority independent of the type approval authority. Each member state will be required to conduct a minimum number of vehicle compliance tests per year. There will have to be at least one test per every 40,000 new motor vehicles registered in the respective member state in the preceding year, with at least 20 per cent of the tests emissions-related. Countries with a low number of car registrations will have to conduct a minimum of five tests per year.

**Change the test cycle for testing emissions — Worldwide Harmonised Light Vehicle Test Procedure (WLTP):**

In addition, the fourth RDE regulation introduces a new, single evaluation method for regulated emissions that replaces the two existing moving average window and power binning methods. As part of this method, the CO<sub>2</sub> emission level during the RDE on-road test are compared to the CO<sub>2</sub> emission level of the vehicle during the Worldwide Harmonised Light Vehicle Test Procedure (WLTP). If the level of CO<sub>2</sub> measured during RDE is less than 20 per cent above during WLTP (30 per cent from January 2020 onwards), the RDE pollutant emissions are reported as measured during the RDE test (raw). Otherwise, the raw pollutant emissions are corrected downwards as a function of the ratio between CO<sub>2</sub> RDE to WLTP. Again, CO<sub>2</sub> emissions are used here as a proxy for the severity of an RDE trip. For plug-in hybrid vehicles, special provisions apply.

**In-service conformity tests for after market vehicles:** As part of the amendment, a minimum number of in-service conformity (ISC) checks of vehicles was introduced to be performed by the granting type approval authority. Today, ISC checks are entirely in the hands of car manufacturers, and they are only carried out for air pollutant emissions, not for CO<sub>2</sub>. Part of this responsibility will now shift to the respective type-approval authorities, which will perform WLTP and RDE tests (the latter only for NO<sub>x</sub> and PN emissions), in addition to the WLTP tests carried out by manufacturers. The granting type approval authority must gather all relevant information on possible emission non-compliances relevant for deciding which ISC families to check in a particular year. The number of compulsory annual ISC checks level is set to 5 per cent of PEMS families or a minimum of two families per manufacturer. This is significantly lower than the 20 per cent that stakeholders, such as environmental NGOs, were originally asking for. In addition to the granting type approval authorities, ISC checks can be performed by other type approval authorities, or commissioned by any third party, provided that an accredited laboratory or designated technical service carries out the testing on their behalf. All parties shall report the results in an electronic platform to coordinate in-service conformity testing.

As part of this test, a sample of vehicles are pulled from the same vehicle family are tested consecutively until a “pass” or “fail” decision is reached. The maximum number of vehicles to decide whether an ISC check is passed is 10 vehicles of a vehicle family. The probability to pass the ISC check is reduced when vehicles have a significant chance to fail the WTLTP or RDE test. Evaporative and low temperature tests have a shorter sampling plan and are only voluntary.

**Enforcement mechanisms:** The new framework will also strengthen enforcement mechanisms available to EU member states. Today, a member state cannot take measures against noncompliant vehicles sold, but not produced, in their national markets, other than notifying the type-approval authority of the country that issued the vehicles’ type-approval certificate and waiting for it to take action. In the future, member states will be allowed to restrict or prohibit the usage of affected vehicles or require actions by the manufacturer. If there are no objections from other member states within one month, all member states must apply the same measures. In case of objections, the EC has the last say.

The implications of this new provision can be illustrated by the ongoing case of the German type-approval authority claim that some vehicles of the Fiat-Chrysler group (FCA) are applying an illegal defeat device that would shut off the exhaust aftertreatment after 22 minutes, while the Italian type-approval authority, which issued the type-approval of the suspicious vehicle models, has so far refused to take any action. The new provision would allow Germany to require action by FCA or restrict the use of effected vehicles.

Further there is access to vehicle software to as a precaution to stop use of defeat devices: In addition to improved enforcement, the new regulation also grants type-approval authorities and technical services access to vehicle software, a step intended to safeguard against the use of defeat devices.

**Fuel consumption meter:** From January 2020 onwards for new vehicle types, and one year later for all new vehicles, manufacturers have to determine on-board the instantaneous as well as the lifetime fuel consumption of each vehicle—the so-called fuel consumption meter.

**Breaking the financial nexus between carmakers and technical testing agencies:** The original proposal by the EC intended to break up the financial relationship between car manufacturers and their technical services. In the current EU type-approval system, member states designate technical services to perform testing and inspection tasks for which they are paid directly by vehicle manufacturers. To avoid any potential conflict of interest and reinforce the independence of testing, a type-approval fee structure was considered to cover the costs of all type-approval tests and inspections carried out by the technical services. However, the European Parliament and EU member states rejected this part of the EC's proposal, so that also in future years technical services will continue to receive funding directly from car manufacturers. The regulators did however recognize the key role that technical services have in the type approval process. In the future, technical services will only receive designations for a limited time, which will only be extended based on the result of on-site assessments. Such on-site assessments can also be conducted by the EC.

## What are the missing links in Indian regulations?

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All eyes in India are now on the upcoming post-2020 BS VI reform process that will happen 2023 onwards. The document that governs regulatory blueprint of BS VI standards in India is called AIS 137 that lays down all the test parameters and compliance requirements. This document is continuously updated depending on the nature of new reforms. It is necessary that the post 2023 reform related to realworld emissions monitoring, in-service compliance mechanism, and independent oversight systems among others align fully with the latest package in Europe. This must narrow down and eliminate the gap between laboratory and on-road emissions performance of vehicles meeting BS VI emissions standards.

**What has India already adopted?** Some of the key elements have already been adopted in India.

In the case of light duty vehicles, RDE testing requirements have already been included in the existing protocol for data generation from April 1, 2020, but real world driving cycle emissions testing by PEMS and conformity for monitoring will be enforced from April 1, 2023. Similarly, Not-to-Exceed emissions limits based on conformity factor will be assessed and introduced from 2023 onwards.

In case of heavy duty vehicles, India is aligned with the European regulations from the beginning. This is mainly because Europe was more conscious of real world performance of this segment given the global experience. Therefore, as part of the document AIS 137, emissions measurements with PEMS for data collection will be carried out from April 1, 2020 onwards. From April 1, 2023, in-service conformity factor will be applicable. Vehicles will have to meet requirements of in-service compliance. Off-cycle laboratory testing limits for gaseous and particulate exhaust emissions on World Not-To-Exceed – have been specified and will be implemented. Also the vehicles manufactured on or after 1 April, 2023 shall have the capability of assessing the in-use performance of on-board diagnostic.

## What is still missing in Indian regulations?

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As of now there are several critical parameters that are not yet fully aligned with the European reform packages. These will have to be addressed in the 2023 reforms in India and included in the AIS 137 document. The real world driving emissions requirements are not fully aligned with Euro 6d packages. Real driving emissions conformity factor – how much deviation from the real world to be allowed? The big change is the requirement of conformity factor and Not To Exceed limits. Conformity factor sets the margin of deviation allowed from the certification level and Not To Exceed limits mean that under real driving condition the actual emission level does not exceed the specified limit. An RDE test is considered compliant with regulation if the reported distance specific mass of emissions is below the NTE limit for total trip.

The European RDE conformity factor for NOx and particle number were first adopted in 2015 as CF= 2.1 for application in September 2017 and CF=1.5 from 2020. This means the actual real world emissions must not deviate from the certified level by 2 times or 1.5 times. This also takes into account the uncertainty

in the PEMS measurement of real world emissions. Europe is further reducing this to CF=1.43 for NOx. For particle number the CF remains 1.5.

India's AIS 137 has stated that a committee will be set up to decide the conformity factor for 2030 timeframe. But it is important to weigh in that India will have to look at the quick phase in CF=1.43 and CF=1.0. More lenient margin will lead to compromises and high real world emissions.

There is no decision yet on the conformity factor to be adopted for enforcement in 2023.

**In service conformity and market surveillance testing:** As per AIS 137 in India-In-Service Conformity test is part of the BS VI regulations that allows tailpipe emissions verification – using the same chassis test carried out during type approval tests. It has detailed out the in service testing frequency, procedure etc, it includes most of the points however third party or independent testing provision is not clear although it says that “The emissions testing to be done at a Test Agency. or Tests can be conducted on manufacturer's accredited test facility”

Global review shows that such testing is carried out by manufacturers on in-use vehicles and components to verify compliance to type approval procedures. It is required of vehicle manufacturers throughout a vehicle's lifetime. In the US this is called in-service verification programme and in-use confirmatory programme. In EU this test for LDVs duplicates the tailpipe emissions tests conducted during type approval stage with chassis dynamometer tests.

**No provision of market surveillance and independent verification:** This system demands market surveillance and independent verification testing and inspection by regulatory authorities on in-use vehicles and components to determine whether they continue to conform with the exhaust emissions standards. The 4th RDE package in Europe introduced a minimum level of ISC checks of vehicles to be performed by the granting type approval authority. These are done entirely by the car manufacturers. The responsibility will now shift to type approval authorities to gather relevant information on non-compliances and to identify the engine family to check for in-service compliance in a year. It is evident that annually compulsory annual in-service compliance checks is set at 5 per cent of PEMS families or a minimum two families per manufacturers. This is quite lower than the public demand of 20 per cent.

It may be noted that China has adopted elaborate China 6 RDE – in-use compliance programme. Manufacturers are required to test in-use vehicles at low (10,000-60,000km), medium (60,000-110,000km) and high (110,000-160,000km) mileages and report their test results to the regulatory agency. Regulatory agency has the authority to randomly test in-use vehicles upto 160,000km driving. India must adopt PEMS based test as part of in-service conformity regulations for passenger vehicles and move to regulatory framework for market surveillance programme that makes testing authorities responsible for testing.

**Need to define the test trip on roads adequately:** Some elements of the RDE test protocol need to be adjusted to suit the Indian driving conditions. Although RDE testing is conducted on public roads open to traffic, there are provisions to ensure that test trips cover a broad range of driving conditions typically

encountered by drivers for testing of emissions control systems. Boundaries have been set to define and cap on what constitutes a valid RDE trip. Experts point out that the normal driving condition should not be too aggressive (that results in high NO<sub>x</sub>) and not too passively and at low speed (that cause low NO<sub>x</sub>). India needs to adopt total NO<sub>x</sub> emissions as per the package 4 of Europe or give more weightage to urban driving category. This will encourage the manufacturers to develop in-cylinder or EGR based NO<sub>x</sub> reduction strategies at low load, which the SCR system will not reduce.<sup>1</sup>

**Change the testing cycle:** India needs to discontinue use of MIDC for vehicle type approval tests within the RDE regulatory framework. This does not represent dynamic driving condition and make emissions testing less exacting. For heavy duty vehicles India has already adopted WHSC and WHTC cycles. For light duty vehicles it will have to be WLTP. This needs clarification from ARAI.

**Public disclosure on Real Driving Emission tests:** Emissions tests results should be made public. This is also important to build public confidence in diesel engines. USEPA shares certification test details for light duty vehicles and heavy duty vehicles on their website. This is updated annually and includes all models and engines sold each year. It includes other information for consumers. Heavy-duty manufacturers have to report PEMS testing data requirement. 5per cent of engine families are tested every year. China has adopted China 6 new LDV emissions standards regulations, which included RDE regulatory component, and require that vehicle manufacturers publish the test results to the public.

**Fuel consumption meter:** In Europe from January 2020 onwards, manufacturers will add this feature to determine the fuel consumption.

**Prevention of tampering of emission control devices:** This is a critical area of intervention. As of now the AIS 137 has defined what defeat devices mean and it has prohibited the use of such devices. It is said that “If for a vehicle the collection of ECU data influences the vehicle’s emissions or performance, the entire PEMS test family to which the vehicle belongs shall be considered as non-compliant. Such functionality shall be considered as a ‘defeat device’.

However ICCT while reviewing the AIS 137 has recommend adopting the European 3rd and 4th RDE package provisions that include cold start emissions as part of the regulatory evaluation. And, to prevent defeat device activation, ICCT has recommend the inclusion of a hot engine test on a minimum number of families to prevent defeat-devices using cold engine start as an indication for laboratory or RDE testing. Apparently, such devices are triggered by cold engines start as an indication for laboratory or RDE testing. This also requires further clarification.

**Urea refill infrastructure for SCR:** India has not yet paid adequate attention to the infrastructure for auto-grade-urea or Adblue refill for diesel vehicles to be fitted with SCR system for NO<sub>x</sub> reduction. Urea tank to fitted to the vehicle

exhaust system will require periodic urea refill. AdBlue consumption and frequency of refill will vary across vehicle models. Illustratively, a heavy duty vehicle with a mileage of 5km/litre will need approximately 12 litres of AdBlue per 1000 km. With truck tank capacity of over 40 litre will cover approximately 3500 km with the tank full of AdBlue. There are some private players who are getting into this market. But reliability of distribution and refill network, quality control of AdBlue pose serious challenges that will have to be addressed immediately – even before the vehicles arrive next year. There are concerns around quality control of urea and regulations for private players who have already invaded the market. According to the industry sources there have been case of misfuelling.

## How should on-road emissions management respond to this new technology?

The ongoing Pollution Under Control certificate (PUC) programme based on basic test of pollution concentration in idling exhaust or smoke density from diesel vehicles that was designed for the older vehicle technologies is not relevant for the new generation of emissions control technologies any more. This will require a paradigm shift in the way we inspect and monitor on-road emissions. Europe is gearing up for change.

In Europe most diesels since late 2009 (Euro 5 onwards) are fitted with diesel particulate filter (DPF). If such vehicles emit smoke of any colour it is considered a major defect. The UK has even lowered smoke limit to 27 HSU in 2014.

Globally, I/M programmes are getting designed to check if any emission control equipment fitted by the manufacturer is missing, obviously modified or obviously defective. If detected this is categorized as a major defect. This includes Diesel Particulate Filters (DPF), Oxidation Catalysts and Selective Catalyst Reduction (SCR) valves. In UK, the inspection programme is restricted to components that are readily visible and identifiable, such as a diesel oxidation catalyst, diesel particulate filter, selective catalytic reduction valve etc (See Table 1: Inspection of emission control system in UK). In any vehicle if diesel particulate filter is removed, or tampered with, or filter canister has been cut open and re-welded, the vehicles are rejected in the inspection tests. These tests look for missing components, exhaust leak that affect the emissions level, or any other sign of tampering. They have integrated on-board diagnostic systems with I/M programme. Also the MIL is now part of the test and will be a major defect if it is inoperative or indicates a malfunction.

**Table 1: Inspection of emission control system in UK**

### 8.2.2 Compression ignition engine emissions

#### 8.2.2.1 Exhaust emission control equipment

**This inspection is restricted to** components that are readily visible and identifiable, such as a diesel oxidation catalyst, diesel particulate filter, selective catalytic reduction valve etc.

**Diesel particulate filters (DPF)** should be checked for evidence that the **DPF** has been removed or otherwise tampered with. Where a DPF canister has clearly been cut open and re-welded, it should be rejected unless evidence can be provided that the canister was cut open for legitimate reasons, such as filter cleaning.

Defect	Category
(a) Emission control equipment fitted by the manufacturer missing, obviously modified or obviously defective.	Major
(b) An induction or exhaust leak that could affect emissions levels.	Major
(c) Evidence that the diesel particulate filter has been tampered with.	Major

## How can we improve on-road monitoring?

There is push towards adoption of remote sensing monitoring of on-road emissions. India has also taken nascent step forward. Simply put, remote sensing is a light source and a detector that is placed on the side of the road or at a height to transmit a laser beam to measure exhaust emissions remotely via spectroscopy as vehicles pass by and cross the light path. This can measure exhaust plume, and detect opacity, nitric oxide, carbon monoxide, hydrocarbons, and carbon monoxide in 0.5 seconds in the exhaust plumes of vehicles. It can record emission rates from thousands of individual vehicles along with speed and acceleration across all driving conditions daily. This can test several vehicles per hour within an interval of one second. A camera captures the image of the vehicle's number plate which, if connected with a vehicle registration database, can identify the make, model, certified emission standard, fuel type, rated power and other details.

It has many uses. At one level, remote sensing helps to detect individual high-emitting vehicles, where high emissions result from poor vehicle maintenance by the vehicle owner, or are caused by the removal and tampering of emission control systems and accidental malfunctioning of emission control equipment among others. But the other big benefit is that it also helps to detect high-emitting vehicle models where the fault lies with the vehicle manufacturer. These could be poor design or defects in the emissions control components; deterioration or poor durability of the emissions control-related components; and intentional cheating of emissions standards and the use of defeat devices.

Kolkata has already introduced remote sensing measurements and been implementing this for 10 years. Under the direction of Supreme Court ICAT has piloted this in Delhi. Fleet profiling is needed to arrive at a threshold limit to weed out gross polluters from road. This can be used for enforcement and more important profiling of on-road performance. This will require regulatory guidelines and testing guidelines that Ministry Road Transport and Highways. The key advantage of this intervention is that it can help to identify early on the real world compliance (durability, defeat devices, etc) and failure of emissions control system.

In China remote sensing method has been in use since 2005. There are 22 removable remote sensing devices and 27 fixed remote sensing devices in Beijing. The car that exceeds the remote sensing standard needs to go to smog station for retest, and it will be fined if it exceeds again. The remote sensing method for HDV is used to analyze and evaluate the vehicle. For compliance Government is revising local law to require that driving a HDV with visible smoke once photographed by the camera will be fined directly.

As part of the independent initiative True Rating has been adopted in Europe. In this colour coding system, three-colour systems based on remote sensing monitoring has been developed. For example, Green indicates good or the lowest available in-use emissions; Red indicates poor when emissions are three times or more than the latest emission limits. This informs the consumers, policymakers and manufacturers. The first results were launched in June 2018.

Overall, it is important to weigh in that emissions control systems in BS VI vehicles will be far more advanced, complex and expensive. We need good maintenance to reduce costs of repair and replacement. It is important to sensitise the driver, vehicle owners, mechanics, about the diesel particulate filter, and SCR and their working. These vehicles require specialised maintenance, maintenance intervals and schedule. Customised inspection protocol is needed. This will require strong action against tampering and cheating devices.

### Is India prepared to prevent tampering with emission control devices?

It is still not well understood in India that as emission control systems for particulate matter and NOx in diesel vehicles become more complex and expensive, propensity for corporate frauds/compromises on quality as well as cheating by vehicle users will increase. For instance, for NOx control, adblue, a urea-based solution, is regularly filled in the Selective Catalytic Reducing (SCR) system attached to the exhaust of the modern diesel vehicles. As refill is a recurring cost, defeat devices tempt users to disable the SCR system.

This is also why Volkswagen had used defeat devices to reduce severity of the SCR system to reduce urea dosage. Defeat devices are openly available on the internet for anyone to use and disable SCR systems to avoid the extra cost of urea solution. Countries like Brazil have reported rampant use of defeat devices.

Any tampering and modification of emission control systems consists to reduce operation costs, increase performances, or eliminate repair costs hugely compromise benefits of new vehicles' emission regulations.

**Tampering EGR:** This leads to use external zapping device like a black box that is plugged behind EOBD socket; there is also mechanical tampering – physical change in engine compartment – blocking gas tube with a baffle; sealing the hose to vacume actuator.

**Tampering with SCR:** SCR disconnected and ECU emulator: Even though emission regulations require vehicle manufactures to install auto checks in the vehicle to sense depletion of urea solution and stop the vehicle automatically, defeat devices can disable this in-built check and allow vehicles to run even with depleted solution and not let onboard diagnostic flash red alert. If this is not checked, India will experience uncontrolled NOx emissions even after introducing BS VI. Reagent tank guage showing exactly 25 per cent, 50 per cent, 75 per cent OR 100 per cent; Fuse removed/blown from SCR system; modified wires in the harness. Electronic device fitted in OBD-port or with wires spiced into the wiring from SCR ECU may be an emulator; Reagent tank empty aor level not corresponding to guage etc

**Tampering with DPF – DPF removed, also with ECU set up:** Missing part or visible alteration (eg welding seam) of the exhaust pipe; soot in the exhaust of Euro VI vehicles indicate DPF removal. DPF gutted, also the ECU set up: Soot in exhaust indicate DPF removal

Other countries have adopted regulations for defeat devices. The US regulation defines a defeat device as “an auxiliary emission control device that reduces the effectiveness of the emission control system”. Any element which senses temperature, vehicle speed, transmission gear, or any other parameter for the purpose of activating, delaying, or deactivating the operation of any part of the emission control system are liable for severe penal action. The US Environmental Protection Agency levy civil penalties of up to \$37,500 per vehicle and \$3,750 per sale of defeat device.

The EU framework regulation empowers the European Commission to adopt “requirements for implementation”. A review by the ICCT shows that the EU vehicle emissions regulation directs member states to “lay down the provisions on penalties applicable for infringement by manufacturers of the provisions of this Regulation and [to] take all measures necessary to ensure that they are implemented”. Penal action includes fines, withdrawal of type approval, recall, repair obligations, and prison.

A government must quickly enforce strong, independent and transparent emission testing regime and in-use compliance mechanism with a recall programme to address cheating both at the manufacturing level as well as consumer level.

## The way forward

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Leapfrog to BS VI emissions standards is an important step forward that needs to be leveraged to maximize emissions and health gains. It may be noted that even though we are aspiring to meet the best European emissions standards, Europe is the third best standard in the world. China has gone ahead of Europe, and combined key lessons and parameters from the US, and Korea to frame its own advance regulations. They have adopted much tighter testing parameters including tighter RDE tests, limits of particle number linked to RDE, in-service conformity right from the beginning, OBD requirements, on-board NOx tracking, and evaporative standard requirements.

This global review and consultation with diverse group of stakeholders in India has made it very clear that even after the introduction of BS VI vehicles in 2020 further urgent steps are needed to fully align with the reform packages in Europe related to regulatory and testing requirements of vehicles to meet the real world emissions targets. India's BS VI regulations are consistent with the reform package 1 and 2 and some parameters of package 4. Without those reforms India stands at serious risk of dieselgate. Even after meeting the tighter emissions standards, diesel cars may have high real world emissions, especially if their emissions control systems are compromised.

Therefore, 2023 BS VI reforms that India is preparing for needs to be informed well. This is the time to good mapping of all actors, responsibilities and pathways to inform the reform process better. A lot attention is needed at the state level for upgrading the inspection regime for the new generation vehicles.

### Action at the national level

- Align AIS 137 with fourth and the latest package of reforms of European regulations to strengthen testing parameters for real world testing and in-service compliance, tighter conformity factor and adoption of improved test cycles and public disclosure of data and market surveillance by type approval agency. This must include adoption of Worldwide Harmonised Light Vehicles Test Procedure (WLTP) cycle.
- Further strengthen compliance and testing regulations for effective real-world emissions performance. This will require effective in-use conformity factor. In-service programme for light duty vehicles will have to be strengthened.
- Introduce public disclosure and independent verification system.
- Introduce a strong system of compliance, penalty, emissions warranty and Recall programme. Emissions warranty and extended emissions warranty to cover the in-service life of vehicles is an important step.
- Amend Central Motor Vehicles Act to enable implementation of remote sensing monitoring for on-road surveillance as well as more effective integration of OBD.
- Build urea refilling infrastructure and quality control and assurance system.

**Action at state level**

Immediately adopt framework and issue guidelines for upgrading on-road emissions inspection appropriate for new generation technology –

- Phase in of remote sensing measurements for fleet characterization and enforcement
- Define and issue the check list for inspection of emissions control systems in vehicles and prevent tampering
- Ensure OBD integration and improved emissions testing procedures for gross polluters in I/C centres.

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