TECHNICAL POLICY BRIEF

Higher Temperatures, Higher Evaporative Emissions

Why India's Climate Warrants India-Relevant Evaporative-Emissions Test Conditions

Executive Summary

India's Climate Requires India-Relevant Evaporative Emissions Testing

India's hot climate is among the most challenging in the world for controlling vehicle evaporative emissions. Yet current India BS6 (AIS-175) and proposed BS7 (AIS-215) evaporative emissions procedures rely on a European-derived diurnal temperature profile of 20°C to 35°C that does not reflect the temperatures routinely experienced across much of India. As a result, certification testing can significantly underestimate real-world hydrocarbon emissions.

Recent vehicle testing completed by ECMA at ARAI demonstrates that systems designed to comply under current certification conditions can emit dramatically higher levels of hydrocarbons when exposed to Indian summer temperatures, particularly during extended parking events. Evaporative emissions of 1.36 grams per test were measured at the certification condition of 20-35°C, increasing to 8.60 grams per test at 25-40°C and 53.37 grams per test at 30-45°C. Under the peak temperature conditions, evaporative hydrocarbon emissions exceed certification conditions by 26x and daily tailpipe hydrocarbon emissions by as much as 11x[1].

The Dieselgate Lesson

Dieselgate demonstrated that compliance under laboratory conditions does not always translate into real-world environmental performance. In response, regulators strengthened certification programs to better align test procedures with actual vehicle operating conditions, including the introduction of Real Driving Emissions (RDE) testing for tailpipe pollutants. While RDE represented a significant expansion of compliance testing, its underlying objective was straightforward: ensuring that certification results accurately reflect real-world emissions performance.

The same principle applies to evaporative emissions. The question is not whether vehicles comply under current certification conditions. The question is whether those certification conditions accurately represent the temperatures encountered by vehicles in real-world operation.

Evidence from India and other hot-climate markets indicates that actual vehicle temperatures can exceed those represented in current certification procedures. Under these higher-

[1] Exhaust non-methane hydrocarbon (NHMC) emission limit for BS6 light-duty vehicles is 68 mg/km. Using an average driving distance of 33 km/day, over two days a vehicle could emit 4.5 g of tailpipe NMHC (0.068g/km * 66 km = 4.5 g). 2-day evaporative emissions are 53.1 g over two days, so evaporative emissions are 11.8x higher at 45C.

temperature conditions, evaporative emissions can increase from compliant levels to more than 53 grams per test due to canister breakthrough.

Importantly, addressing this gap does not require a new testing paradigm comparable to RDE. The solution is far more targeted and simple: updating the temperature profile within the existing evaporative emissions procedure so that certification results better reflect real-world operating conditions. This is a practical, data-driven refinement designed to improve environmental effectiveness while minimizing additional testing burden. No new test procedures or testing infrastructure is required to improve real-world compliance.

A Proven and Cost-Effective Solution

The technology needed to control evaporative emissions already exists and is adopted in other leading world markets, including the U.S, China and Brazil. Testing by MECA on a U.S. Tier 3 vehicle under India high temperature conditions revealed emissions were maintained below 1.0 grams per test for even the peak temperature condition of 30-45°C (compared to 53 grams from the India BS6 vehicle). India canister systems could achieve similar compliance with modest increases in canister capacity and optimization of existing evaporative-control systems, resulting in a reduction of emissions by more than 97%, even at temperatures up to 45°C. These improvements utilize proven, commercially available technology and can be implemented at a low incremental cost of less than ₹1400 per vehicle. Furthermore, reducing evaporative emissions conserves fuel, generating lifetime consumer savings that can exceed the cost of the control system. Analysis indicates that enhanced evaporative-control systems can save consumers more than 4.2 liters of fuel annually, generating lifetime fuel savings exceeding ₹4,200 per vehicle. These savings fully offset the incremental cost of the additional canister control technology while delivering meaningful air-quality and public health improvements.

Recommendation

Revise AIS-215 to adopt a 48-hour diurnal evaporative-emissions test using a 25°C to 40°C temperature profile that is more representative of Indian conditions.

This targeted solution of updating the temperature profile within the existing AIS-175 and draft AIS-215 procedures ensures certification results better reflect real-world operating conditions. Doing so will deliver meaningful air-quality benefits, reduce fuel losses, and ensure certification compliance translates into real-world emissions control.

1. India’s Climate is Hot: 35°C+ Is a Routine Condition and Heat Drives Increased Fuel Evaporation.

India does not experience high temperatures as rare extremes; they are a routine feature of daily life across large, populous regions for a substantial part of the year. Long-term meteorological records make this clear:

- As shown in Figure 1, temperatures across many large India cities exceed 35°C for more than 100 days a year, with heatwave highs approaching 45 to 50°C. In contrast, large EU cities experience temperatures exceeding 35°C generally less than 5% of all days in a year[2].

- As an example, Ahmedabad now records 53–60 days per year at or above 40°C - up from about 35 such days in the 1990s[3].
- Nationally, India averaged about 131 heatwave days per year (2010-2024), rising to roughly 200 in 2024; every heatwave day is, by definition, a 35°C+ day under India Meteorological Department (IMD) criteria.[4]

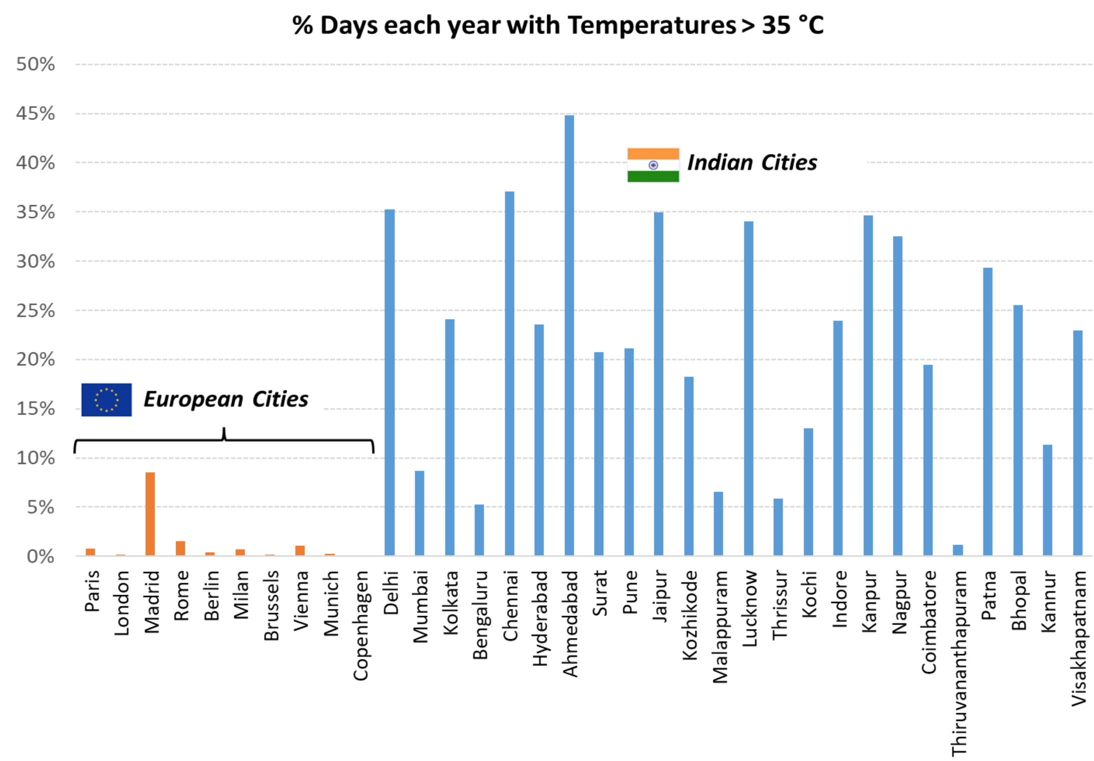

Figure 1: Percentage of days each year with temperatures exceeding 35°C. European cities in orange, Indian cities in blue.

Gasoline is volatile. As fuel warms, its vapor pressure and the volume of vapor generated in the tank increase. The fuel in 4W light-duty vehicle fuel tanks, even though they are shielded from the sun, can heat up higher than ambient temperatures due to excess heat radiated from a hot road surface. The European Commission Joint Research Centre observed fuel tank temperatures can exceed 40°C depending on ambient and driving conditions[5]. A vehicle's carbon canister must adsorb the vapor generated from fuel tank heating while the vehicle is parked. When vapor generation exceeds the canister's working capacity, hydrocarbons "break through" and escape to

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[2] India Meteorological Department. Master Data: Year- and Month-wise Minimum, Maximum and Mean Actual Temperatures recorded in India (from 1901) . Preprint at https://dataful.in/datasets/18471/.
[3] Of 56 days of summer 2026, Ahmedabad suffered 53 days of above 40-degree temperature | Ahmedabad News - The Times of India
[4] Chart: India's Relentless Heatwaves and Extreme Temperatures | Statista
[5] JRC Publications - An experimental study to investigate typical temperature conditions in fuel tanks of European vehicles

the atmosphere. Higher ambient temperatures therefore place greater demand on the entire evaporative control system.

This relationship between higher temperature and higher evaporative emissions is well established in literature. Foundational testing by the Society of Automotive Engineers (SAE) in 1986 on 40 in-use passenger cars demonstrated that diurnal and hot-soak evaporative emissions are highly sensitive to temperature, and that the temperature sensitivity increases with the use of higher volatility fuels[6]. Evaporative emissions ranging from 10 grams per test to 40 grams per test were observed when temperatures exceeded 40°C. The increase in evaporative emissions with temperature has not just been observed in the laboratory. Ambient, time-resolved measurements of evaporative volatile organic compounds (VOCs) were conducted in California during the summer of 2001, where it was determined there was a 6.5% increase in vapor-pressure driven evaporative emissions per degree Celsius rise in maximum ambient temperature[7]. The practical implication is direct: a certification test conducted at moderate European temperatures of 20-35°C does not represent how a vehicle behaves during an Indian summer where ambient temperatures can exceed 45°C, and fuel tank temperatures can be even higher.

2. Evaluation of Vehicle Evaporative Emissions Under Elevated Temperature Conditions: New Evidence from ECMA and MECA

To better understand how India's climate affects vehicle evaporative emissions, the Emission Controls Manufacturers Association of India (ECMA) and the Manufacturers of Emission Controls Association (MECA) coordinated a global testing program across India, Europe, and the United States. Comparable light-duty vehicles were tested using consistent fuels and test procedures to isolate the impact of temperature on evaporative emissions. This testing program was designed to quantify how increasing temperatures affect evaporative emissions and to evaluate whether current evaporative-control systems are sufficient for the higher temperatures commonly experienced in India.

Testing was conducted on a Bharat Stage 6 vehicle in India, a Euro 6e vehicle in Europe, and a U.S. Tier 3 vehicle in the United States. Table 1 provides the specifications for each vehicle tested. While the vehicles were broadly similar, the U.S. vehicle's stock configuration included an activated carbon canister approximately twice the size of those used in India and Europe, reflecting a design to meet the more stringent U.S. evaporative emission requirements.

Table 1: Vehicle specifications

Specification	Vehicle A	Vehicle B	Vehicle C
Test region / laboratory	India, ARAI	Europe, IDIADA Spain	United States, Roush
Model year	2024	2026	2026
Certification	BS6	Euro 6e	Tier 3 / LEV III
Powertrain	1.5 L MPi	1.2 L mild hybrid, MHEV	1.5 L MPi
Fuel-tank capacity	50 L	44 L	50 L
Carbon-canister volume	1.0 L	1.06 L	2.3 L
Vehicle mileage	9,600 km	7,400 km	5,400 km
Test fuel	E20	E10	E10
Measured fuel RVP	62.5 kPa	62 kPa	62.0 kPa

[6] SAE Technical Paper Series, 860529, Effects of Fuel Volatility and Temperature on Vehicle Evaporative Emissions, 1986.
[7] Rubin et al., Temperature dependence of volatile organic compound evaporative emissions from motor vehicles, Journal of Geophysical Research, Vol. 111, D03305, 2006.

Preconditioning cycle	WLTP	WLTP	FTP-75
Diurnal test duration	48 hours	48 hours	48 hours
Temperature profiles tested	20–35°C; 25–40°C; 30–45°C	25–40°C	20–35°C; 25–40°C; 30–45°C

All evaporative emissions tests followed the hot soak and diurnal Type IV test procedures of AIS-175[8]. Prior to testing, vehicles were cleaned, serviced and inspected to ensure compliance with all applicable requirements for in-service conformity testing following EU Regulation 2017/1151[9]. Leak checks and use of handheld hydrocarbon detectors were also completed prior to testing to ensure there were no leaks or other sources of hydrocarbon contamination present. Certification fuel was used for all testing. Fuel samples were collected and sent to independent laboratories for RVP analysis. OBD data loggers were installed to record engine speed and commanded evaporative purge data during the preconditioning drives. Figures 2 to 4 show the vehicles during testing and the associated evaporative emission control canisters installed on the vehicle.

Figure 2: Vehicle A tested at ARAI in India

Figure 3: Vehicle B tested at IDIADA in Spain

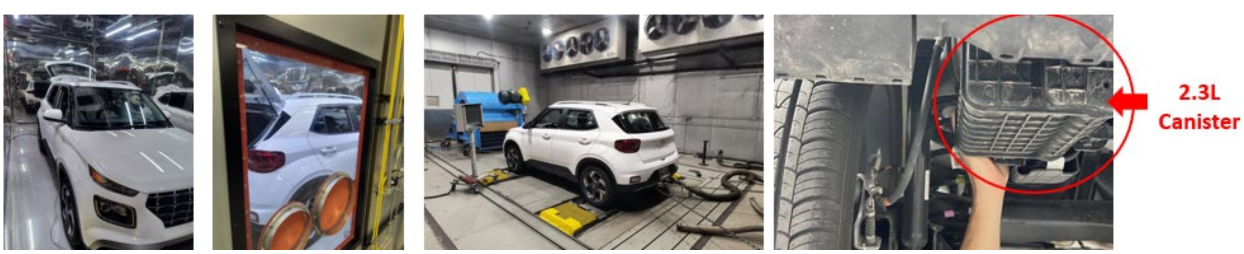

Figure 4: Vehicle C tested at Roush in U.S.

[8] https://hmr.araiindia.com/storage/ais-details/1786438388_AIS-175_with%20Amd%201.pdf
[9] Commission Regulation (EU) 2023/ of 8 February 2023 amending Regulation (EU) 2017/1151 as regards the emission type approval procedures for light passenger and commercial vehicles

3. The Evidence: Test Data at Elevated Temperatures

Controlled vehicle testing coordinated across three continents provides the clearest demonstration. Vehicle A (BS6, E20 fuel) was tested by ECMA at ARAI under identical 48-hour procedures at three diurnal temperature profiles. The results in Table 2 show a dramatic, temperature-driven rise in total evaporative emissions.

Table 2: Total hot soak and 48-hr diurnal evaporative emissions for BS6 vehicle

Diurnal Temperature Profile	Total Evaporative Emissions	Increase vs. Baseline
20–35°C (baseline)	**1.36 g/test**	—
25–40°C (India average)	**8.35 g/test**	**6.1× higher**
30–45°C (India maximum)	**53.1 g/test**	**39× higher**

Most of the increase occurred on the second diurnal day, which for the 25-40°C test condition rose from 0.86 grams of emissions on Day 1 to 7.40 grams on Day 2, for a total of 8.35 grams over two days. Similarly, for the 30-45°C test condition, emissions rose from 16.54 grams on Day 1 to 36.47 grams of Day 2, for a total of 53.1 grams over two days. This is the central technical reason a 48-hour procedure matters and should be adopted for all vehicle categories operating on gasoline fuels: the first hot day can consume much of the canister's remaining capacity, so a second heating cycle produces disproportionately high emissions that a shorter test would miss.

Complementary testing at Roush (U.S.) by MECA on a Tier 3 certified Vehicle C, with a stock canister configuration consisting of a larger 2.3L ORVR-sized canister, remained below 1.0 grams per test, even at 30–45°C. Figure 5 provides a summary of the India BS6 vs U.S. Tier 3 evaporative emissions at identical test conditions. The only difference is the size of the canister, with the U.S. Tier 3 vehicle having a 2x larger canister due to the more stringent evaporative emission regulations in the U.S. compared to India. **This is a crucial and constructive finding: robust control is technically achievable today in India with systems already adopted in other markets due to stricter regulations already in place.** A representative high-temperature test adopted in India does not penalize good engineering - it distinguishes systems that protect air quality under real conditions from those that do not.

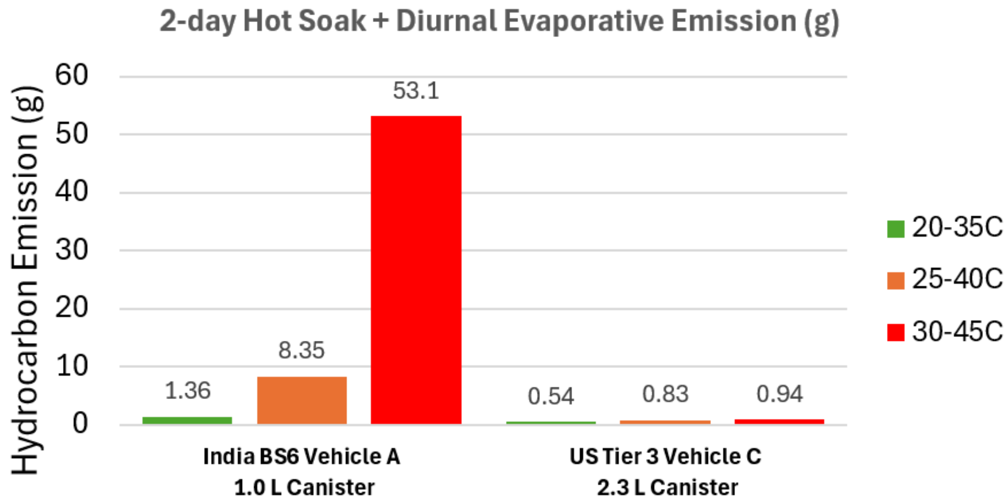

Figure 5: Comparison of evaporative emissions from India BS6 Vehicle A with 1.0 L canister and U.S. Tier 3 Vehicle C with 2.3 L canister. The larger and more efficient Tier 3 canister controls evaporative emissions by greater than 97% even at temperatures up to 45°C, demonstrating that the technology is available and feasible to implement in India.

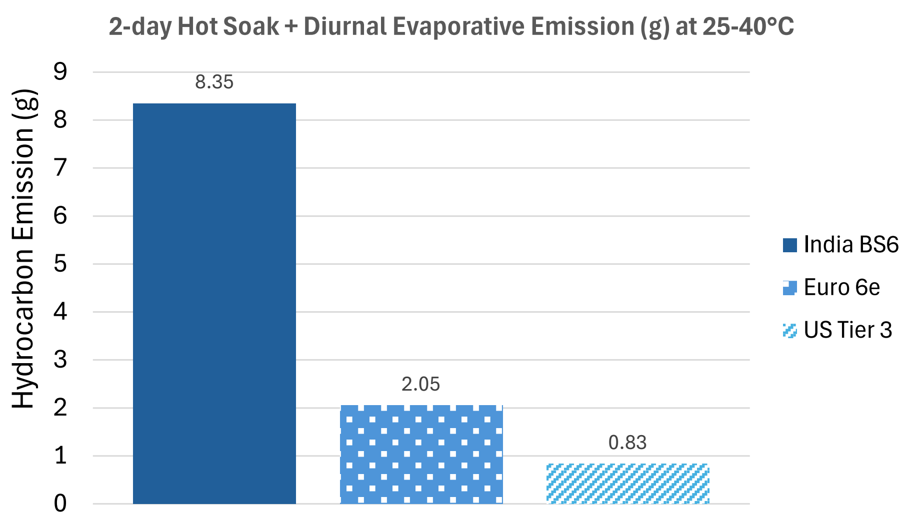

Figure 6: Comparison of evaporative emissions at 25-40°C from India Vehicle A with 1.0 L canister, Euro 6e Vehicle B and with 1.06 L canister and U.S. Tier 3 Vehicle C with 2.3 L canister.

Vehicle A (India - BS6) 50 L fuel tank, 1.0L canister			
Test	Test Set 01	Test Set 02	Test set 03
Temperature Profile	20 – 35°C	25 – 40°C	30 – 45°C
Hot Soak Test	0.17 g	0.09 g	0.09 g
Diurnal Day 01	0.64 g	0.86 g	16.54 g
Diurnal Day 02	0.55 g	7.40 g	36.47 g
Sub TOTAL HS+Dbl1+Dbl2	1.36 g/test	8.35 g/test	53.1 g/test

Vehicle C (US - Tier 3) 50 L fuel tank, 2.3 L canister			
Test	Test Set 01	Test Set 02	Test set 03
Temperature Profile	20 – 35°C	25 – 40°C	30 – 45°C
Hot Soak Test	0.052 g	0.054 g	0.038 g
Diurnal Day 01	0.272 g	0.423 g	0.500 g
Diurnal Day 02	0.211 g	0.353 g	0.399 g
Sub TOTAL HS+Dbl1+Dbl2	0.535 g/test	0.830 g/test	0.937 g/test

Vehicle B (Spain - Euro6e), 44L tank, 1.06 L canister	
Test	Test Set 01
Temperature Profile	25 – 40°C
Hot Soak Test	0.082 g
Diurnal Day 01	0.721 g
Diurnal Day 02	1.251 g
Sub TOTAL HS+Dbl1+Dbl2	2.05 g/test

Figure 7: Hot soak and Diurnal emissions results from India BS6 Vehicle A with 1.0 L canister, U.S. Tier 3 Vehicle C with 2.3 L canister, and Euro 6e Vehicle B with 1.06 L canister.

While both the Euro 6e and India BS6 vehicles exceeded current certification emission limits (2.0 grams per test) when tested under elevated temperature conditions, the Euro 6e vehicle produced lower evaporative emissions overall for a similar sized canister around 1 L. (Figure 6). However, the Euro6e vehicle was not tested at the maximum condition of 30-45°C. The emissions observed during this elevated temperature testing is consistent with differences in canister working capacity and/or fuel system design. The Euro 6e vehicle demonstrated a slower increase in evaporative emissions and lower overall emission levels compared to the India BS6 vehicle, despite having a canister of comparable size, suggesting that the canister retained additional vapor before breakthrough occurred. While this observation alone cannot confirm differences in carbon performance, it is consistent with the use of a higher-capacity activated carbon or a more optimized canister design. However, direct measurement of carbon volume and carbon properties was not conducted because such analyses would have required destructive disassembly of the canisters. Consequently, the contribution of activated carbon properties to the observed emissions differences could not be quantified within the scope of this study.

Additionally, the Euro 6e vehicle utilized a plastic fuel tank, whereas the India BS6 vehicle was equipped with a metal fuel tank. This difference may have influenced evaporative emissions performance. Plastic fuel tanks generally provide greater thermal insulation than metal tanks, which can absorb and transfer heat more readily from the surrounding environment. Under elevated ambient temperatures and solar loading conditions, a metal fuel tank is likely to experience faster and larger increases in fuel temperature. Higher fuel temperatures increase fuel vapor pressure and vapor generation rates within the tank, placing a greater load on the evaporative emission control system. As a result, the BS6 vehicle's canister may have been exposed to a significantly higher vapor challenge despite having a canister of similar size.

The results suggest that evaporative emissions performance at elevated temperatures is influenced not only by canister volume, but also by the overall system design, including activated carbon working capacity, fuel system calibration, tank material selection, and the vehicle's intended regulatory compliance requirements. Nevertheless, even with these design advantages, the Euro 6e vehicle still exceeded Euro 6e certification-level emissions (above 2.0 grams per test) when tested at higher temperatures, demonstrating the substantial impact that elevated temperatures can have on fuel vapor generation and evaporative emissions.

The lower emissions observed from the Euro 6e vehicle should not be interpreted as evidence that higher temperatures have a limited effect. Rather, they demonstrate that vehicles specifically engineered with more robust evaporative emission control systems can better manage the increased vapor generation that occurs at elevated temperatures. Even these enhanced systems, however, experienced significant emission increases when subjected to hotter test conditions.

3. Why This Matters for Public Policy

Air quality and public health

Evaporative hydrocarbons are volatile organic compounds (VOCs) — a key precursor of ground-level ozone and secondary particulate matter (PM2.5). Recent research shows that Indian heatwaves already drive surface ozone above World Health Organization guidelines across all regions studied, with significant associated respiratory and cardiovascular mortality[10]. Because heat simultaneously increases VOC emissions and accelerates ozone and PM formation, uncontrolled evaporative emissions compound a public-health problem precisely when conditions are most dangerous.

Evaporative emissions are not merely a source of smog-forming VOCs; they also contain hazardous air pollutants, including benzene, a known human carcinogen. The International Agency for Research on Cancer (IARC) classifies benzene as carcinogenic to humans, and long-term exposure has been associated with leukemia and other blood cancers. Benzene is present in gasoline and is released through vehicle refueling and evaporative fuel losses[11].

Recognizing the public health risks associated with gasoline vapor exposure, India's regulatory authorities and courts have supported the installation of Vapor Recovery Systems (VRS) at petrol

[10] Heatwaves trigger severe surface ozone pollution in India: regional hotspots, trends and health effects | npj Clean Air
[11] Benzene and Cancer Risk | American Cancer Society

stations to capture fuel vapors and reduce public exposure to benzene and other evaporative VOCs. The Supreme Court of India directed implementation of VRS controls at major retail petroleum outlets, and the Central Pollution Control Board (CPCB) identified petrol refueling stations as significant sources of benzene and VOC emissions that contribute to ozone pollution and public exposure risks[12].

However, refueling emissions are only one component of the gasoline vapor emission inventory. Elevated-temperature testing conducted by ECMA and MECA demonstrates that evaporative emissions from parked vehicles can increase dramatically as temperatures rise and canister capacity is exhausted. In some cases, measured evaporative emissions at higher temperature conditions exceeded certification-level emissions by an order of magnitude. These evaporative vapors contain the same gasoline-derived VOCs and hazardous constituents, including benzene, that policymakers have sought to reduce through vapor-recovery requirements at fuel stations.

As a result, focusing only on refueling emissions while maintaining evaporative-emissions test procedures that do not adequately represent India's high-temperature operating conditions risks leaving a significant source of benzene and VOC exposure uncontrolled. Updating AIS-215 to better reflect real-world Indian temperatures would complement existing efforts to control vapor emissions at petrol stations and further reduce public exposure to harmful gasoline vapors, particularly during hot summer periods when evaporative emissions are greatest.

In addition to station-based Vapor Recovery Systems (VRS), India should also consider requiring on-board refueling vapor recovery (ORVR) on new petrol vehicles. Although VRS provides important interim control, its real-world efficiency depends on proper installation, inspection, and maintenance and can fall to approximately 50 percent. ORVR captures refueling vapors directly on the vehicle and has demonstrated 98 percent control under in-use conditions[13]. This proven technology is already required on new petrol vehicles in the United States, China, and Brazil.

Fuel conservation and consumer value

Every gram of evaporative emissions represents fuel that consumers have already purchased but never get to use. By adopting stronger evaporative emissions standards, India can keep more than 4.2 liters of fuel per vehicle per year in the tank, reduce unnecessary fuel imports, improve vehicle efficiency, and deliver approximately ₹4,200 in lifetime savings to every vehicle owner[14]. This is a rare policy opportunity where environmental protection, consumer savings, and energy security are fully aligned. Every gram of evaporated hydrocarbon is fuel that leaves the vehicle instead of powering it. Stronger vapor capture returns that fuel to the engine. ARAI should include a cost-benefit analysis inclusive of fuel savings to support the modification of AIS-215 to incorporate higher temperature testing. Table 3 provides an ECMA and MECA summary of the cost savings that can be realized by revising AIS-215.

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[12] Supreme Court directed the Central Pollution Control Board (CPCB) to ensure that petroleum outlets Should install VRS (Vapor Recovery System) mechanism - Free Law

[13] MECA Whitepaper; Refueling_Vapor_Recovery_WhitePaper_Final.pdf

[14] Assumes an average evaporative emission loss of 8.5 grams per vehicle per day, which is recovered by the larger canister system. 8.5 g/day *365 = 3103 g/year = 4.2 L/year * 10 year = 42 L * ₹100/L = ₹4200/vehicle lifetime

Item	Cost	
Activated Carbon Canister	+ ₹1000/vehicle	Incremental cost to increase canister volume 2x to 2.1L from 1.2 L of BS6 Phase III (Euro6d)
SHED/infrastructure costs	Minimal	No SHED modifications required – only a software update needed to program a revised profile
Fuel tank, valves, and hoses	None	No changes required relative to BS6 Phase III
R&D/Calibration Costs	Less than + ₹400 /vehicle*	*A 1000 Lakhs (10 Crore) calibration cost for new type approval would be shared amongst the number of vehicles produced under that type approval. Example: If a manufacturer produces 250,000 vehicles under a type approval certificate, the cost is ₹400/vehicle.
Total Hardware Costs	**< ₹1400 / vehicle**	
Estimated Fuel Savings (10 year life of vehicle)	**> (₹4200/vehicle) *in savings***	Assumes an average evaporative emission loss of 8.5 grams per vehicle per day, which is recovered by the larger canister system. 8.5 g/day *365 = 3103 g/year = 4.2 L/year * 10 year = 42 L * ₹100/L = ₹4200/vehicle lifetime
Net cost, including savings	**> (₹2800 / vehicle) *in savings***	

4. Recommendations

- The Automotive Industry Standards Committee (AISC) was entrusted with the responsibility to consider Indian operating and environmental conditions, where applicable, when developing AIS-215. This responsibility must be upheld.
- The evidence clearly indicates that current certification test conditions underestimate evaporative emissions under Indian operating environments. To ensure regulatory relevance and effective emissions control, AISC should incorporate a 48-hour 25-40°C diurnal profile into AIS-215. This profile better represents typical Indian summer temperatures and should be applied uniformly across all vehicles operating on gasoline or gasoline-blended fuels.
- AISC should consult the automotive supplier industry to evaluate compliance costs of evaporative emissions control, including fuel conservation and fuel savings benefits to the consumer. The supplier industry analysis indicates that improved evaporative control is readily achievable at an incremental cost of less than ₹1,400 per light-duty vehicle. Adopting this control can conserve more than 4.2 liters of fuel per light-duty vehicle annually and provide lifetime fuel savings exceeding ₹4,200 per vehicle.

Bottom line

India's already-high temperatures mean vehicles routinely operate under conditions that sharply increase evaporative emissions. A 48-hour, 25–40°C test provides a more realistic, policy-relevant measure of control — protecting air quality, conserving fuel, and rewarding proven technology that is available today.