Issue Brief

NAVIGATING THE SHIFT

Optimizing India's Vehicle Energy Efficiency Testing for a Sustainable Future

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India's Current Vehicle Energy Efficiency Testing: An Overview

India's approach to vehicle energy efficiency testing (which refers to how effectively a vehicle uses energy, like fuel or electricity, to travel) has historically relied on methodologies that, while serving as foundational steps, are aimed at aligning with the complexities of modern vehicle technology and diverse on-road conditions. These testing methodologies are in place to regulate the amount of emissions being generated by vehicles and to enable the government to come up with regulations to set standards for the manufacturers. Such regulations also provide consumers with comparable information, encourage the adoption of more efficient vehicles, and help the nation meet its energy security and environmental targets by regulating fuel consumption and emissions.

A comparative analysis of these existing standards- primarily the Modified Indian Driving Cycle (MIDC) for light-duty vehicles, the Constant Speed Fuel Consumption (CFSC) test for heavy-duty vehicles, and the Worldwide Harmonized Light Vehicles Test Procedure (WLTP) (which is also envisioned in proposed CAFE Phase III and IV) reveals significant aspects that impact consumer trust, policy effectiveness, and the nation's broader energy and environmental goals. The recent introduction of Real Driving Emissions (RDE) testing marks a move towards greater realism, with its current application primarily focused on pollutant emissions.

Modified Indian Driving Cycle (MIDC)

MIDC serves as the current cornerstone for type-approval tests of light-duty vehicles (LDVs) in India, conducted in a laboratory setting on a chassis dynamometer.[1] This cycle is largely equivalent to the New European Driving Cycle (NEDC) and comprises an urban driving part (Part I) and an extra-urban driving part (Part II), with a maximum test speed of 90 km/h.[2] For electric vehicles (EVs), the certified range is determined based on Part I of the MIDC.[3] The test protocol involves specific speed-time profiles, predetermined acceleration and deceleration phases, and periods of idling, typically with auxiliary systems like air conditioning switched off.[4]

While the MIDC provides a standardized and repeatable laboratory testing procedure, a significant body of evidence points to its inadequacy in reflecting typical driving operations of LDVs on Indian roads.[5] The cycle's parameters often diverge considerably from real-world Indian conditions characterized by high traffic density, varied land-use patterns, inconsistent road infrastructure, and often chaotic traffic management.[6]

One of the most cited deficiencies of the MIDC is its failure to capture realistic acceleration and deceleration profiles. Driving in Indian cities frequently involves more aggressive and dynamic speed changes than those prescribed in the MIDC, particularly in high power requirement zones, which are not adequately represented in the cycle.[7] This discrepancy is particularly problematic for EV range certification. Research indicates that MIDC Part I is unsuitable for determining EV range under Indian conditions, leading to a substantial gap between the certified range and the actual range experienced by consumers.[8] This gap can be as high as 20-40%, with a few specific instances showing a 46% difference where the MIDC-certified range was significantly higher than the more realistic Worldwide Harmonized Light

Vehicles Test Procedure figure.[9]

Furthermore, the MIDC's basis on the NEDC renders it outdated, as the NEDC itself has been superseded globally due to its recognized limitations in representing modern driving.[10] Historically, India adopted the MIDC in the early 2000s to estimate fuel consumption and emissions under controlled conditions. Over time, as global test procedures evolved, the WLTP was introduced by the United Nations Economic Commission for Europe (UNECE) and implemented in Europe starting in 2017 for new vehicle types and by 2019 for all cars. This evolution reflected a broader international shift toward more representative and real-world test cycles.

The disconnect between MIDC test results and on-road reality is also evident in pollutant emissions; studies on BS IV passenger cars found real-world nitrogen oxides (NOx) emissions to be 5–7 times higher, and carbon monoxide (CO) emissions 10–22 times higher, than type-approval limits set under MIDC.[11] While this pertains to emissions, it highlights the cycle's general lack of real-world fidelity, which inherently extends to fuel consumption measurements.

The persistent and often large gap between MIDC-certified fuel efficiency or EV range and the performance consumers achieve in the real world has considerable implications. It can lead to an erosion of consumer trust in official figures and labeling programs. If certified values are perceived as unattainable, it complicates informed purchasing decisions. It may even dampen enthusiasm for more efficient vehicle technologies, especially EVs, where misleadingly optimistic certified ranges can add to the range anxiety. This disconnect also poses a challenge for policymakers, as regulations and targets, such as Corporate Average Fuel Consumption (CAFE) norms, based on MIDC data, may not translate into the desired real-world fuel savings or CO2 reductions. While CAFE norms in India are a significant policy step, their effectiveness can be further enhanced by aligning test procedures with evolving international standards such as WLTP or RDE. The shift toward more representative cycles would not only improve accuracy but also future-proof regulatory instruments like CAFE for the next generation of technologies.

Moreover, a certification cycle that does not accurately reflect real-world dynamic driving conditions may inadvertently hinder technological advancement geared towards on-road efficiency. If the MIDC fails to adequately reward innovations that excel in dynamic scenarios, such as sophisticated engine control strategies, hybrid systems optimized for fluctuating loads, or highly efficient air conditioning systems used extensively in India, manufacturers might have diminished incentives to prioritize these for the Indian market. Instead, efforts could be skewed towards optimizing performance specifically for the MIDC's less realistic demands, a phenomenon sometimes referred to as "cycle beating." This could perpetuate the divergence between laboratory-certified figures and actual on-road fuel efficiency.

Constant Speed Fuel Consumption (CFSC): Application for Heavy-Duty Vehicles

For heavy-duty vehicles (HDVs) in India, fuel efficiency evaluation for regulatory purposes has utilized the Constant Speed Fuel Consumption (CFSC) test.[12]

This procedure involves driving the vehicle on a test track at predefined constant speeds, typically 40 km/h and 60 km/h, and measuring fuel consumption under these steady-state conditions.[13] The test is conducted with the vehicle at its Gross Vehicle Weight (GVW).[14]

The primary advantage of the CFSC method in the Indian context is its existing familiarity and implementation within the HDV certification process.[15] It offers a simpler testing protocol compared to transient dynamometer cycles. It has been noted by the experts that establishing an efficiency standard based on CSFC, even with its limitations, could be preferable to extended delays in implementing any regulation while waiting for the development of more sophisticated methodologies like vehicle simulation tools. Furthermore, it is anticipated that efficiency improvements demonstrated over CSFC cycles are likely to yield at least some tangible real-world benefits.[16]

However, the CFSC test suffers from significant drawbacks when considered as a comprehensive measure of HDV fuel efficiency. Its most critical limitation is its poor representation of real-world HDV operations. The test exercises the vehicle's engine only at very specific, narrow points on its operating map, failing to capture the diverse conditions encountered in actual use, such as acceleration, deceleration, cruising at variable speeds, and idling.[17] This means the CSFC test is not a realistic depiction of how these vehicles are typically driven.[18]

Other noted disadvantages include potentially high costs associated with track testing and relatively poor test-to-test repeatability compared to laboratory-based methods like engine dynamometer testing, partly due to the inherent variability of on-track testing conditions.[19] Crucially, the CSFC method does not incentivize manufacturers to design their engines and vehicles for optimal efficiency across the broad spectrum of operating conditions encountered on the road.[20]

The continued application of CSFC for HDV fuel efficiency standards in India[21], despite its acknowledged deficiencies, reflects a pragmatic regulatory stance. It suggests a prioritization of achieving incremental progress using available tools, particularly while more advanced and complex solutions like the Bharat VECTO simulation tool (based on European VECTO) are still under development and validation.[22] The urgency of regulating HDV fuel consumption, a significant contributor to overall fuel use and emissions[23], makes an imperfect but immediate standard preferable to a prolonged regulatory vacuum.

Nevertheless, the limitations of CSFC mean its impact on overall HDV fleet efficiency is likely constrained. Because the test focuses on a very narrow operating range, manufacturers are incentivized to optimize vehicle performance primarily for these specific constant speeds. This may result in minimal or disproportionately smaller improvements in fuel efficiency during the more frequent transient operations (acceleration, deceleration, varied load and speed conditions) that characterize the majority of real-world HDV duty cycles. Consequently, the actual fuel savings achieved across the HDV fleet might be less than what could be achieved with a more representative testing methodology.

Real Driving Emissions (RDE) & Portable Emissions Measurement Systems (PEMS): Stepping Towards On-Road Reality

A significant evolution in India's vehicle testing landscape has been the introduction of Real Driving Emissions (RDE) testing under the Bharat Stage VI (BS-VI) norms. Since April 1, 2020, RDE measurements using Portable Emissions Measurement Systems (PEMS) have been mandated for data collection purposes during the type-approval and Conformity of Production (CoP) for light-duty vehicles.[24] Subsequently, from April 1, 2023, all new vehicles produced and sold must comply with real-world driving emission limits, which are specified as a range around the laboratory test limits.[25]

The RDE methodology involves equipping a vehicle with PEMS and driving it on public roads under a wide array of real-world conditions, including urban, rural, and motorway segments, as defined by standards like Automotive Indian Standard (AIS) 137.[26] PEMS directly measures pollutant concentrations in the exhaust gas. To account for the inherent uncertainties and lesser precision of PEMS compared to laboratory-grade equipment, Conformity Factors (CFs) are applied.[27] These CFs are multipliers applied to the laboratory emission limits to establish the permissible RDE limits. There is an ongoing need for India to define CFs that are in line with international best practices while also catering to specific Indian requirements; for reference, the European Union has implemented CFs such as 1.5 for NO_x and Particulate Number (PN).[28]

The primary objective of RDE testing is to bridge the often substantial gap observed between emissions performance in controlled laboratory settings (currently based on MIDC) and actual emissions during on-road operation.1 While PEMS inherently measures CO_2 output, which is directly related to fuel consumption (as evidenced by CO_2 data in PEMS test results[29]), the current regulatory focus of RDE in India is predominantly on controlling criteria pollutants like NO_x and PM/PN. Fuel efficiency standards, such as the CAFE norms, are still primarily based on laboratory test cycle results.[30] Thus, RDE currently functions more as a verification tool for emission compliance and a data-gathering mechanism for real-world fuel efficiency, rather than the foundational basis for setting fuel efficiency targets themselves.

The implementation of mandatory RDE testing from April 2020 is generating a vast and valuable dataset on real-world vehicle performance across diverse Indian driving environments. This data, encompassing vehicle speed, route characteristics, ambient conditions, pollutant emissions, and CO_2 levels, holds immense potential. If systematically compiled and analyzed by regulatory and testing agencies like the Ministry of Road Transport and Highways (MoRTH) and the Automotive Research Association of India (ARAI), as recommended by experts[31], this information can be instrumental. It can precisely quantify the gap between MIDC results and on-road performance, inform the development of more realistic future Indian driving cycles, aid in tailoring parameters for WLTP adoption in India, and provide an efficient evidence base for future fuel efficiency policies and the setting of appropriate CFs.

Furthermore, the technical infrastructure, expertise, and regulatory familiarity being developed through the PEMS-based RDE program could significantly smooth the path for potential future adoption of On-Board Fuel Consumption Monitoring (OBFCM) systems. Similar to initiatives in the EU, OBFCM devices can continuously record real-world fuel consumption data throughout a vehicle's operational life. This offers a powerful, large-scale tool for verifying long-term efficiency retention, assessing the impact of real-world variables like AC usage and driving styles, and ensuring that vehicles maintain their certified efficiency levels in the hands of consumers.

The Global Shift: Understanding WLTP and its Significance

The limitations of older test cycles like the NEDC (and by extension, India's MIDC) have spurred a global movement towards more realistic and harmonized testing procedures. The Worldwide Harmonized Light Vehicles Test Procedure (WLTP) has emerged as the leading international standard, designed to provide consumers and regulators with more accurate data on fuel consumption, CO_2 emissions, and electric vehicle range. Its adoption represents a significant step towards bridging the gap between laboratory figures and real-world vehicle performance.

Globally, countries with advanced regulatory frameworks have moved toward more rigorous and real-world-oriented testing. For example, the European Union adopted WLTP and then later on RDE. China began transitioning to WLTP-equivalent testing with its China 6 standards in 2020. These updated procedures allow regulators to capture more accurate emissions and efficiency data, aiding better policy calibration. The gap between India's current test cycle and WLTP/RDE is therefore not just technological, but also reflects differing regulatory timelines and priorities.

Deconstructing WLTP: Key Features, Cycle Classes, and Advantages

The WLTP is a comprehensive global standard developed to ensure that laboratory measurements of vehicle fuel consumption and emissions are more representative of actual on-road driving conditions.[32] Compared to the NEDC/MIDC, the WLTP introduces several key enhancements: it features higher average and maximum speeds, incorporates a wider spectrum of driving scenarios (urban, suburban, main road, and highway), covers a longer test distance (approximately 23 km versus MIDC's ~11 km), involves higher average and maximum drive power, and includes more dynamic and steeper acceleration and deceleration phases. A notable procedural improvement is that WLTP also mandates separate testing for the impact of optional equipment on a vehicle's performance. The typical duration of the WLTC (Worldwide Harmonized Light Vehicles Test Cycle), which is the core driving schedule within the WLTP, is around 30 minutes.[33]

A crucial aspect of WLTP is its classification of vehicles into different cycle classes based on their Power-to-Weight Ratio (PWr), expressed in Watts per kilogram (W/kg).[34] This differentiation ensures that the test cycle is appropriate for the vehicle's capabilities[35,36]:

- Class 1: For low-power vehicles with PWr ≤ 22 W/kg. This class is particularly relevant for a segment of the Indian vehicle market. The Class 1 cycle typically consists of Low, Medium, and then Low speed phases again.

- Class 2: For vehicles with 22 W/kg < PWr ≤ 34 W/kg. This class also represents a portion of vehicles driven in India, as well as lower-powered vehicles in markets like Japan and Europe. The Class 2 cycle generally includes Low, Medium, High, and Extra-High speed phases, though modifications can apply if the vehicle's maximum speed (vmax) is limited.

- Class 3: For high-power vehicles with PWr > 34 W/kg. This is the most common class for cars sold in Europe and Japan. It also comprises Low, Medium, High, and Extra-High speed phases. Specific parameters for each phase within these classes, such as duration, stop times, distance covered, maximum speeds, and acceleration/deceleration values, are meticulously defined.

The advantages of WLTP over older cycles like MIDC/NEDC are manifold. Its dynamic nature and inclusion of a broader range of operating conditions lead to a significantly better representation of real driving behavior.[37] Unlike the NEDC, which prescribed fixed gear shift points, the WLTP allows the vehicle to use its optimal gear shift strategy, further enhancing realism. These characteristics are specifically designed to reduce the often-significant gap between laboratory-certified figures and actual on-road performance.[38]

For the Indian context, the selection of the appropriate WLTP class is of paramount importance. Given India's diverse vehicle parc, which includes a large number of smaller, lower-powered cars, the direct applicability of WLTP Class 1 and Class 2 cycles is critical.[39] The distinct parameters of these classes, such as lower maximum speeds and different acceleration profiles compared to Class 3, are more aligned with a substantial segment of the Indian fleet and prevalent driving conditions. Applying a Class 3 cycle, designed for higher-powered vehicles typical in European or Japanese markets, to all Indian cars would be inappropriate, potentially leading to unrealistic test demands or results that do not accurately capture typical performance.

It is also vital to understand that WLTP refers to a comprehensive "Procedure," not merely a "Cycle." While WLTC is the driving schedule, the WLTP, as defined in UN GTR No. 15, encompasses a whole suite of testing protocols, including stricter conditions for test execution, dynamometer calibration, accounting for the impact of optional equipment, ambient temperature, and road load determination, and standardized calculation methods.[40] This holistic and more rigorous procedural framework is a key contributor to its improved correlation with real-world outcomes, moving beyond just the adoption of a more dynamic speed-time trace.

India's Urgent Need for Reforming Fuel Efficiency Testing Standards

India finds itself at a pivotal point in its journey toward sustainable transportation.

The current testing framework, which is rooted in the MIDC, is proving increasingly inadequate for capturing real-world driving conditions, particularly in the context of India's dynamic and rapidly expanding automotive sector. The MIDC, based on the outdated NEDC, tends to overstate electric vehicle ranges and underreport fuel consumption, eroding consumer trust and reducing the credibility of policies like the CAFE norms. As India's vehicle population is projected to swell by nearly 300 million by 2040, continued reliance on MIDC poses risks to energy security, public trust, and climate goals. To align policy with reality and maintain momentum towards electrification and low-carbon mobility, India must adopt a more representative and efficient testing framework. Doing so will support accurate policy-making, enable informed consumer choices, and ensure industry accountability in delivering real-world fuel and emissions performance.

A Dual Testing Strategy: WLTP for Certification and RDE for Real-World Verification

A forward-looking and scientifically sound strategy for reforming India's fuel efficiency regime involves adopting the WLTP as the basis for laboratory certification and complementing it with RDE testing using PEMS. WLTP offers a globally harmonized, technology-neutral, and significantly more accurate alternative to MIDC, already slated for inclusion in India's CAFE Phase III norms (2027–2032). Its flexible class structure (particularly Class 1 and 2 cycles) better represents the Indian light-duty vehicle fleet. Meanwhile, RDE should play a critical role in in-service conformity checks and in capturing real-world CO2 and fuel efficiency data. Clear Conformity Factors tailored to Indian conditions must be developed to compare RDE results with WLTP values. Importantly, while WLTP ensures repeatability and regulatory clarity, RDE serves as an audit tool to detect deviations, enhance credibility, and improve long-term policy calibration. For heavy-duty vehicles, the CFSC test may be retained temporarily, but the eventual goal should be the full rollout of Bharat VECTO, which is a simulation tool capable of offering comprehensive efficiency metrics.

Food for Thought

Transitioning to a WLTP-RDE testing regime will require coordinated investment, infrastructure upgrades, and a phased implementation strategy. Significant financial input will be needed from both government and manufacturers to upgrade test facilities, procure PEMS, and expand WLTP-compatible labs under the National Automotive Testing and Research and Development Infrastructure Project (NATRiP) framework. Skill development will be essential, with training required for testing agency personnel and OEM engineers. A phased rollout, including a parallel MIDC-WLTP testing period for calibration and data comparison, is advisable. As the primary regulatory body for the automotive sector, the Ministry of Road Transport and Highways can lead the policy and regulatory changes necessary for the WLTP-RDE implementation. They can be the ultimate decision-makers on the transition strategy. The Bureau of Energy Efficiency can also play a crucial role in leveraging the WLTP data for enhancing fuel efficiency labeling and potentially integrating it into broader energy conservation policies for the transportation sector. They can also focus on the energy consumption aspects revealed by the new testing regime. The testing agencies, including Automotive Research Association of India (ARAI), International Centre for Automotive Technology (ICAT), and Global Automotive Research Centre (GARC), may be made responsible for the practical implementation of the new testing protocols. Their role can include upgrading their facilities, conducting the WLTP and RDE tests, training their personnel, and providing technical expertise to both the government and the industry. They can become the technical backbone of the transition.

Industry stakeholders, including the Society of Indian Automobile Manufacturers (SIAM) and OEMs, may be central to the execution of the transition. OEMs may be made responsible for designing and manufacturing vehicles that meet the WLTP-RDE standards, investing in necessary research and development and production upgrades, and collaborating with testing agencies. SIAM can act as a body for industry feedback and facilitate a smooth transition across its members. The Ministry of Environment, Forest, and Climate Change can be involved in assessing the environmental impact as measured by the RDE testing, ensuring that the transition contributes to reducing real-world emissions and aligning with broader environmental goals. It can focus on the environmental outcomes of the new regime. The Ministry of Heavy Industries can likely be involved to oversee aspects related to the financial support and infrastructure development, particularly concerning the utilization of the NATRiP framework for upgrading testing facilities. It may be concerned with the investment and infrastructure aspects of the transition. In essence, a central task force including all the mentioned players may provide a platform for these diverse stakeholders to coordinate their efforts, address challenges collaboratively, and ensure a harmonized and effective transition to the WLTP-RDE testing regime. If implemented effectively, this strategy has the potential to empower consumers, support regulatory transparency, encourage the development of efficient vehicle technologies, and enhance India's global automotive competitiveness. Aligning domestic standards with international norms will also support India's global trade, innovation, and climate leadership aspirations.

References

1 Real-driving emissions from Bharat Stage VI (phase 1) passenger cars and a light commercial vehicle in India – PEMS testing, Working Paper, ICCT, accessed on May 7, 2025, https://theicct.org/wp-content/uploads/2024/06/ID-123-%E2%80%93-PEMS-India_wp_final.pdf.

2 Measuring emissions from vehicles in the real world: Policy steps in India - Down To Earth, accessed on May 7, 2025, https://www.downtoearth.org.in/pollution/measuring-emissions-from-vehicles-in-the-real-world-policy-steps-in-india-81046.

3 Impact of Driving Cycles on the Range Performance of Battery Electric Vehicle, accessed on May 7, 2025, https://www.sae.org/publications/technical-papers/content/2024-01-2149/.

4 Indian Drive Cycles and RDE Program for Effective Emission Norms, Controls and Policies - IIT Kanpur, accessed on May 7, 2025, https://home.iitk.ac.in/~mukesh/Publications/Indian%20Real%20Driving%20Emission%20Reprort%202021.pdf.

5 Real-driving emissions from Bharat Stage VI (phase 1) passenger cars and a light commercial vehicle in India – PEMS testing, Working Paper, ICCT, accessed on May 7, 2025, https://theicct.org/wp-content/uploads/2024/06/ID-123-%E2%80%93-PEMS-India_wp_final.pdf.

6 Measuring emissions from vehicles in the real world: Policy steps in India - Down To Earth, accessed on May 7, 2025, https://www.downtoearth.org.in/pollution/measuring-emissions-from-vehicles-in-the-real-world-policy-steps-in-india-81046.

7 Ibid.

8 Impact of Driving Cycles on the Range Performance of Battery Electric Vehicle, accessed on May 7, 2025, https://www.sae.org/publications/technical-papers/content/2024-01-2149/.

9 Study: Electric vehicle benefits are limited in India due to energy mix - Team-BHP, accessed on May 7, 2025, https://www.team-bhp.com/news/study-electric-vehicle-benefits-are-limited-india-due-energy-mix.

10 Indian Drive Cycles and RDE Program for Effective Emission Norms, Controls and Policies - IIT Kanpur, accessed on May 7, 2025, https://home.iitk.ac.in/~mukesh/Publications/Indian%20Real%20Driving%20Emission%20Reprort%202021.pdf.

11 Real-driving emissions from Bharat Stage VI (phase 1) passenger cars and a light commercial vehicle in India – PEMS testing, Working Paper, ICCT, accessed on May 7, 2025, https://theicct.org/wp-content/uploads/2024/06/ID-123-%E2%80%93-PEMS-India_wp_final.pdf.

12 Fuel Consumption Standards for Heavy Duty Vehicles in India, ICCT, accessed on May 7, 2025, https://theicct.org/wp-content/uploads/2021/06/ICCT_India-HDV-fuel-consumption_policy-update_20171207.pdf.

13 Ibid.

14 Ibid.

15 Constant-speed fuel consumption testing of heavy-duty vehicles in India, ICCT, accessed on May 7, 2025, https://theicct.org/wp-content/uploads/2021/06/PosBrief_CSFC_nov2015.pdf.

16 Ibid.

17 Ibid.

18 Ibid.

19 Ibid.

20 Ibid.

21 Fuel Consumption Standards for Heavy Duty Vehicles in India, ICCT, accessed on May 7, 2025, https://theicct.org/wp-content/uploads/2021/06/ICCT_India-HDV-fuel-consumption_policy-update_20171207.pdf.

22 ARAI and MoRTH Launch Bharat VECTO Project: A Calculation Tool ..., accessed on May 7, 2025, https://www.mobilityoutlook.com/news/arai-and-morth-launch-bharat-vecto-project-a-calculation-tool-for-estimating-emissions-through-simulation/.

23 Fuel Consysmption Standards for Heavy-Duty Vehicles in India, ICCT, accessed on May 7, 2025, https://theicct.org/wp-content/uploads/2021/06/ICCT_India-HDV-fuel-consumption_policy-up-

date_20171207.pdf.

24 Real-driving emissions from Bharat Stage VI (phase 1) passenger cars and a light commercial vehicle in India – PEMS testing, ICCT, accessed on May 7, 2025, https://theicct.org/wp-content/uploads/2024/06/ID-123-%E2%80%93-PEMS-India_wp_final.pdf.

25 Ibid.

26 Ibid.

27 Ibid.

28 Measuring emissions from vehicles in the real world: Policy steps in India - Down To Earth, accessed on May 7, 2025, https://www.downtoearth.org.in/pollution/measuring-emissions-from-vehicles-in-the-real-world-policy-steps-in-india-81046.

29 Real-driving emissions from Bharat Stage VI (phase 1) passenger cars and a light commercial vehicle in India – PEMS testing, ICCT, accessed on May 7, 2025, https://theicct.org/wp-content/uploads/2024/06/ID-123-%E2%80%93-PEMS-India_wp_final.pdf.

30 Role of fuel efficiency norms in accelerating sales of electric vehicles in India - International Council on Clean Transportation, accessed on May 7, 2025, https://theicct.org/wp-content/uploads/2024/06/ID-175-%E2%80%93-India-FE-policy_final.pdf.

31 Technical Considerations for Implementing a Real Driving Emissions Test for Passenger Vehicles in India, accessed on May 7, 2025, https://theicct.org/wp-content/uploads/2021/06/RDE_India_Position-Brief_20180531.pdf.

32 Measuring emissions from vehicles in the real world: Policy steps in India - Down To Earth, accessed on May 7, 2025, https://www.downtoearth.org.in/pollution/measuring-emissions-from-vehicles-in-the-real-world-policy-steps-in-india-81046.

33 How is an electric car's range measured?, Skoda Storyboard, accessed on May 14, 2025, https://www.skoda-storyboard.com/en/emobility/how-is-an-electric-cars-range-measured/.

34 International: Light-duty: Worldwide Harmonized Light Vehicles Test Procedure (WLTP), Transport Policy, accessed on May 14, 2025, https://www.transportpolicy.net/standard/international-light-duty-worldwide-harmonized-light-vehicles-test-procedure-wltp/#:~:text=Low%2C%20Middle%20Comments-,If%20v_max%20%E2%89%A5%2070%20km/h%2C%20phase%20'low',.

35 Electric 2-wheeler drive cycle based drivetrain sizing: A comprehensive analysis, IIT Gauhati, accessed on May 14, 2025, https://www.iitg.ac.in/e_mobility/drivetrain_sizing_report.pdf.

36 International: Light-duty: Worldwide Harmonized Light Vehicles Test Procedure (WLTP), Transport Policy, accessed on May 14, 2025, https://www.transportpolicy.net/standard/international-light-duty-worldwide-harmonized-light-vehicles-test-procedure-wltp/#:~:text=Low%2C%20Middle%20Comments-,If%20v_max%20%E2%89%A5%2070%20km/h%2C%20phase%20'low',.

37 Indian Drive Cycles and RDE Program for Effective Emission Norms, Controls and Policies - IIT Kanpur, accessed on May 7, 2025, https://home.iitk.ac.in/~mukesh/Publications/Indian%20Real%20Driving%20Emission%20Reprort%202021.pdf.

38 RDE Norms: all you need to know - Autocar Professional, accessed on May 7, 2025, https://www.autocarpro.in/feature/rde-norms-all-you-need-to-know-114614.

39 Emission Test Cycles: WLTC - DieselNet, accessed on May 7, 2025, https://dieselnet.com/standards/cycles/wltp.php.

40 Worldwide Harmonized Light Vehicles Test Cycle (WLTC), Diesel Net, accessed on May 14, 2025, https://dieselnet.com/standards/cycles/wltp.php.

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