

POLICY BRIEF 2020–21

BS-VI LEAPFROG

WHAT MORE TO DO



Centre for Science and Environment

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Shakti Sustainable Energy Foundation (Shakti) seeks to facilitate India's transition to a sustainable energy future by aiding the design and implementation of policies in the following sectors: clean power, energy efficiency, sustainable urban transport, climate policy and clean energy finance.

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1. Introduction

India implemented Bharat Stage VI (BS-VI) emissions standards nationwide on 1 April 2020 amidst the raging novel coronavirus pandemic (Covid-19) and economic slowdown. It leapfrogged directly from BS-IV emissions standards that were introduced nationwide in 2017 and selectively in a few cities in 2010. This leapfrog promises to reduce emissions from the new vehicles fleet by at least 60–90 per cent, depending on the pollutant and vehicle segment. This has catapulted India into a much cleaner technology paradigm.

Health benefits from this move are expected to be significant and much higher than the actual costs of the makeover. 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 makeover will be US \$10 billion, the health benefit will amount to US \$90 billion—nine times higher.

It is notable that this transition has happened despite the economic shock from the pandemic. Initially, however, there were worries that the pandemic and economic dislocation might delay the timeline for its implementation. In fact, automobile dealers had moved the Supreme Court just before the pandemic to seek extension of the deadline for registration of BS-IV vehicles. The Supreme Court had rejected the appeal in March. Subsequently, in its order of 13 August 2020, the Supreme Court allowed the registration of only those BS-IV vehicles that were sold before the countrywide lockdown was imposed in March. Only vehicles with details uploaded on the government's E-Vahan portal were allowed to be registered. This firmly allayed fears about any delay in BS-VI implementation.

While there are enough reasons for cheer for India's leapfrog action, the story has not ended. After adoption of the basic BS-VI emissions standards in 2020, more regulatory reforms are needed to ensure that these new vehicles equipped with advanced emissions control systems remain low emitting during their useful life on road. This requires further improvement in the testing parameters for certification of BS-VI vehicles as well as new strategies for monitoring of emissions under real-world driving conditions and independent market surveillance to ensure that these vehicles do not emit more than the certified emissions level.

This is one of the biggest reforms in emissions regulations and testing procedures that unfolded globally immediately after the Volkswagen emissions fraud and Dieseldgate, which hit major markets in 2015. It exposed the risk of manipulation by manufacturers to programme their vehicles to cheat certification test procedures but lower the guards and severity of the emissions control systems when on road. Globally, this has led to more systematic testing of popular car models by the governments, which revealed large-scale violation of standards on road. The key focus of the governments is now to adopt appropriate testing systems to be able to monitor emissions in real-world driving conditions. They have adopted the Real-world Driving Emissions (RDE) legislation to narrow the gap between emissions measured during type-approval or certification of vehicles in laboratory and emissions in the real-world driving condition so that

vehicles remain low emitting and within the margin of certified levels on road. These new approaches can ensure vehicle manufacturers integrate emissions control technologies with engine measures optimally to achieve effective emissions reduction under driving conditions.¹

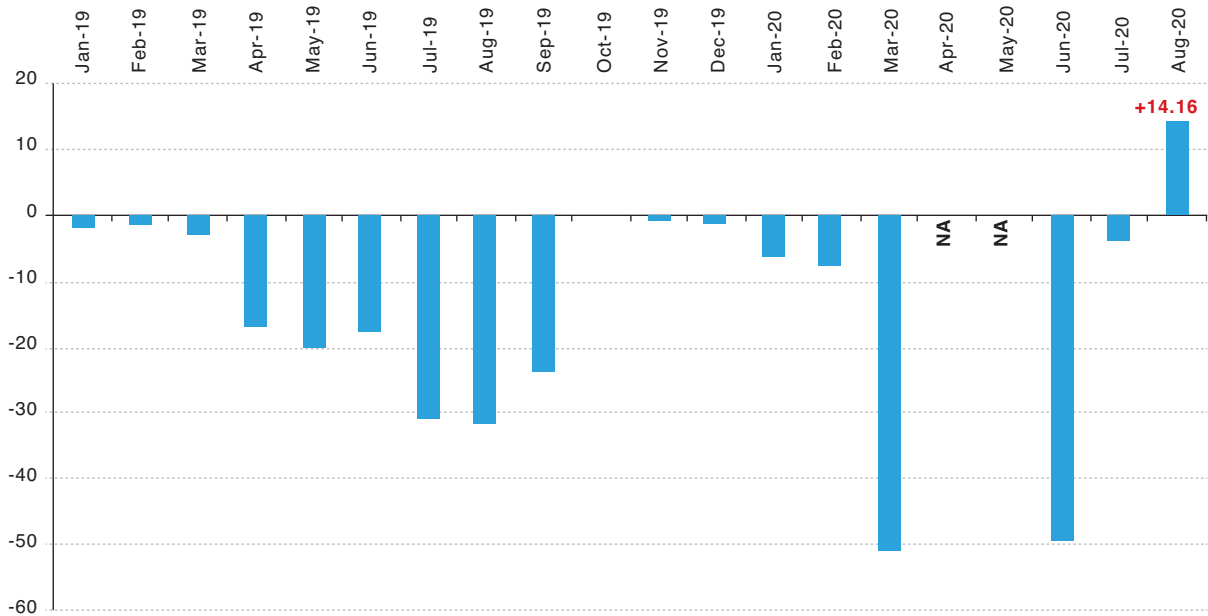
Europe has adopted RDE legislation within the framework of Euro VI (BS-VI is the equivalent of Euro 6) regulation to address the gap and achieve low emissions when vehicles are driven on road. This requires new vehicles to be tested for emission on public roads during the certification process. Additionally such tests are done selectively after they are sold to check if they conform to the specified margin of deviation from the certified level. Europe has already phased in reforms through four successive stages between 2015 and 2018 to adopt a robust RDE regulation to minimize the gap between emissions that manufacturers report based on the vehicle certification test and what is emitted on roads.

The good news is that India has already adopted some of the reform packages in Europe and is already on its way to adopt some of the key reforms in 2023. This process has already started under the aegis of the Ministry of Road Transport and Highways (MoRTH). But steps are needed to quickly bridge the gap and align with all the reform packages to avert the crisis of Dieselpgate and any other compromise in emissions performance and to maximize the emissions gains from the massive investment made to leapfrog to BS-VI.

There are concerns in India that the vehicle industry may want to defer the process of reform because of the economic slowdown and Covid-19 pandemic. The Society of Indian Automobile Manufacturers (SIAM) reported to have taken the position that the industry has made significant investment in BS-VI technology and this combined with the slump in the market has created financial difficulties in meeting new regulations planned for 2022–23. In fact, Industry has categorically pointed towards the new regulations related to real-world driving emissions requirements and also the next revision of fuel economy standards for passenger cars that are due to be implemented in 2022–23.² Industry is blaming supply chain disruptions, halting of production and sharp drop in sales amid the Covid-19 pandemic.³ The nationwide lockdown has also hit the freight transport hard.⁴

Vehicle sales plummeted during the hard lockdown. However, despite de-growth during lockdown, the market has started to recover during the unlocking phase starting August.⁵ In fact, SIAM has reported growth especially in the two-wheeler and the passenger vehicle segments.⁶ Passenger vehicles registered positive growth of 14.16 per cent in August 2020 as compared to the same month last year.⁷ Reported data also brings out the same trend (see *Graph 1: Recovery—Year-on-year change in domestic passenger vehicles sales*). Further, given the dormant demand for vehicles, the market is expected to recover with unlocking of the economy.

If industry does not stay on course in meeting the reforms for real-world emissions control, it can create serious risks. When the country is fighting serious pollution, unchecked real-world pollution from the fleet that can stay on road for at least 15 years and more will lock in enormous pollution. Experiences around the world have proven that if the requisite checks are not put in place to control real-world driving emissions, then even after meeting the tighter emissions standards vehicles may fall victim to manipulation and emissions frauds, negating the benefits of huge investments.

Graph 1: Recovery—Year-on-year change in domestic passenger vehicle sales (%)

Note: NA = data not available

Source: Auto Sales In India Grow For The First Time Since January 2019: SIAM Data, 11 September 2020; <https://www.bloomberquint.com/business/auto-sales-in-august-2020-were-the-best-in-more-than-a-year-siam-says>

Also, if the vehicle industry pushes back and defers such critical reforms on emissions performance and widens the gap with global good practices, it will lose its competitive edge in the global market. Most vehicle manufacturers in India are global players and have to comply with the exacting emissions measures in other markets. Therefore, a harmonized approach will benefit both the industry as well as public health in India.

Given India's vulnerability to dieselization, it cannot risk another Dieseltgate. India has witnessed rapid growth in diesel cars over the last two decades due to lower diesel fuel prices and comparatively better fuel efficiency of diesel cars. By the middle of the last decade, diesel cars accounted for nearly half of new sales. However, the sales curve began to bend thereafter due to a combination of factors. Regulations on diesel cars in one of the biggest car markets of Delhi—including the ban on ten-year-old diesel vehicles and imposition of environment pollution charge on big diesel cars and SUVs—got harsher. Truck entry was restricted and penalized. This led to more uncertainty in the diesel market. Moreover, the industry anticipated that packaging complex emissions control systems in the BS-VI compliant cars—especially small and compact cars will be expensive and unaffordable. Also, post 2015, India witnessed a gradual rise in diesel fuel prices, negating the advantage of lower operational cost for the consumers. In 2020, for the first time in the history of India, diesel fuel prices were lower than petrol.

The impact of the combination of these factors on the diesel car market has been quite dramatic. Sale of diesel cars has dropped. During April–July 2020, when overall vehicle sales were already down, the share of diesel cars in the overall passenger vehicle segment was down to 17.2 per cent and the share of petrol cars share was as high as 82.5 per cent. The share of diesel variants in the

sale of small cars and sedans fell to just 1.8 per cent during April–July 2020.⁸ Automobile companies have announced that they would discontinue several diesel models in the BS-VI regime.

But this is not the trend in SUV models that have remained attractive for consumers. Steady increase in bigger and compact SUVs is offsetting the change in the small-car market. According to reports on data from SIAM, SUVs logged 14 per cent growth in volumes in July over the corresponding period last year. The rise helped the industry soften the double-digit blows suffered in the demand for sedans and hatchbacks category (–12 per cent) and vans (–19 per cent). The share of SUVs in total sales of passenger vehicles is now at 39 per cent, compared with 33 per cent in July last year.⁹

This trend is likely to continue to fan new wave of dieselization in India. This has implications for public health. The ICCT study has shown that exhaust from only on-road diesel vehicles is responsible for nearly half of the premature deaths worldwide. And two-thirds of this is in India, France, Germany and Italy. Among the 100 major urban centres assessed for deaths related to the transport sector, Delhi ranks sixth. India needs to tame dieselization and ensure very stringent monitoring of real-world emissions and in-service compliance.

The learning curve from Dieselgate in global markets is well documented globally. Following the Volkswagen emissions fraud that shocked the world in 2015 and also sent ripples in India led to the National Green Tribunal seeking penal action on the company. More assessment globally has shown how well-known brands of diesel cars of reputed companies were found to be emitting several times higher NO_x in the real world compared to the emissions measured and reported during certification. 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 has even triggered decisions across European cities, including Paris, London, Madrid and cities in the Netherlands, to phase out diesel cars.

It is now well understood how car manufacturers can resort to programming of vehicles to perform optimally when on test bed under stationary regulatory testing conditions in labs. The software could sense the parameters of regulatory test and performed as needed. But vehicles would perform differently when on road leading to higher on-road NO_x emissions or more. The incentive for this cheating was to reduce the severity of operations of the selective catalytic reducing system (SCR) used in new cars to control NO_x emissions. This helps to reduce the urea dosage and therefore the attendant costs of periodic refilling of SCR system with auto grade urea. It is clear why stringent regulatory requirements for real-world emissions are needed to ensure that the engine systems and emissions-control systems are well integrated in the design to optimize performance on road.

Improved testing procedures and market surveillance will not only prevent manipulation but also promote well-integrated engine measures and improved emission-control systems for better performance on road.

In view of this, Centre for Science and Environment based on a rapid review of the new developments in regulations related to testing procedures and real-world emissions monitoring and compliance for BS-VI emissions standards to outline the key reforms needed for adoption post-2023.

2. BS-VI emissions standards 2020: First steps

The Bharat Stage VI (BS-VI) emissions standards that India adopted in 2020 represent fundamental shifts in several approaches to emissions control, monitoring and compliance. It is therefore important to understand the key elements of BS-VI regulations and the status of progressive reforms.

BS-VI narrows down difference in emissions between petrol and diesel cars substantially. Until now the nitrogen oxide (NOx) emissions standards for diesel vehicles—as patterned along the lines of European standards—have allowed diesel light-duty vehicles to emit several times higher NOx—at least three times more—compared to petrol vehicles. Under BS-VI, this gap between will be narrower. NOx emissions from diesel cars will be about 1.5 times higher. On the other hand, particulate matter is not regulated in petrol vehicles as it is negligible. But particulate emission standard has been introduced for petrol vehicles that are equipped with direct injection systems. It is also important to note that other countries are now fully equalizing the diesel and petrol standards to be fuel neutral. The US has already eliminated the difference. 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.

India adopts particle number standard for diesel vehicles: Under the new BS-VI standards particle numbers from tailpipes will be counted to ensure adoption of effective emissions control devices or particulate filters to at least eliminate 95 per cent of the particles. Earlier only mass of particles in exhaust was weighed. But that is not adequate to address the tiniest particles to design effective emissions control systems.

Vehicles will be tested for real-world emissions: India has also adopted the requirement of real-world driving emissions measurement as part of the BS-VI regulations. In addition to the lab-based certification tests, vehicles will also be driven on real roads and their emissions will be measured with the help of portable emission monitors. This system has been introduced now only for data generation. This data will be reviewed to develop the margin of deviation from the certification level to be allowed on road for enforcement from 2023 onwards. This is called conformity factor. Even as vehicles are driven in the real world, emissions monitored from the full range of driving conditions will be measured to ensure that this does not exceed the specified limit. This is an effective way to monitor deviation from the certification level of emissions. The conformity factor will be adopted in 2023.

Two-wheeler standards undergo significant improvement. BS-VI norms for two-wheelers that align with Euro 5 are significantly tighter. For the first time in India NOx and hydrocarbon emissions from two-wheelers will be measured separately as opposed to the earlier practice of combining the two for measurement. This separation is needed to ensure that emission control strategies do not reduce emissions of one pollutant at the expense of the other. Under BS-VI, two wheelers will also have on-board diagnostic system (OBD) and specifications. This will open up the opportunity for more advanced

Box: Heavy-duty and light-duty vehicles: Next steps

Heavy-duty vehicles

- 1 April 2020: India has adopted the provision of emission measurement using portable emissions measurement systems (PEMS) for on-road data collection
- 1 April 2023: In-service conformity factor to be applicable
- 1 April 2023: Vehicle to meet requirements of in-service compliance
- World Not-to-Exceed (WNTE): Off-cycle laboratory testing limits for gaseous and particulate exhaust emissions limits specified

Light-duty vehicles

- 1 April 2020: Data collection for real world driving cycle will begin
- 1 April 2023: Real world driving cycle emission monitoring with conformity factor and in-service conformity as per AIS 137 to become applicable
- 1 April 2023: Not-to-Exceed emission limits based on conformity factors to be assessed for implementation by 2023

technologies and electronics. 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. With these changes the two-wheeler industry will witness a massive makeover to the electronic fuel injection (EFI) system.

Heavy-duty vehicles: With regard to heavy-duty vehicles, India has aligned with the European regulations from the beginning. This is mainly because Europe has been more proactive with regard to the concern over real-world performance of this segment. In this segment, as per the AIS 137, emissions measurements with PEMS for data collection begin from 1 April 2020 onwards. From 1 April 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 and Not-to-Exceed standards have been specified and will be implemented. Also, vehicles manufactured on or after 1 April 2023 shall have the capability of assessing in-use performance of on-board diagnostics.

3. Euro 6 standards in Europe: Reform packages

Since the exposé of Dieselgate in 2015, Europe has introduced four reform packages of additional testing requirements related to the real-world emissions from light-duty vehicles. Major reforms were brought about in the light-duty vehicle segment. In fact, Europe had already adopted more stringent emissions testing requirements for heavy-duty vehicles anticipating that this segment is likely to be more vulnerable to emissions frauds. But Dieselgate exposed gaps and vulnerability of the light-duty vehicle segment as well. The new reform packages in Europe therefore were quickly introduced in successive stages between 2015 and 2018 to strengthen the emissions testing parameters for real-world emissions monitoring. India has to take note of these reform packages in Europe to chart its roadmap. The available global evidences and the ICCT review of India's AIS-137 document help to identify the key reforms needed in India in 2023.

Reform package one—RDE Act 1, 2016: New Euro 6 passenger car models have to be tested not only on the regulatory test cycle for type-approval of models but also on the road where emissions are measured with a Portable Emissions Measurement System (PEMS). During this phase, RDE measurements will be carried out but the capping of emissions or Not-to-Exceed (NTE) limit in the real world will not be applied. Several other parameters were included such as characterization of the route to be selected for RDE testing on roads for real-world emissions measurements; vehicle family concept to be applied, description of the data-evaluation tools, technical requirements of the Portable Emissions Measurement Systems (PEMS) equipment to be used for real-world emissions monitoring, and reporting obligations. At this stage RDE testing was done only for monitoring purposes, and was not included in actual type approval, which continued to be based on laboratory measurements. It looked at the boundary conditions and data evaluation methods.

Reform package 2—RDE Act 2, 2017: In this package, real-world emissions measurements of NO_x was made compulsory for new car models from September 2017, and for all new vehicles from September 2019. It further introduced the conformity factor (margin of deviation in the real world from the certified level) for NO_x with additional boundary conditions of driving to ensure emissions do not deteriorate from the certified level beyond a specified margin. This is called Not-to-Exceed (NTE) emissions limit that was set for RDE emissions testing of new car models with a conformity factor, i.e. NTE/Euro 6 limit ratio of 2.1 for NO_x. It applies to all new cars from September 2019 onward. From January 2020–21 for new models and all new cars respectively, the NO_x conformity factor are to be lowered to 1.0 + an error margin of 0.43. This error margin is to be reviewed annually. From September 2017, the real driving emissions test procedure was made mandatory part of the type-approval procedure for new passenger cars and light-commercial vehicles in the European Union.

Reform package 3—RDE Act 3, 2017–18: RDE testing or real-world emissions testing was extended to cover particle number emissions for all new vehicle types by September 2017–18. A confirmatory factor for particle number of

1.5 was introduced. 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. It should be transparent and available for all citizens and public authorities. Thus, this introduced the 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 of diesel particulate filters. This included PEMS test procedure and test equipment for particle number and Conformity Factor for particle number.

Reform package 4—RDE Act 4, 2020: This reform package has made provisions for 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. This is part of in-service conformity testing. Authorities and independent parties will be able to perform officially mandated tests through accredited testing centres. The fourth Act has changed the conformity factor in RDE measurements, from 1.50 to 1.43. Research results by the European Commission 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 deviation on road.

The EC 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 emissions of a valid RDE test are compliant with the regulation if the reported distance-specific mass of emissions is below the corresponding Not-to-Exceed (NTE) Emission Limit. The Not-to-Exceed limit has to be valid for the total trip and its urban section. 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 6d version: Euro 6d will thus be required from January 2020 onwards for newly developed models—and from January 2021 onwards for all new vehicles. In this temporary ‘Euro 6d-TEMP’ version, the 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 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.

New type-approval process: A new type-approval scheme rules is scheduled to 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 in European Union. The European Commission (EC) will play a stronger role as 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 per non-compliant 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 in test cycle for testing of emissions and vehicle certification: For more rigorous testing requirements Europe has adopted the Worldwide Harmonized Light Duty Cycle (WLTC) running on a chassis dynamometer for emission testing and Worldwide Harmonized Light Vehicle Test Procedure (WLTP) for certification in laboratory. This is expected to overcome the substantive difference between the emissions results from the test conducted on the New European Driving Cycle (NEDC) used so far. The EC has introduced this new cycle and procedures to address some of the limitations in the NEDC driving cycle and test procedures including soft acceleration and unrepresentative road loads. It is said that the speed profiles that are used in WLTC are patterned using real vehicle speed data along with some other changes, which have made the WLTC more representative of real-world emissions compared to the NEDC.¹⁰

Improving the test cycle is critical. The 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 five times) was noticed compared with the regulatory limit for Euro VI vehicles. This shows that there are many boundary conditions of driving conditions that are not included in the test cycle to check emissions but have strong bearing on real-world emissions.

In-service conformity tests for aftermarket 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 CO₂. Part of this responsibility will now shift to the

respective type-approval authorities, which will perform WLTP and RDE tests (the latter only for NOX and particle number emissions) in addition to the WLTP tests carried out by manufacturers.

The type approval authority would need to gather relevant information on non-compliance to decide vehicle families to be checked in a particular year for ISC. The number of compulsory annual ISC checks level based on PEMS testing is set to 5 per cent of 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, 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, sample of vehicles is pulled from the same vehicle family and 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 non-compliant 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 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 after-treatment 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 affected vehicles.

Action on defeat devices: 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. This is 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.

4. BS-VI and what is still missing in India

While several key regulatory parameters have already been adopted as part of BSVI emissions regulations in India, there are still some critical parameters that need quick adoption and implementation to control real-world emissions performance. The Automotive Industry Standard Code 137 that governs the testing parameters for vehicles in India are under revision and are expected to introduce several new reforms related to real-world emissions and in-service compliance in the 2023 time frame. Therefore, informing that process and to ensure there is no delay in adoption has become necessary.

The European reform packages present the learning curve and what needs to be done to control real-world driving emissions in India. There are several critical parameters in the reform packages 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 for implementation.

Adopt conformity factor for real-world emissions testing and compliance: For real-world emissions measurements the big change awaited is the requirement of conformity factor and Not-to-Exceed limits. As mentioned earlier, the 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. Conformity factor is a cap imposed on the NO_x emission limit, which cannot be exceeded in real-world driving. This will be the Not-to-Exceed limit. Initially some deviation will be allowed from the emissions limit tested in laboratories when vehicles will be driven on the roads. It is intended to reduce the margin of deviation gradually. As mentioned earlier, in Europe the European Parliament and the Council have adopted as a first step the compliance factor (or margin of deviation) of 2.1 in all new vehicles until 2020. This margin of deviation has been allowed to account for statistical uncertainty of the test procedures and measuring instruments. But a much lower compliance factor of 1.5 will apply now. This margin will be further reviewed annually to assess progress in the accuracy of the portable emission measurement system so that this margin can be further reduced. After accounting for all these the post 2020 compliance factor is reduced from 1.50 to 1.43. In fact, India should consider this factor to design vehicles and not reinvent the wheel. This means the actual real-world emissions must not deviate from the certified level by 1.5 times.

It is to be noted that real Driving Emissions testing with specified conformity factor is a very rigorous test compared to the lab certification tests that require a driving cycle to be followed. This will require the original equipment manufacturers and the emissions-control system suppliers to optimize vehicle performance to meet the on-road emissions target; ensure that the exhaust after treatment systems provide for treatment of higher exhaust flow possible under real driving testing when speed and acceleration are different from the lab based test on dynamometers.

India's AIS 137 has stated that a committee will be set up to decide the conformity factor for 2030 time frame. But it is important to weigh in that India will have to look at the quick phase in of CF=1.43 and CF=1.0. A 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. It is not clear yet if particle number will be included in RDE in 2023.

In-service conformity and market surveillance testing: In India as per AIS 137, the 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 the in-service testing frequency, procedure etc. and includes most of the points. However, the requirement of third party or independent testing provision is not clear although it states, ‘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 fourth 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 are set at 5 per cent of PEMS families or a minimum two families per manufacturer (choosing a representative vehicle from a ‘PEMS test family’—families are considered to be vehicles with the same technical characteristics). This is quite lower than the public demand of 20 per cent.

It may be noted that China has adopted elaborate the China 6 RDE in-use compliance programme. Manufacturers are required to test in-use vehicles at low (10,000–60,000 km), medium (60,000–110,000 km) and high (110,000–160,000 km) mileages and report their test results to the regulatory agency. Regulatory agency has the authority to randomly test in-use vehicles up to 160,000 km driving. India must adopt the 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_x) and not too passive and at low speed

(that cause low NO_x). India needs to adopt total NO_x 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_x-reduction strategies at low load, which the SCR system will not reduce.

Change the testing cycle: India needs to adopt Worldwide Harmonized Light Duty Cycle (WLTC) and Worldwide Harmonized Light Vehicle Test Procedure (WLTP) for certification of vehicles in laboratory and discontinue the use of MIDC for vehicle type approval tests within the RDE regulatory framework. MIDC does not represent dynamic driving condition and make emissions testing less exacting. For heavy-duty vehicles India has adopted WHSC and WHTC cycles. But it said that the WLTP framework has not been fully adopted in India. For light-duty vehicles it will have to adopt WLTP.

It is also important to define the RDE test trip on roads as per the package 4 of Europe or increase the weighing factor in the urban driving category to promote in-cylinder or EGR-based NO_x-reduction strategies at low load, which the SCR system will not reduce. The RDE trip route should be adequately representative of the urban driving conditions. Also introduce cold start testing and measurement of particulate number testing for in-service conformity for a more rigorous regime.¹¹

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. AIS 137 states that the manufacturer shall ensure that information is made available on a publicly accessible website without costs. But government and testing agencies should also release data and disclose RDE results. 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—5 per cent of engine families are tested every year. China has adopted China 6 new LDV emissions standards regulations, which includes the RDE regulatory component, and requires that vehicle manufacturers publish the test results to the public.

Fuel consumption meter: On-board fuel consumption meters are still not included and the RDE proposal and this is not yet consistent with Euro 6d. 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, AIS 137 has defined what ‘defeat device’ means and it has prohibited the use of such devices. It says, ‘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 a “defeat device”.’

However ICCT while reviewing the AIS-137 has recommended adopting the European third and fourth RDE package provisions, which includes 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 needs to pay adequate attention to the infrastructure for auto-grade urea or Adblue refill for diesel vehicles to be fitted with SCR system for NOx reduction. Urea tank 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 5 km/litre will need approximately 12 litres of AdBlue per 1000 km. With a truck, a tank capacity of over 40 litres will cover approximately 3,500 km with the tank full of AdBlue. Reliability of distribution and refill network, and quality control of AdBlue pose serious challenges that will have to be addressed immediately.

Oil companies are setting up auto grade urea dispensation network tied to retail outlets of oil companies in cities and highways and also adopting quality benchmark for auto-grade urea. IOC has adopted AUS 32 Quality requirements as per ISO 22241-1. This will require a certification system. 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.

5. The way forward

India's leapfrog to BS-VI emissions standards and its nationwide introduction on schedule despite the pandemic disruption is commendable. But global experience has also shown that only introduction of these new standards will not be adequate. They will have to be implemented with stronger regulatory testing of real-world driving emissions to maximize emissions and health gains.

If not addressed, this can create serious risks of uncontrolled emissions. India therefore needs to adopt the entire regulatory framework, including advanced testing procedures for monitoring real-world emissions, WLTC and WLTP for type-approval of vehicles, in-service conformity and compliance strategies, emission disclosure and independent market surveillance among others. This will encourage industry to optimize the integration of overall engine technology approaches and emissions control systems for best results and improved on-road performance.

It is to be noted that India is just about catching up with the emissions regulations in Europe. But the European standards are the third best standard in the world. The US has already moved ahead with even tighter standards. China has gone ahead of Europe, and combined key lessons and parameters from the US and Korea to frame its own advance regulations to include 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.

As global upward harmonization takes place based on improved regulatory framework, the Indian vehicle industry needs to move quickly to keep its edge in the global market. Therefore, Indian industry has to plan for green recovery and not delay adoption of the critical BS-VI reforms. India needs to quickly align with all the reform packages that Europe had to adopt post Dieselgate. As of now India's BS-VI regulations are consistent with the European reform packages of 1 and 2 with some parameters of package 4. This is the time to chart a quick pathway to inform the reform process better.

- Align AIS 137 with the fourth and the latest package of reforms of European regulations to strengthen testing parameters for real-world emissions testing and in-service compliance regulations; align and adopt conformity factor; and adopt Worldwide Harmonized Light Vehicles Test Procedure (WLTP) cycle and fuel consumption meter. In-service programme for light-duty vehicles will have to be strengthened.
- Introduce public disclosure of emissions data and independent verification system and market surveillance by type approval agency.
- Introduce a strong system of compliance, penalty, emissions warranty and recall programme to cover the in-service life of vehicles.

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