Beyond the Tailpipe: Unpacking the True carbon footprint of passenger vehicles

Date: 26th August 2025
Time: 10–11.30 AM

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What is Life Cycle Assessment?

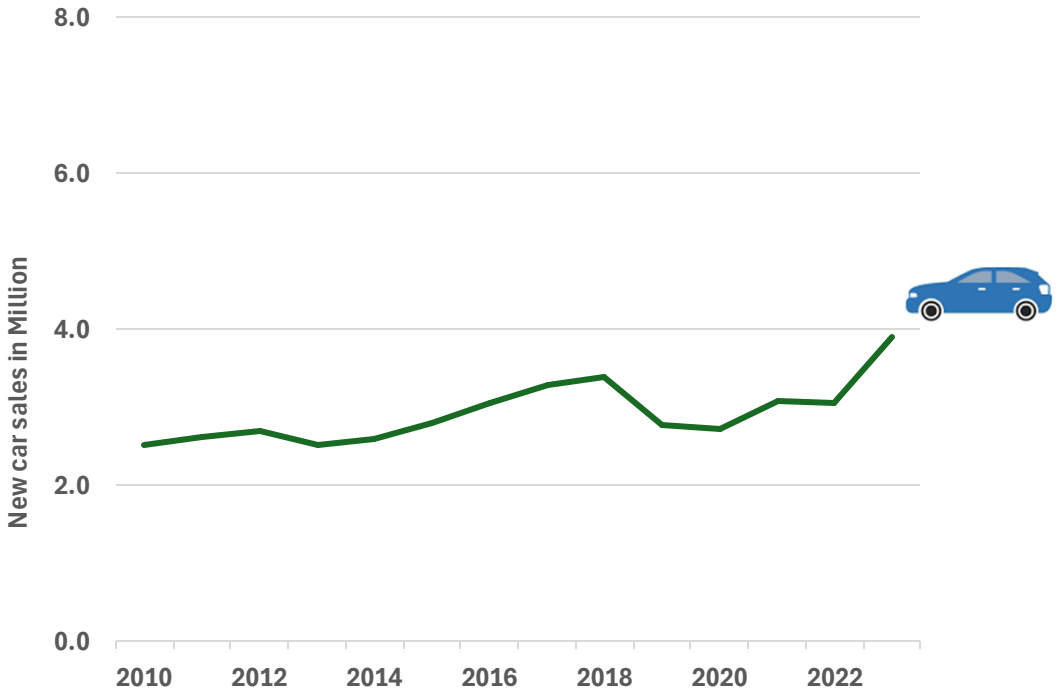
A life cycle assessment (LCA) estimates emissions over a vehicle's entire lifetime.

It includes

- **Fuel cycle:** Well-to-tank emissions from fuel and electricity production & tank-to-wheel emissions from consumption
- **Vehicle cycle:** emissions produced in manufacturing, operation, and maintenance.
- **End of a vehicle's useful life**, such as those from recycling and disposal

Why LCA of Passenger Vehicles is needed?

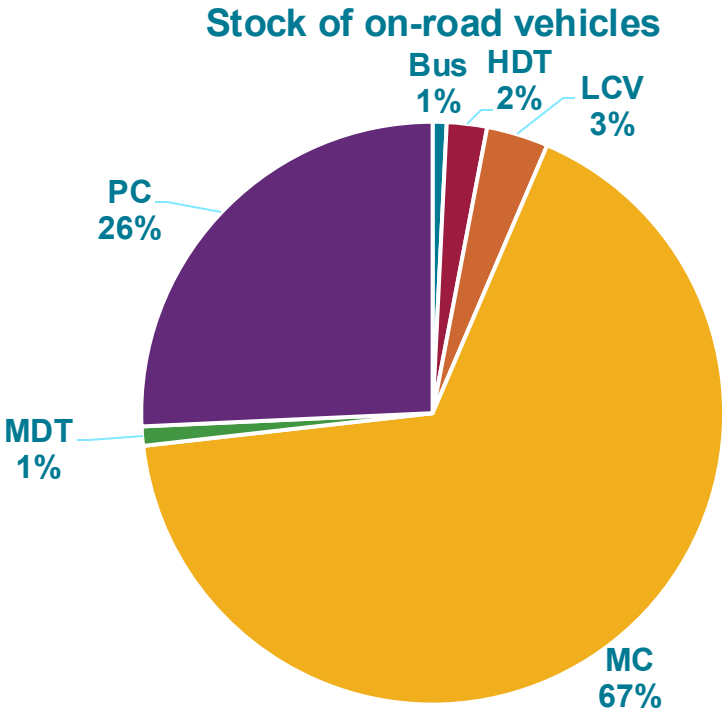
Passenger cars sales in India increased by a growth rate of 3.4% from 2010–2023

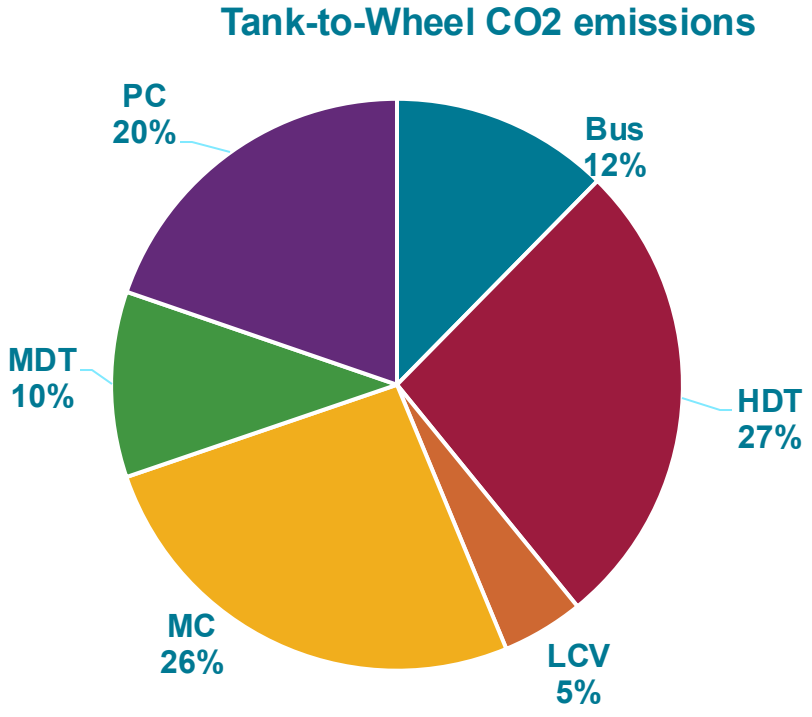


India’s passenger car market is one of the largest and fastest-growing globally

Source: SIAM

On-road status of Passenger cars in India for the year 2023





PC: Passenger Car, **MDT**: Medium Duty Truck, **MC**: Motorized Two- and Three-wheelers, **LCV**: Light Commercial vehicles, **HDT**: Heavy Duty Truck

LCA analysis of Passenger Cars: BEVs are cleanest powertrain option with stated policy outlook on electricity grid in India over their vehicle lifetime.

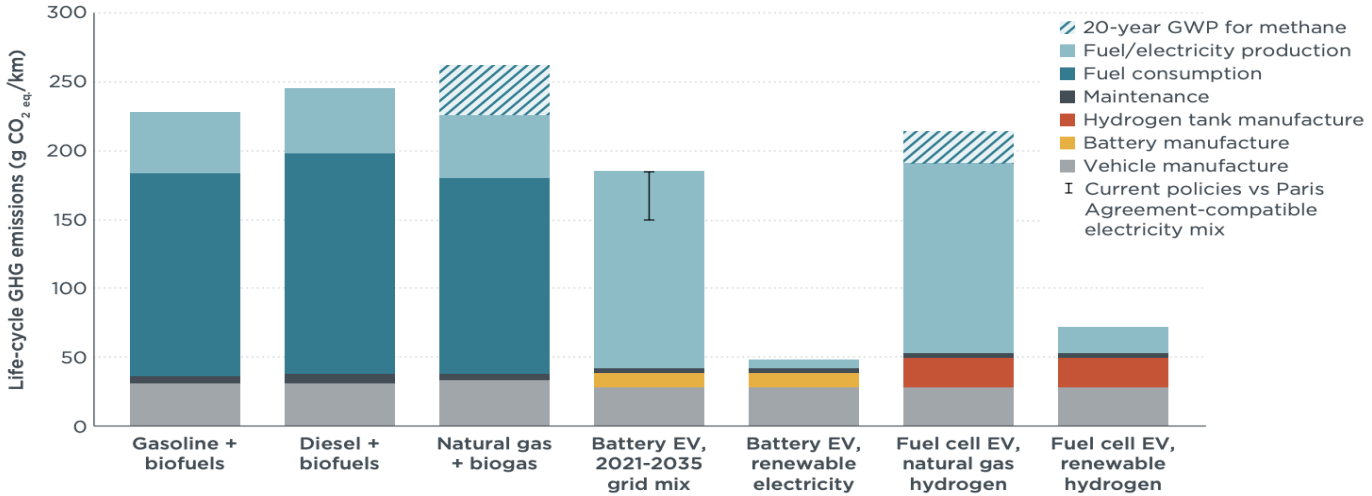


Figure 1. Life-cycle greenhouse gas (GHG) emissions of average new sedan segment gasoline, diesel, and compressed natural gas (CNG) cars, battery electric vehicles (BEVs) and fuel cell electric vehicles (FCEVs) registered in India in 2021. The error bars indicate the difference between the development of the electricity mix according to stated policies (the higher values) and what is required to align with the Paris Agreement. GWP = global warming potential.

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Source: Bieker, G. (2021) https:// theicct.org/publication/a-global-comparison-of-the-life-cycle-greenhouse-gas-emissions-of-combustion-engine-and-electric-passenger-cars/

What are the key variables in Passenger Cars LCA analysis?

JUNE 2025

Review of greenhouse gas life-cycle assessments of passenger cars in India

THE RESEARCH WAS CONDUCTED BY THE TEAM LED BY SUNITHA ANUP (ICCT) AND HEMANT K. SUMAN (IIT ROORKEE)

Comprehensive Review of Lifecycle Assessments

Passenger Cars in India - Joint Research Initiative between

ICCT and IIT Roorkee

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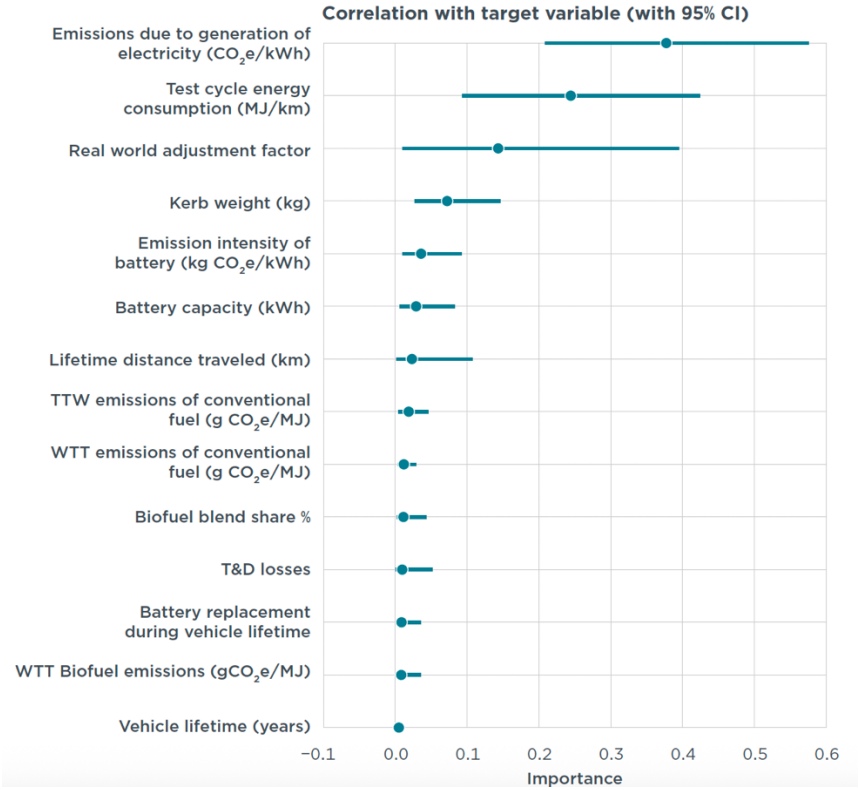
MAJOR STUDIES

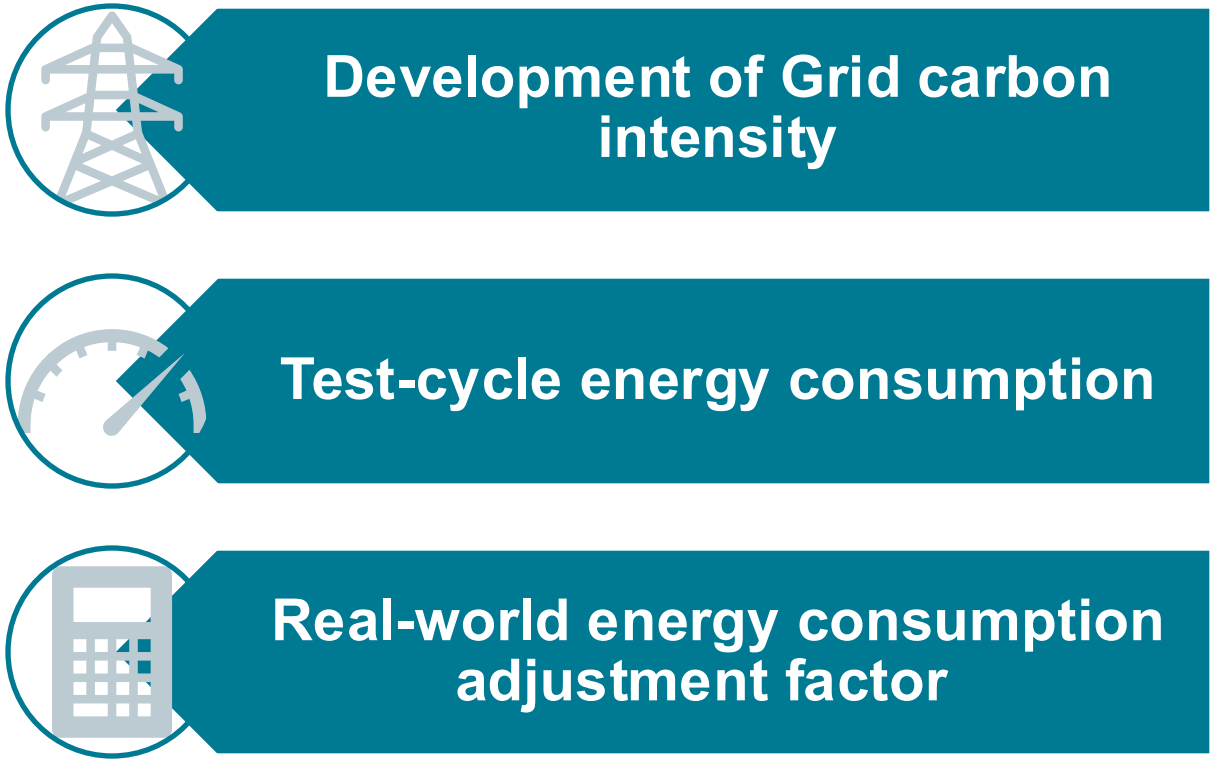
Summary of the six studies of Passenger car emissions considered in this analysis

Study	Description	Scope of GHG emissions considered for LCA
Electrifying passenger road transport in India requires near-term electricity grid decarbonization (Abdul-Manan et al., 2022)	Assessment of the impact of grid decarbonization on BEV emissions in India	Fuel and vehicle cycle
A global comparison of the life-cycle greenhouse gas emissions of combustion engine and electric passenger cars (Bieker, 2021)	Analysis of GHG emissions from BEVs and ICEVs globally, with a chapter on India	Fuel and vehicle cycle, indirect land-use change emissions from biofuel feedstocks, maintenance
Comparative life cycle GHG emission analysis of conventional and electric vehicles in India (Das, 2022)	India-specific study comparing ICEVs and BEVs	Fuel and vehicle cycle
LCA and TCO analyses of BEVs, HEVs, and ICEs (Agarwal, 2023)	India-specific comparison of the cost and emissions of BEVs, HEVs, and ICEVs	Fuel and vehicle cycle
Life-cycle assessment of passenger transport: an Indian case study (Gadepalli et al., 2023)	India-specific case study-based LCA on different transport modes	Fuel and vehicle cycle
Well-to-wheel analysis of energy efficiency & CO_2 emissions for hybrids & EVs in India: current trends & forecasting for 2030 (Nadola et al., 2023)	India-specific study on energy efficiency and CO_2 emissions	Fuel and vehicle cycle

Grid carbon intensity, lab test assumptions, and real-world driving conditions together drive nearly 75% of car emissions variability.



Understanding Variability in LCA Studies: Top 3 Assumptions Impacting Results



Key Findings of the Review of the 6 Major Studies

- **All studies point to an electric future:** BEVs offer the strongest emissions reduction potential when real-world performance and evolving grid mix are considered.

- **Act now:** BEVs are already cleaner with today's grid and will continue to get cleaner. Delaying BEV adoption locks in ICE emissions for years.

Discussion Points for the Round table

- **Bridging research & policy**: How can scientific evidence guide India's clean mobility policies and industry strategies?

- **Technology & efficiency debates**: What do LCAs reveal about ethanol blending, EV grid integration, and fuel efficiency trade-offs?

- **Pathways to net-zero**: How can innovations in energy systems, cooling, and alternate fuels accelerate India's transport decarbonization?

Thank you!

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