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Evaporative emissions:

Improving air quality in India through reducing emissions

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ECMA's ECT - 2022

10 November 2022

AGENDA

1. Recent advances in evaporative emissions regulations – A global perspective

2. India’s current vehicle and fuel market trends

3. Evaluating the impact of Europe’s Euro 7 proposal on reducing evaporative emissions, including during heatwaves.

4. Summary of India’s evaporative emission reduction potential for harmonizing with the latest Euro standards.

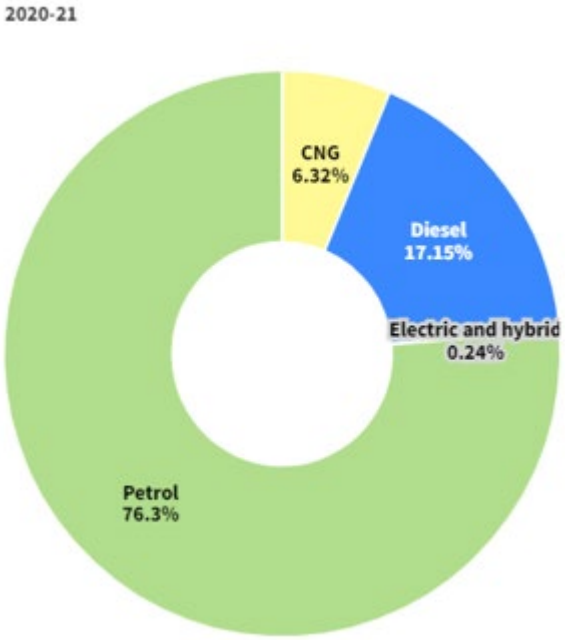
Recent Advances in Evaporative Emissions Regulation

- **Brazil PROCONVE L7/L8**
  - ✓ Adopted On-board Refueling Vapor Recovery (ORVR)
  - ✓ Diurnal: 1-hr, 1.5 g/test → 48-hr, 0.5 g/day
- **China 6**
  - ✓ Adopted On-board Refueling Vapor Recovery (ORVR)
  - ✓ Diurnal: 24-hr, 2.0 g/test → 48-hr, 0.7 g/day
- **Euro 6d / Euro 7**
  - ✓ Diurnal: 24-hr; 2.0 g/test → 48-hr; 2.0 g/test
  - ✓ ORVR and a 0.3 – 0.5 g/day diurnal standard are expected in Euro 7
- **UN/ECE GTR-19, Amendments 1 and 2**
  - ✓ Added canister aging and durability procedures
  - ✓ Added procedures for sealed tank systems (Puff Loss)

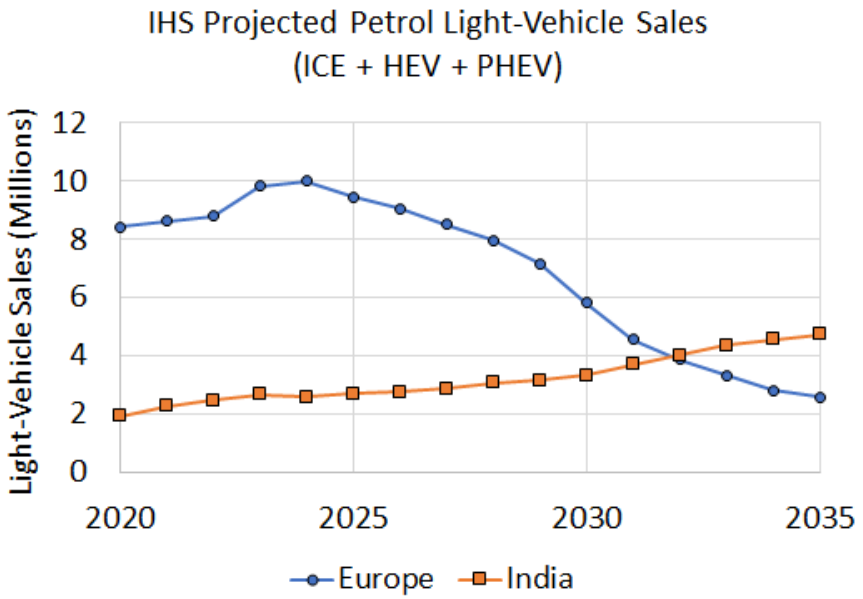
Factors Motivating Regulation Changes:

- Growing petrol vehicle populations increasing the magnitude of evaporative emissions.
- Desire to improve urban air quality and a need to control evaporative emissions to reduce ozone (O_3) and particulate matter ($PM_{2.5}$).
- Increasing focus on control of emissions during all conditions of use, including elevated temperatures.

India's Vehicle and Fuel Market Trends



Source: Society of Indian Automobile Manufacturers
Theprint Article, 11 October 2021



Source: IHS Inflections, August 2022

- In 2020-2021, **76.3%** of new passenger car registrations in India have petrol engines
- **54 M** petrol-engine vehicles are projected to be sold in India from 2025 to 2035
- India aims to introduce **E20** petrol at fuel pumps by January 2023

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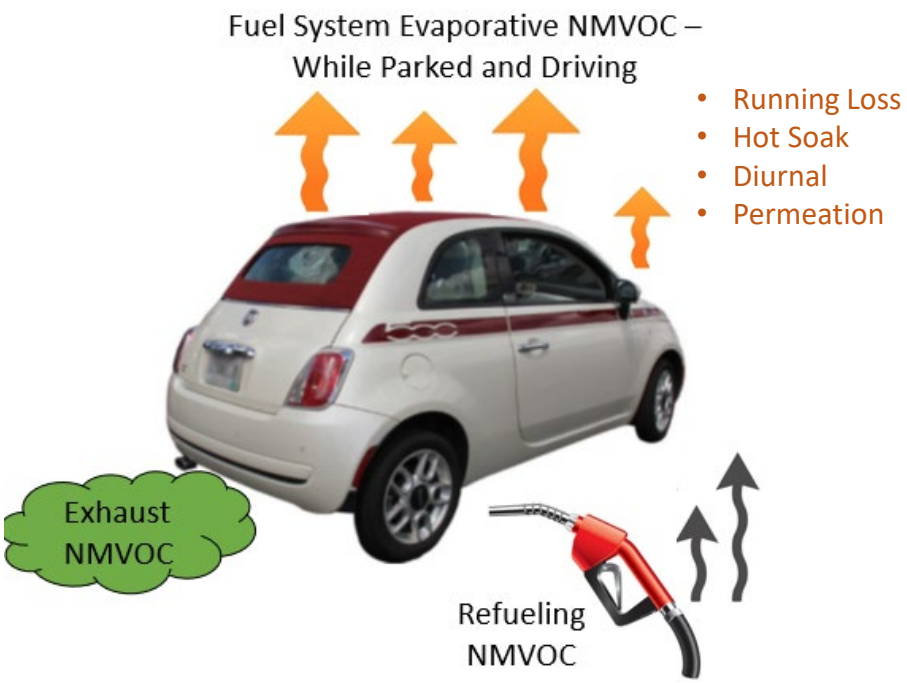
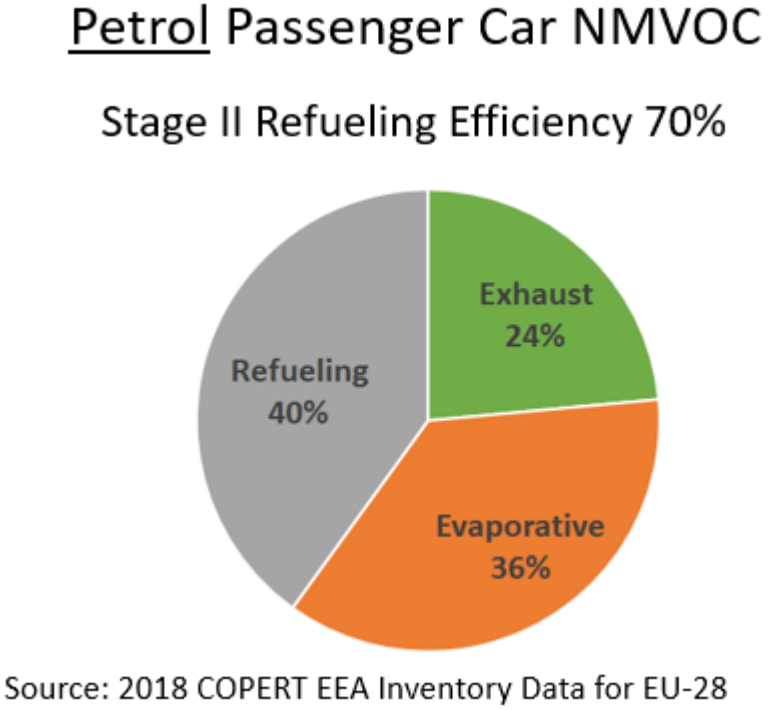
Non-Methane Volatile Organic Compounds (NMVOC)

Evaporative emissions of NMVOC from Euro 5-6 vehicles are significant, including conventional, hybrid, and plug-in hybrid electric petrol vehicles.





Source: 2018 COPERT EEA Inventory Data for EU-28

>75% of NMVOC from Euro 5-6 petrol vehicles is from Evaporative & Refueling.

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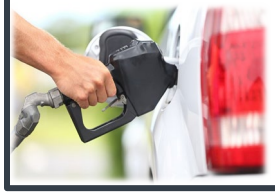
Euro 7 Options

To control petrol vehicle refueling and evaporative NMVOC in Europe, the following options are to be proposed for Euro 7

NMVOC Control Element	Current Standards Euro6d / Stage II	Recommendations[1] Post-Euro6 (Euro7)
Refueling	Stage II – control at pump • 55 – 85% in-use efficiency[1] • 20 – 30 g NMVOC per vehicle refueling	**Add ORVR – control on vehicle** • 97%+ in-use efficiency[1] • 2 – 3 g NMVOC per vehicle refueling
2-day Parking Evaporative Emission Limit	< 2.0 g	**< 0.3 g or < 0.5 g**
Leak Detection Limit	None	**On-board Detection for leaks** > 0.5 mm diameter

[1] As presented by CLOVE consortium to European Commission's Advisory Group on Vehicle Emission Standards (AGVES) on 27 October 2020.

What is ORVR? On-board Refueling Vapor Recovery



Bharat VI vehicles contain a 1-function canister. ORVR is a 2-function canister that also will capture the petrol NMVOC vapors from refueling.

Petrol vapors are stored in the canister until the vehicle operates, they are then used by the engine during combustion.

ORVR captures > 98% of petrol vapors from refueling[1], preventing them from going to the atmosphere. *No ORVR maintenance is needed for life of vehicle.*

800 – 1,600 INR per vehicle cost for ORVR[2]. This cost is recovered by the consumer in fuel savings – refueling vapors are captured and re-used as fuel.

activated carbon canister (ORVR on large-scale factory-produced U.S. Fiat 500)

- ORVR is fully implemented in the United States, Canada, and China
- ORVR will be implemented in Brazil from 2023-2025
- ORVR is expected to be proposed in Euro7 for implementation 2025+

[1]SAE, 2017 - https://saemobilus.sae.org/content/2017-01-5008/
[2]€10-20, MECA, 2020 - http://www.meca.org/resources/Refueling_Vapor_Recovery_WhitePaper_Final.pdf

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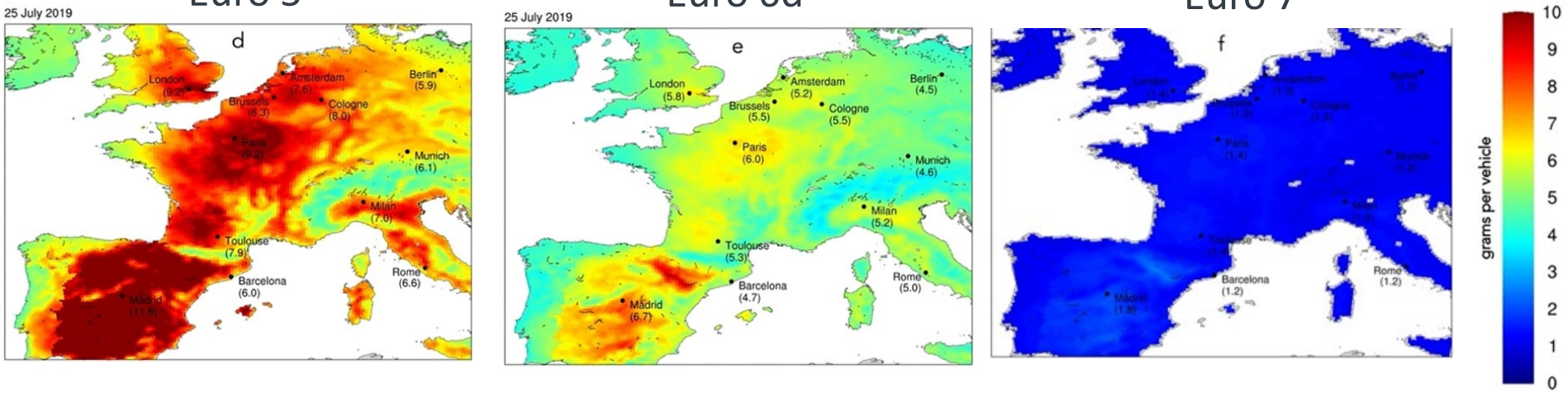
Modeling the evaporative emission reduction benefits of Euro 7 in Europe during heatwaves

Daily Evaporative Emissions (grams per vehicle per day)

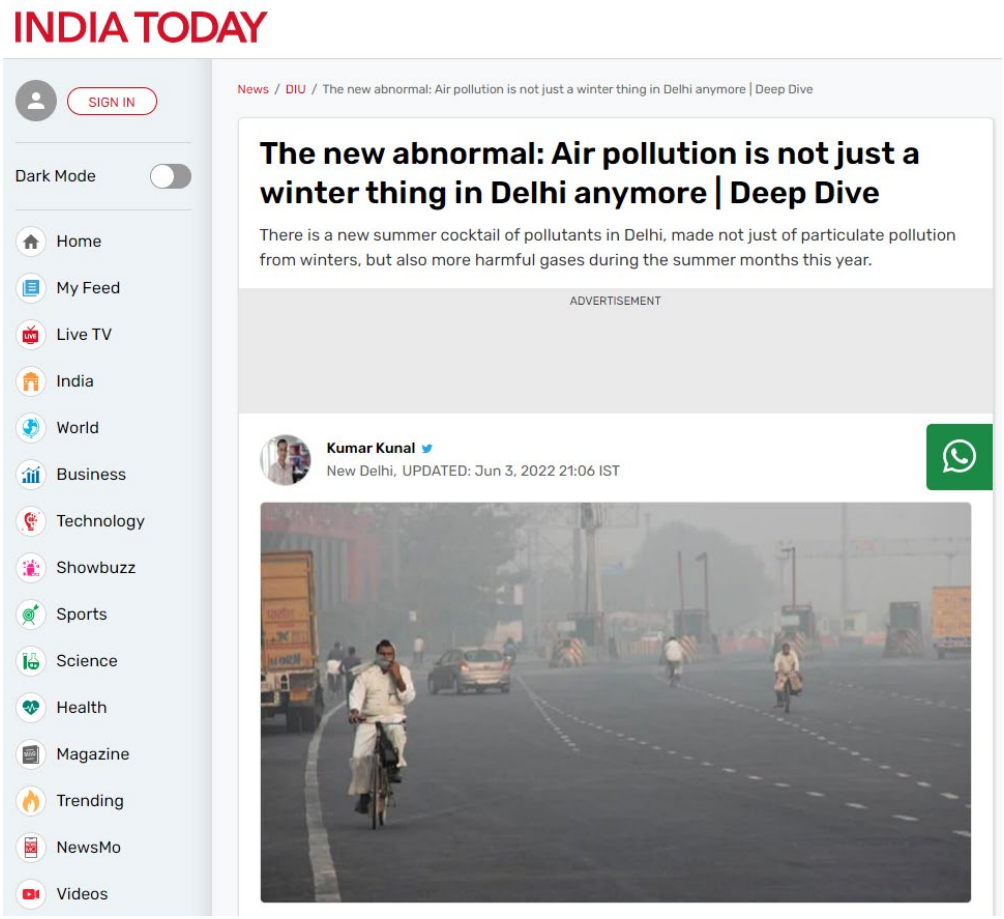
Euro 5 | Euro 6d | Euro 7

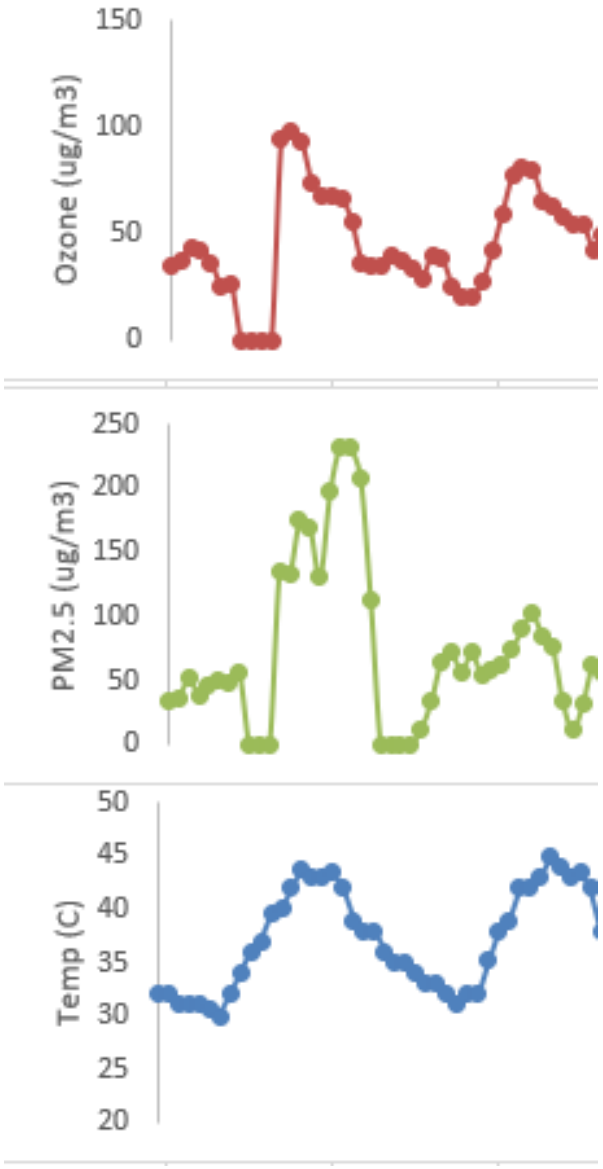


The proposed Euro7 controls would provide up to an additional **75% emissions reduction in evaporative emissions relative to Euro6d.**

Source: Effectiveness of emissions standards on automotive evaporative emissions in Europe under normal and extreme temperature conditions - IOPscience

Air Quality is often worse during heat waves





The new abnormal: Air pollution is not just a winter thing in Delhi anymore | Deep Dive - India Today

Source: CPCB | Central Pollution Control Board

Aya Nagar, Delhi – IMD; 19 May 2022

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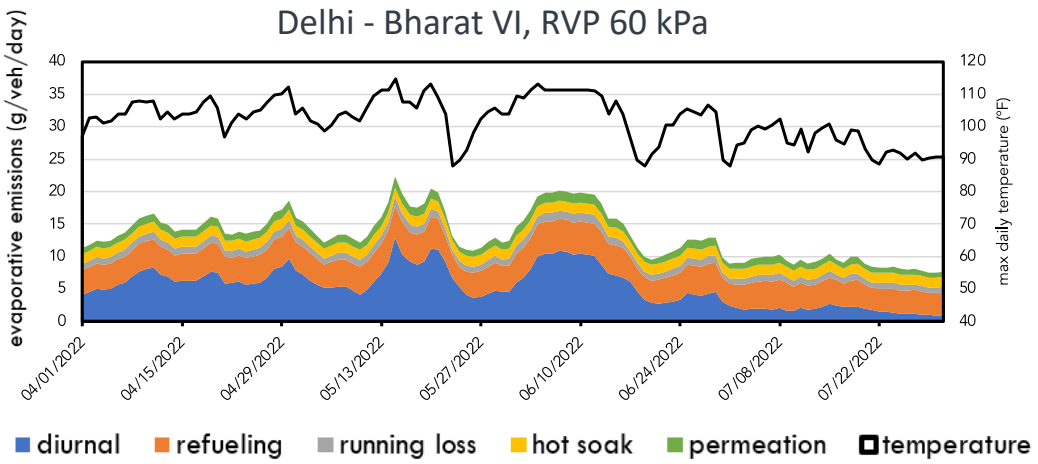
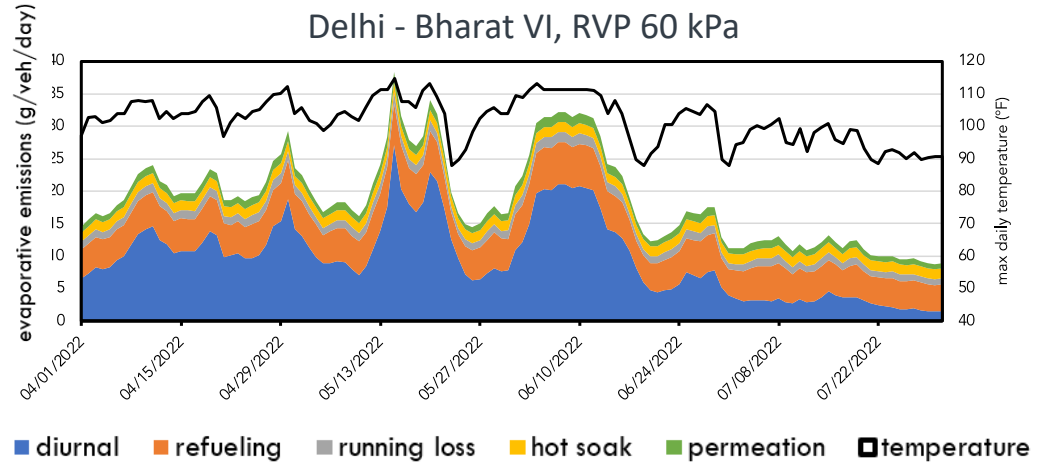
Higher ethanol fuel blends increase evaporative emissions, especially during heatwaves





- India aims to introduce **E20** petrol at fuel pumps by January 2023
- The maximum allowable vapor pressure for commercial **E0** petrol is **60 kPa** (IS 2796:2017)
- The maximum allowable vapor pressure for commercial **E20** petrol is **70 kPa** (IS 17021:2018)
- With no change to evaporative emission standards or controls, increasing the fuel vapor pressure from 60 to 70 kpa is estimated to increase the daily evaporative emission rate by **38%.**

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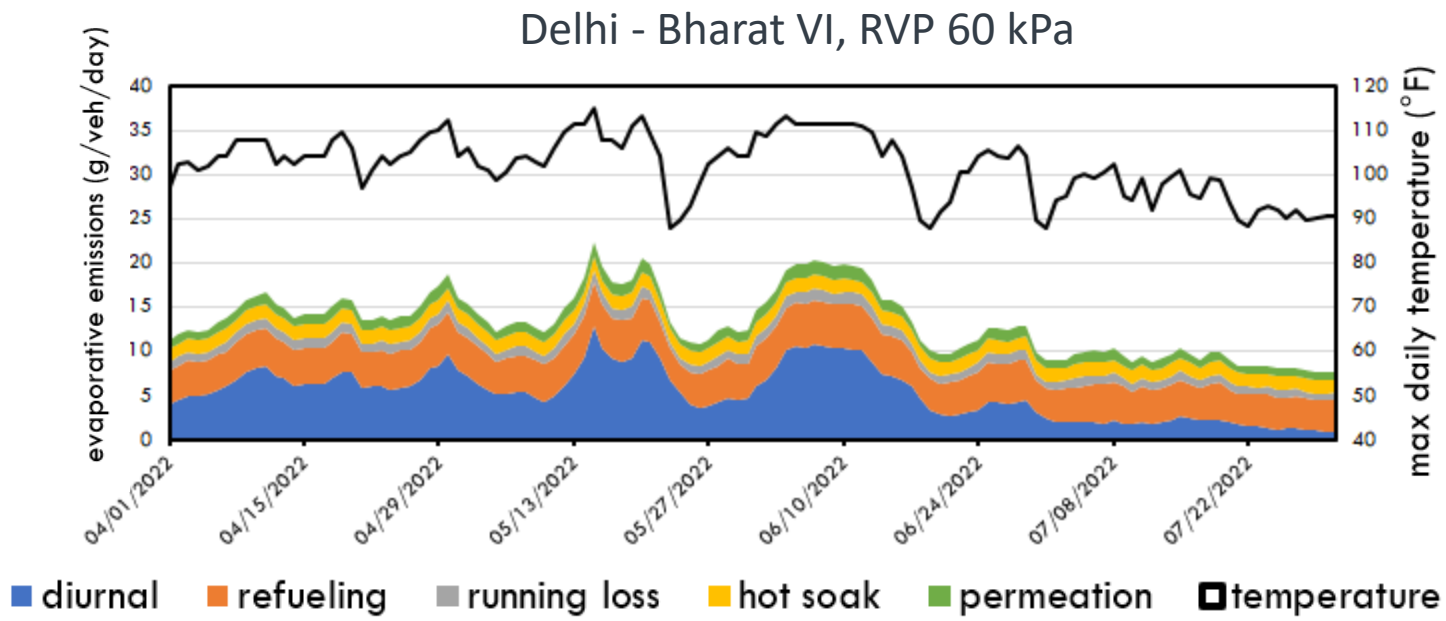
Modeling the evaporative emission reduction benefits of aligning with Euro standards in India – case study for Delhi

Daily Evaporative Emissions (grams per vehicle per day)



For evaporative emissions, Bharat VI is equivalent to **Euro 5** – gasoline vehicles have **no refueling control and certify to a 1-day diurnal limit of 2 g/test**.

During heatwaves, up to **20 grams** per vehicle per day of evaporative emissions is emitted. This is an estimated 113 tons/day of evaporative emissions for all Delhi petrol vehicles.

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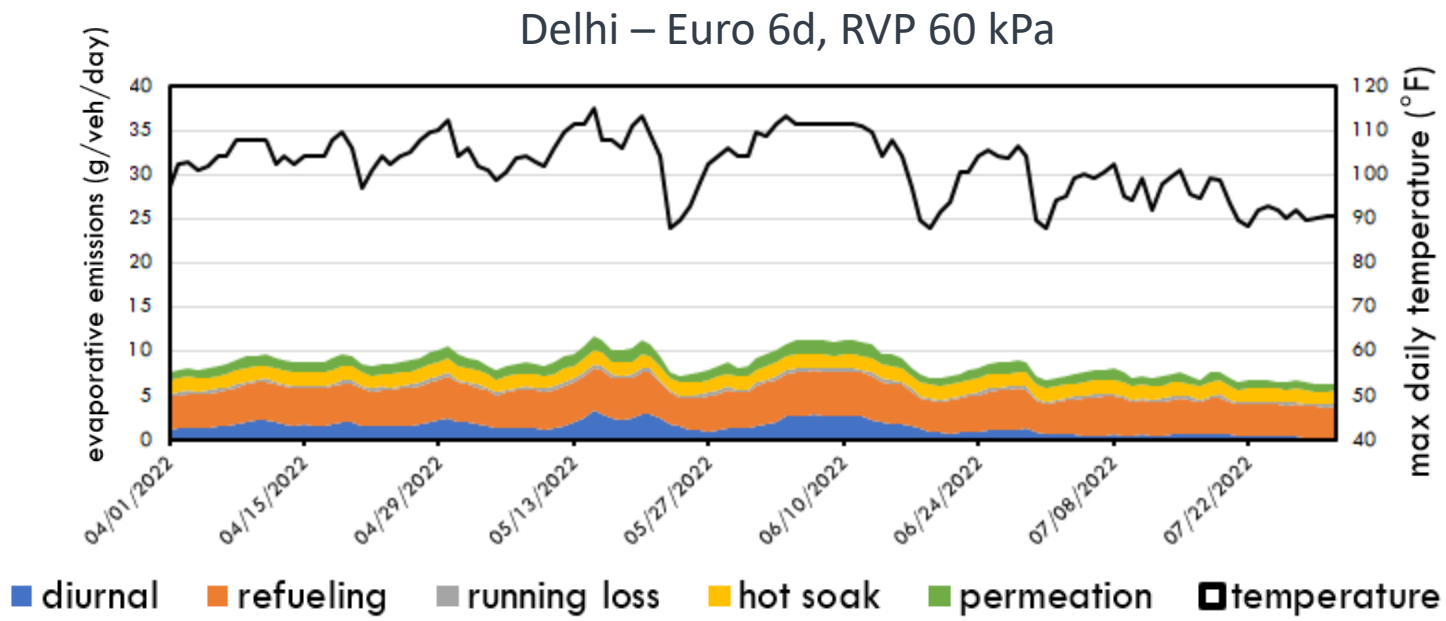
Daily Evaporative Emissions (grams per vehicle per day)



Adopting evaporative emission standards equivalent to **Euro 6d / UN GTR 19** would reduce the daily evaporative emission rate by **33%** from current levels.

During heatwaves, up to **10 grams** per vehicle per day of evaporative emissions would be emitted.

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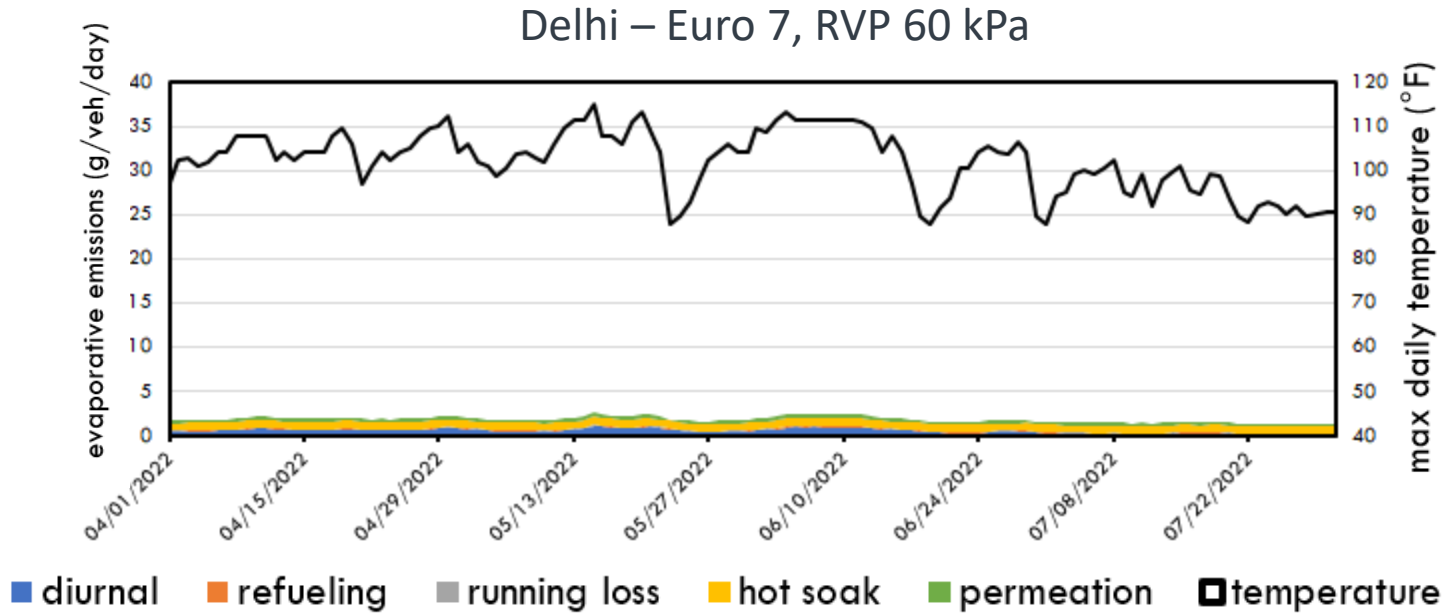
Daily Evaporative Emissions (grams per vehicle per day)



Adopting evaporative emissions standards equivalent to the E.U.'s proposed **Euro 7** would reduce the daily evaporative emission rate by **80%** compared to current levels.

During heatwaves, **< 2.5 grams** per vehicle per day of evaporative emissions would be emitted.

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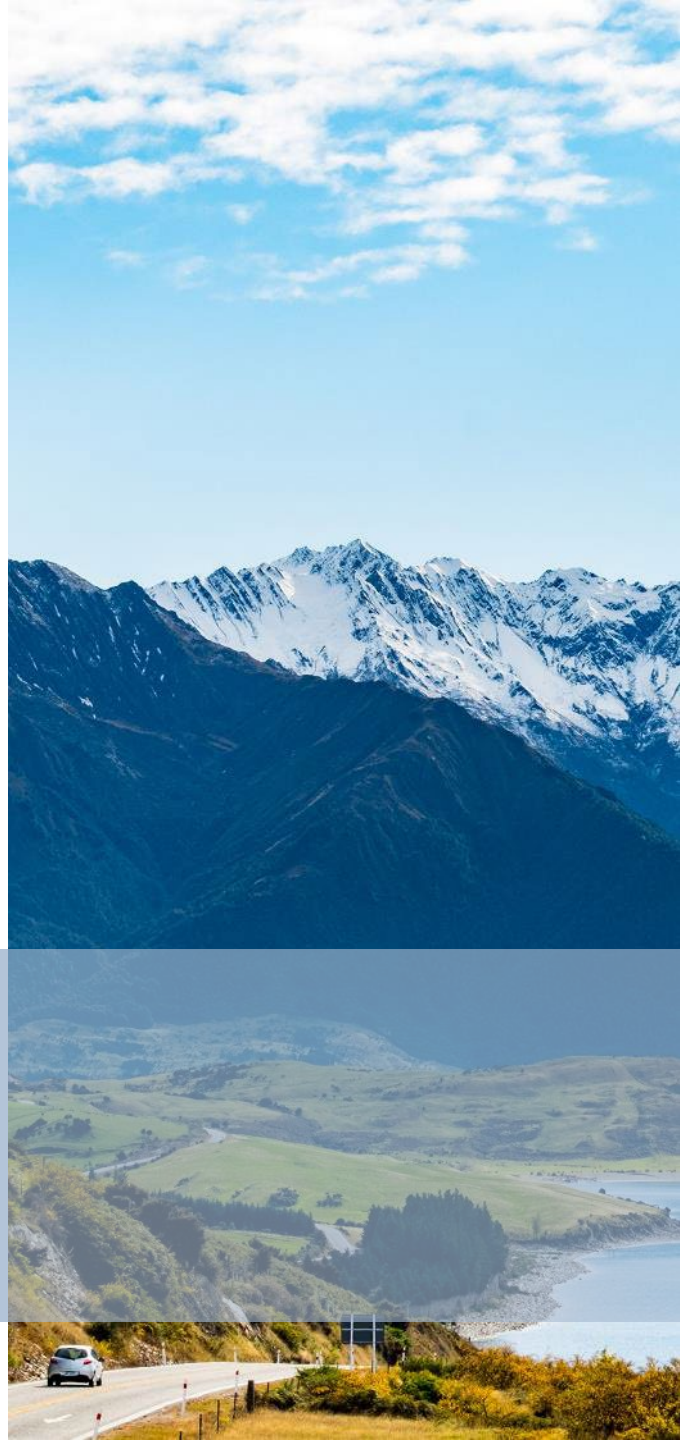
Conclusions

- Petrol internal combustion vehicles (including flex-fuel and hybrids) are a large and growing proportion of the Indian light-duty fleet.
- The stringency of Bharat VI evaporative emissions standards lags behind many other regions, including Europe, China, Brazil, United States and Canada.
- India is promoting a greater use of ethanol fuels and flex-fuel vehicles. It is important to understand the impact of higher ethanol blends on evaporative emissions and air quality, especially during higher temperatures.
  - Increasing the vapor pressure of the fuel from 60 to 70 kPa is estimated to increase the daily vehicle evaporative emissions rate by 38% during heatwaves.
- European evaporative emission standards are proposed to become more stringent with the adoption of Euro 7, which is expected to include refueling control and stricter diurnal emission limits.
- If India adopted the proposed Euro 7 equivalent standards, daily vehicle evaporative emission rates could be reduced by 80%, including during heatwaves when the emissions are highest.



Contact

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THANK YOU

Global Evaporative Standards		India	Europe	China	Brazil	United States & California
Latest Standard		Bharat III-VI	Euro 6d-TEMP-EVAP-ISC	China 6a/6b	PROCONVE L7	Tier 3/LEV III
Implementation Dates		2020	2019	2019-2020/2023	2022-2025	2017-2022
Diurnal + Hot Soak	24-hr SHED	2.0 g/test	-	-	-	-
	48-hr SHED	-	2.0 g/test	0.70 g/day	0.50 g/day	0.300 g/day
	48-hr Zero Evap	-	-	-	-	0.020 g/test
	72-hr SHED	-	-	-	-	0.300 g/day
Refueling	Stage II Recovery (controls on gasoline pump)	Future Limited (Delhi)	Phased-in	Phased-out	-	U.S. Phased-out; California Only (EVR)
	ORVR (controls on vehicle)	No	No	0.05 g/L	0.05 g/L	0.20 g/gal (0.05 g/L)
Running Loss		No	No	38°C drive cycle	No	0.05 g/mile
Sealed Tank Requirement		No	Puff Loss Test (0.5 g limit)	Design based requirement	Design based requirement	Design based requirement
In-Use Standard (In-Use Verification Program, In-Use Compliance Program)		In Service Conformity; 5 yrs, 100,000 km	In Service Conformity; 5 yrs, 100,000 km; Type 4 EVAP test is optional	In-use Surveillance ; Low, Medium and High Mileage	Full Useful Life Standard	In-use Verification, Low and High Mileage
Useful Life /Durability Requirement		160,000 km	160,000 km	160,000 km / 200,000 km	160,000 km	150,000 miles (242,000 km)
Certification Fuel Specifications		E10, 56-60 KPa	E10, 56-60 kPa	E0, 56-60 kPa	E22, 60-63 kPa; E100	E10, 62 kPa (US) 48 kPa (CA)
OBD Leak Monitoring		EOBD	EOBD	OBDII (Leak)	OBD BR3	OBDII (Leak) + Leak Standard
Drive Cycle		MIDC	NEDC/WLTP	WLTP	FTP	FTP

Impact of Ethanol on petrol vapor pressure

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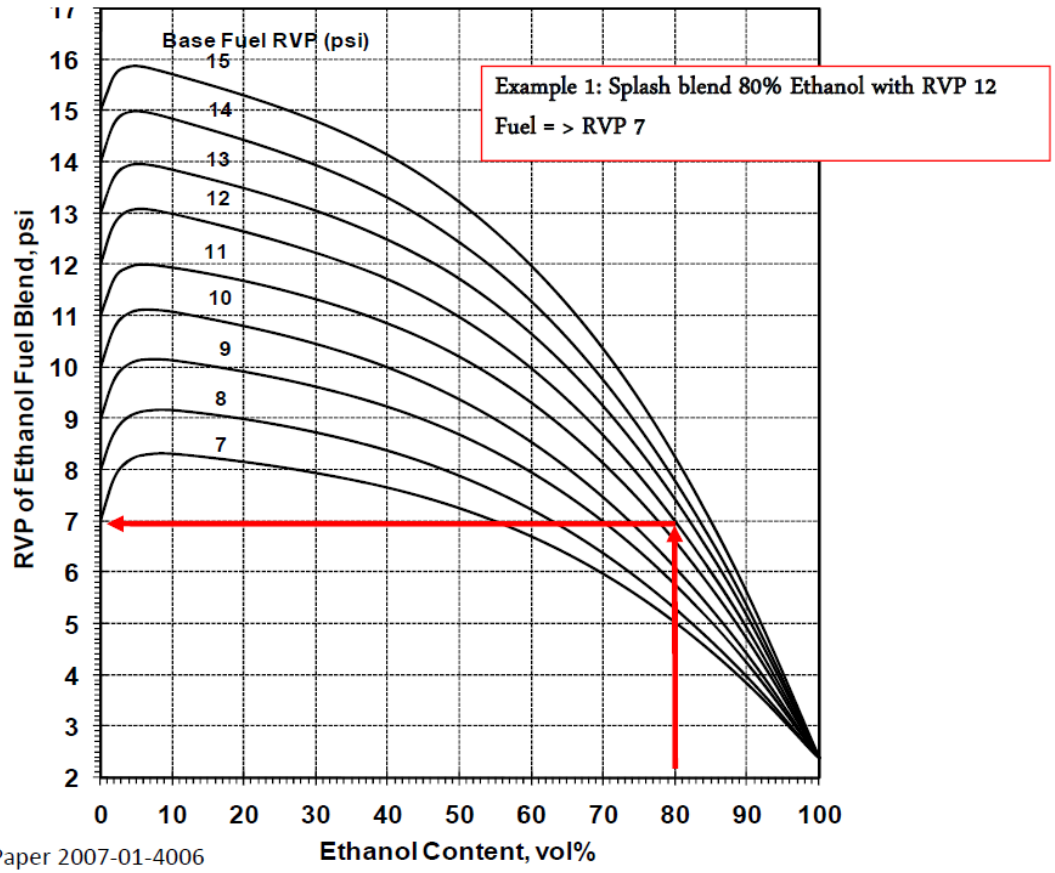
Nomograph for Estimating RVPs of Ethanol/Gasoline Blends



Reference: SAE Paper 2007-01-4006

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