A Comparison Of The Life-cycle Greenhouse Gas Emissions From Combustion And Electric Heavy-duty Vehicles In India

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Background

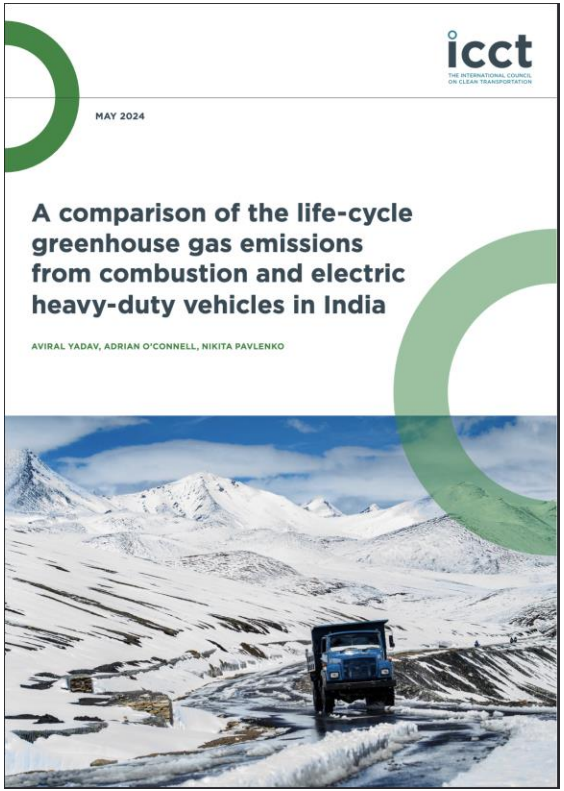
~4% share of HDVs in total on-road vehicular stock in India

>58% share of HDVs in total on road WTW CO_2 emissions

~2X% emissions from HDV by 2050

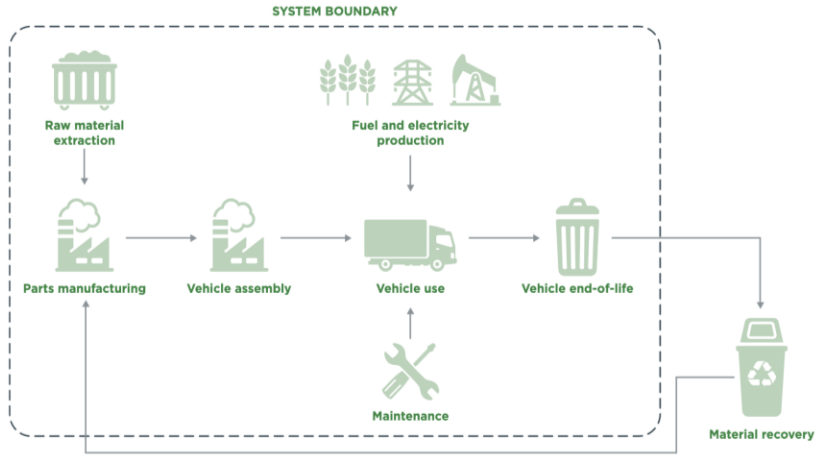
Source: ICCT's India emissions model and ICCT analysis on Segment Y data

- India's climate ambitions-
  - Emission intensity reduction by 45% by 2030
  - Energy Independence by 2047
  - Net-Zero by 2070
- To meet its decarbonization goals, India must reduce HDV emissions.
- Need for Zero Emissions Pathways: Diesel Powertrain will not suffice even with highest efficiency



Goal and Scope

- Life-cycle approach includes GHG emissions from vehicle production, maintenance, recycling, and fuel and electricity production and consumption
- Functional unit of gCO2e per kilometre travelled throughout a vehicle's lifetime
- Studied Segments covered 51% of total HDV sales in India in 2020-21
- Best-in-class HDVs in India in 2023 and 2030 are compared



Powertrains	12 Tonne Rigid Truck	16 Tonne Urban Bus	55 Tonne Tractor Trailer
Diesel	✅	✅	✅
CNG	✅	✅	
LNG			✅
Battery Electric	✅	✅	✅
Fuel Cell Electric	✅	✅	✅

Methodology and Assumptions: Vehicles

Upstream Manufacturing Emissions

- Emission factor specific to HDV manufacturing scaled by weight
- Scaled upwards by 6% for CNG and LNG vehicles
- Per-tank emission factor for fuel cell manufacturing
- Per-kWh basis for battery manufacturing emissions
- LFP Batteries, One battery replacement over life of vehicle covered.
- Second life of batteries and hydrogen component recycling not covered
- 20% decline in upstream manufacturing emissions in 2030 scenario for Batteries and fuel cells

Vehicle Use Phase Emissions

- Simulations used to determine fuel or energy consumption values
  - Virtual models created for diesel, validated by real world data
  - Modified to battery electric and fuel cell vehicles
  - Natural gas vehicle performance derived from diesel fuel consumption based on MOVES model
- 4% cumulative reduction in fuel consumption by 2030 for diesel and natural gas vehicles
- Advancements in technology lead to decrease in battery weight and capacity requirement for electric powertrains. 160 Wh/kg in 2023 to 234 Wh/kg in 2030
- 60% efficient fuel cell maintained for fuel cell powertrains

Methodology and Assumptions: Fuels

Fossil Fuels

- Includes fuel consumption during vehicle use and upstream emissions. Full WTW emissions.
- Natural gas emissions expressed as CO2e based on their global warming potential (GWP).
- Bio-Diesel share of 5% by 2030 and 10% by 2040

Electricity Grid

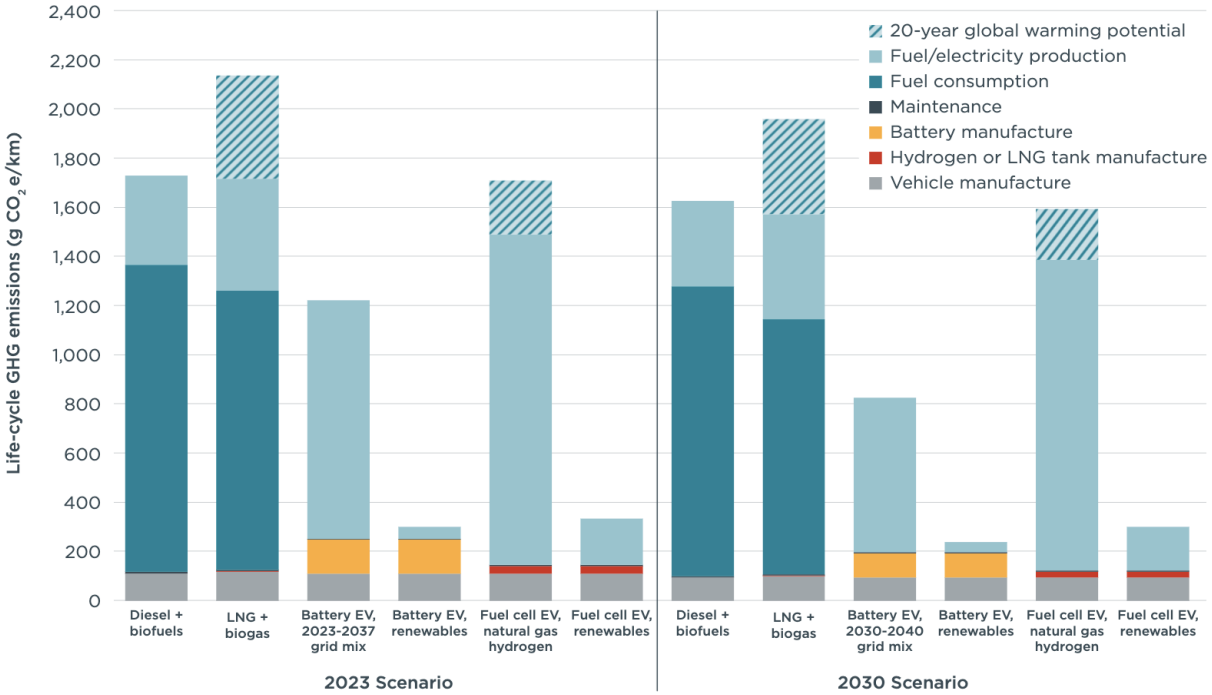
- Used IEA's STEPS and SDS scenario
- Assesses emissions of grid-average upstream GHG emissions of electricity per year of vehicle life
- T&D losses reduce from 19% currently to 10% by 2030

Renewable Energy and Green Hydrogen

- Renewable electricity is fully additional
- 2:1 ratio of solar to wind power.
- Life-cycle emissions attributable to renewable electricity sources
- Study the Grey and Green Hydrogen separately

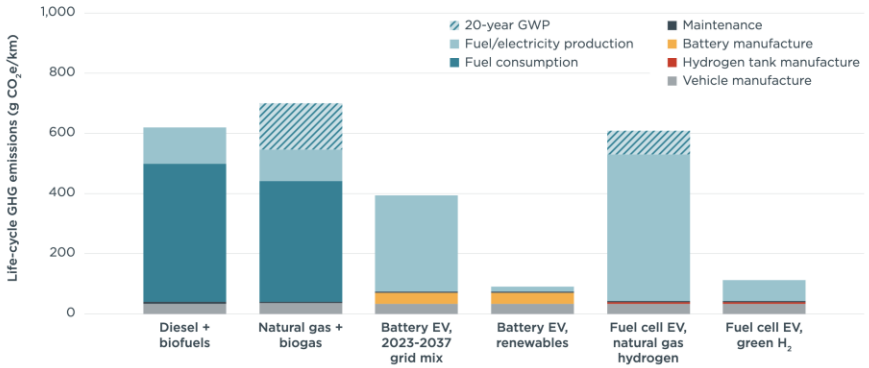
Results: Tractor-Trailer

Comparison of GHG emissions of 55-tonne tractor-trailers produced in 2023 and 2030, by powertrain and fuel type.

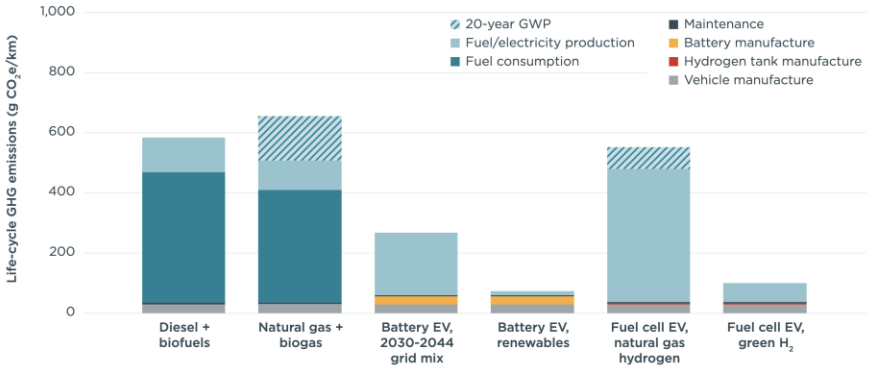


Results: Rigid Truck

Life-cycle emissions for a 12-tonne truck driven in India, 2023–2037.

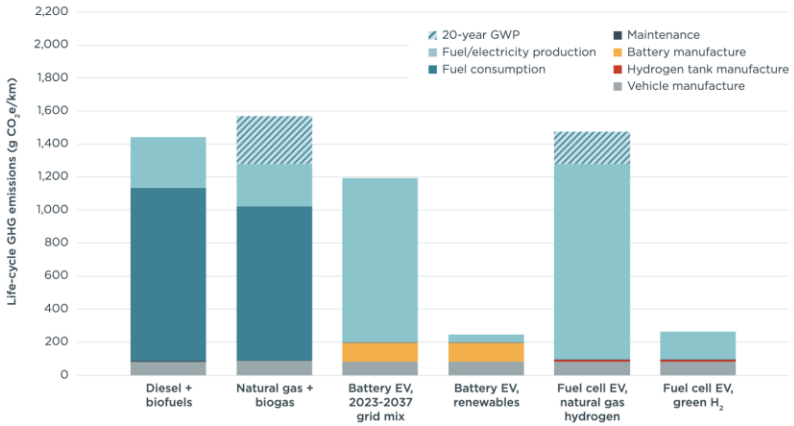


Life-cycle emissions for a 12-tonne truck driven in India, 2030–2044.

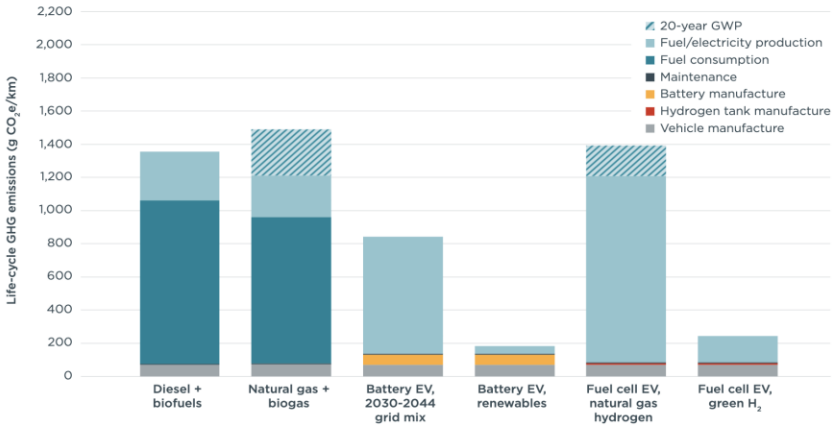


Results: Urban Bus

Life-cycle emissions for an urban bus driven in India, 2023–2034.

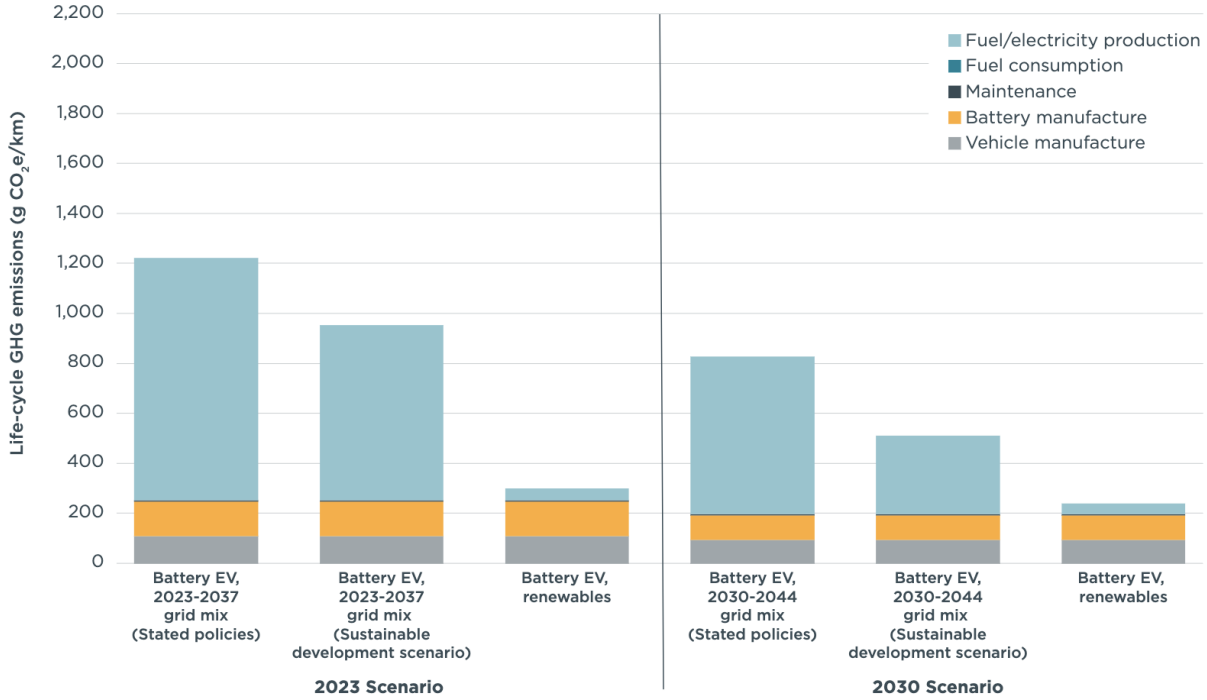


Life-cycle emissions for an urban bus driven in India, 2030–2041.



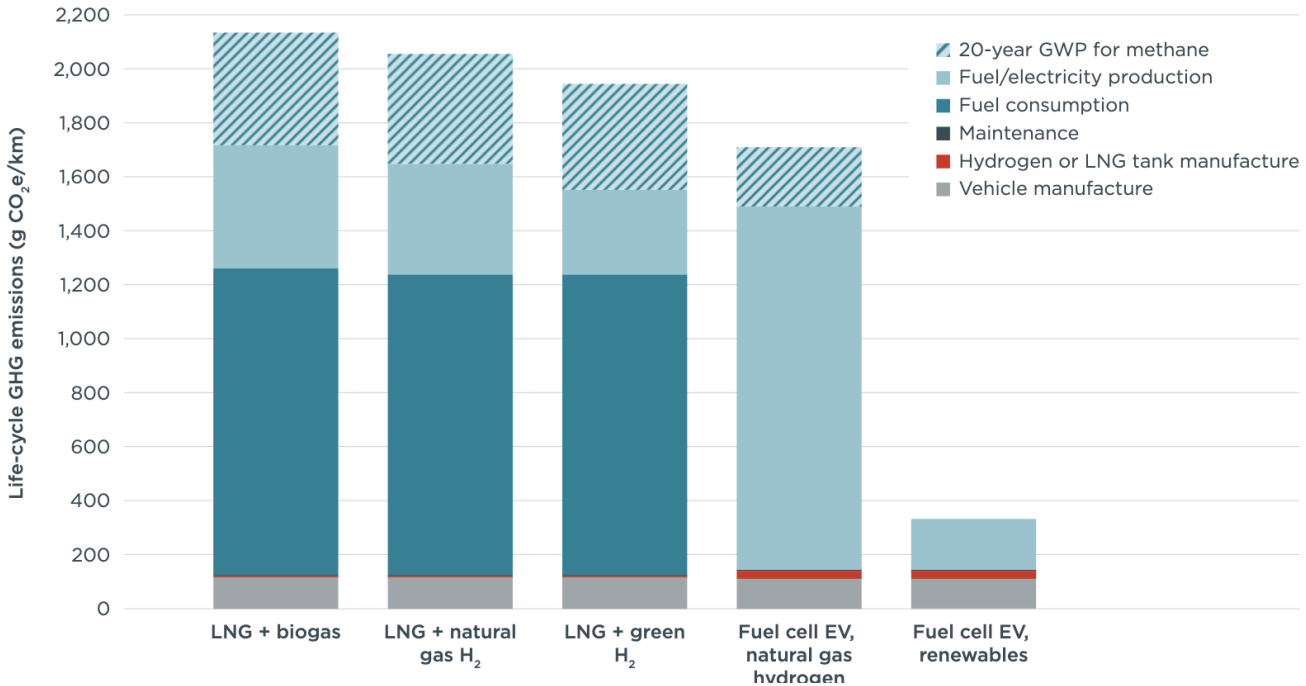
Results: Impact from Grid Decarbonization

Comparison of life-cycle GHG emissions of a 55-tonne tractor-trailer entering the fleet in India in 2023 vs. 2030, across different scenarios of electricity grid composition.



Results: H_2 Blending Impact

Comparison of life-cycle GHG emissions of a 55-tonne tractor-trailer produced in 2023 using grid mix LNG vs. natural gas hydrogen hythane blend (18%), green hydrogen hythane blend (18%), and fuel cell EV trucks.



Conclusions

- Battery electric HDVs produced in India today can provide the greatest GHG emission reductions of present-day vehicle technologies.
- The emission savings from Battery Electric HDVs will keep on growing as the grid gets decarbonized.
- Biofuel blending will have a limited impact on HDV emissions in India.
- At best, natural gas-fueled HDVs provide modest GHG savings compared to their diesel counterparts.
- Blending hydrogen into the natural gas grid will have a modest impact on the emissions of LNG trucks.
- The overall life-cycle impact of fuel cell HDVs varies considerably based on the source of hydrogen used.

Assessing the scale of zero-emission truck deployment required for meeting India's net-zero goal

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27th May, 2024

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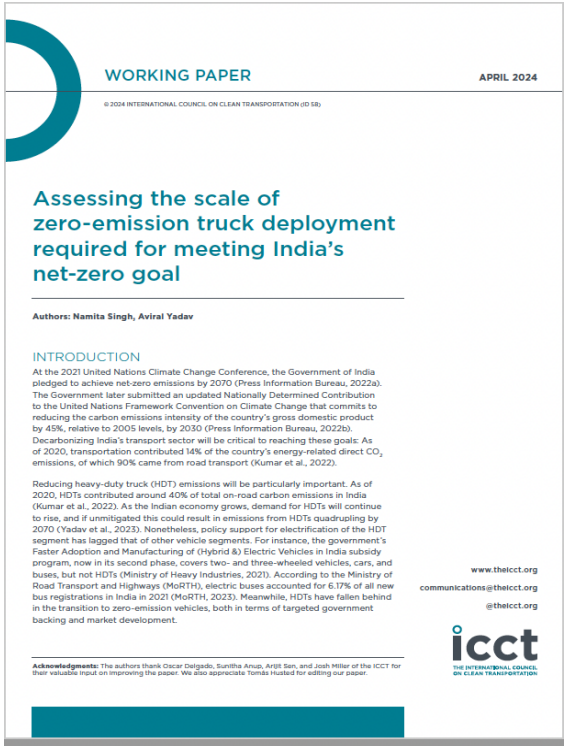
Assessing the scale of Zero-emission truck (ZET) penetration under different policy scenarios

- **ZETs** include Battery-electric trucks (**BETs**) and Fuel cell electric trucks (**FCETs**)
- Policy support for the **electrification of the HDT** segment has **lagged** compared to other segments.
- As India strives to achieve its **climate objectives**, it is important to have clear targets to ensure the pace of **ZET adoption aligns with its national goals**.
- The study evaluates the impacts of ZET penetration on total **fleet tank-to-wheel (TTW) and well-to-wheel (WTW) CO_2** emissions.



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Assessing the scale of zero-emission truck deployment required for meeting India's net-zero goal

Authors: Namita Singh, Aviral Yadav

INTRODUCTION

At the 2021 United Nations Climate Change Conference, the Government of India pledged to achieve net-zero emissions by 2070 (Press Information Bureau, 2022a). The Government later submitted an updated Nationally Determined Contribution to the United Nations Framework Convention on Climate Change that commits to reducing the carbon emissions intensity of the country's gross domestic product by 45%, relative to 2005 levels, by 2030 (Press Information Bureau, 2022b). Decarbonizing India's transport sector will be critical to reaching these goals: As of 2020, transportation contributed 14% of the country's energy-related direct CO_2 emissions, of which 90% came from road transport (Kumar et al., 2022).

Reducing heavy-duty truck (HDT) emissions will be particularly important. As of 2020, HDTs contributed around 40% of total on-road carbon emissions in India (Kumar et al., 2022). As the Indian economy grows, demand for HDTs will continue to rise, and if unmitigated this could result in emissions from HDTs quadrupling by 2070 (Yadav et al., 2023). Nonetheless, policy support for electrification of the HDT segment has lagged that of other vehicle segments. For instance, the government's Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles in India subsidy program, now in its second phase, covers two- and three-wheeled vehicles, cars, and buses, but not HDTs (Ministry of Heavy Industries, 2021). According to the Ministry of Road Transport and Highways (MoRTH), electric buses accounted for 6.17% of all new bus registrations in India in 2021 (MoRTH, 2023). Meanwhile, HDTs have fallen behind in the transition to zero-emission vehicles, both in terms of targeted government backing and market development.

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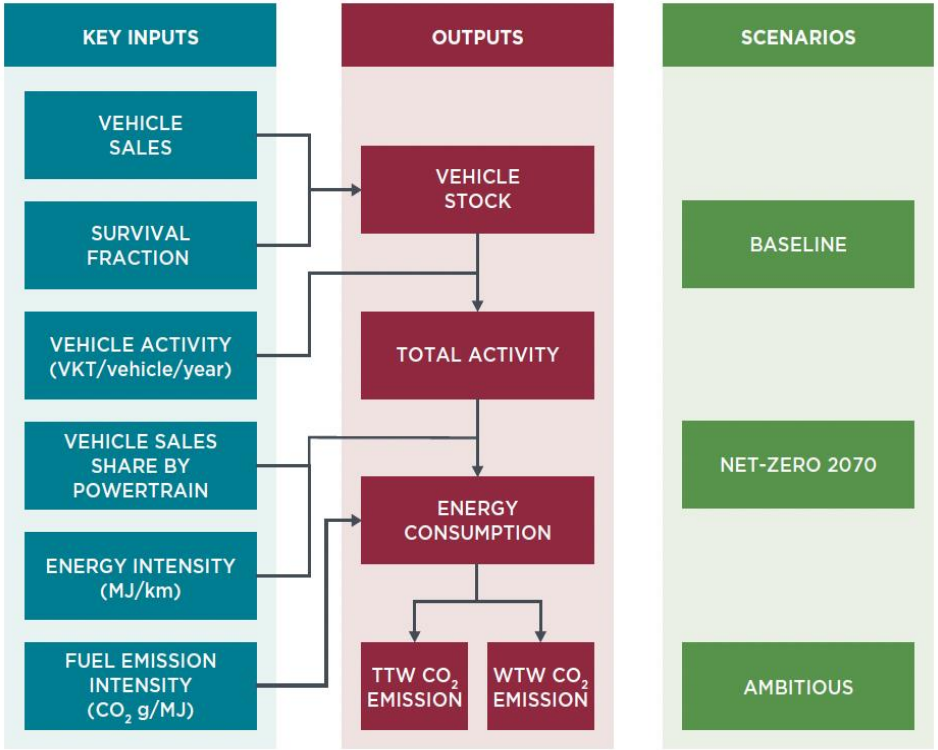
Methodology: Bottom-up approach based on Activity-structure-energy intensity-fuel carbon (ASIF) framework.



- ICCT's **Roadmap global transportation emissions model** covers all on-road vehicle segments.
- The plot shows **key inputs** and the paper details the assumptions behind each each input parameter used for the estimation.
- These inputs are combined to estimate **energy and emissions**.

Scenarios analyzed with different policy assumptions

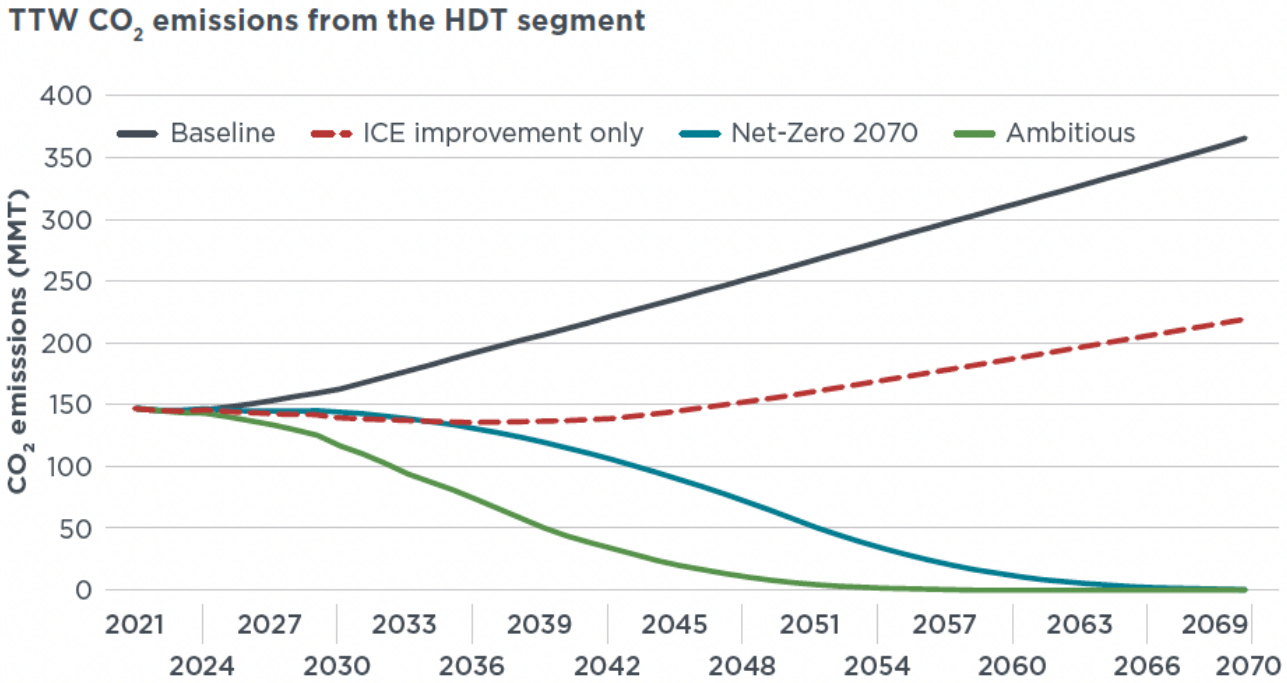
Scenario	Brief Description	Energy Intensity Improvement	ZET Penetration	Electricity Grid	Hydrogen	Additional Policy Assumptions
Baseline	Reference scenario, no new policies assumed after 2021	No improvement	**Zero**	**IEA State Policies Scenario** (STEPS)	**No FCETs**	
India 2070 Net-Zero	Focuses on ZET penetration required to meet India's 2070 Net-Zero target	**Ambitious EI** Improvement of ~40% in Diesel trucks	**100% ZET Sales by 2050**	**Ambitious decarbonized grid** (Kumar et al., 2022)	**Green Hydrogen**	**Scrappage** of vehicles causing residual emissions in 2070, all of which are at least 20 years old.
Ambitious	Most Aggressive decarbonization scenario	**Ambitious EI** Improvement of ~40% in Diesel trucks	**100% ZET Sales by 2045**	**Ambitious decarbonized grid** (Kumar et al., 2022)	**Green Hydrogen**	**Scrappage** of 15 years old diesel trucks and **avoid-and-shift** in VKT by improvements in freight logistics.

ZET sales in Baseline, India Net-Zero 2070, and Ambitious scenarios

	Baseline		India Net-Zero 2070		Ambitious	
Year	BET sales	FCET sales	BET sales	FCET sales	BET sales	FCET sales
2020	0%	0%	0%	0%	0%	0%
2025	0%	0%	0%	0%	2%	1%
2030	0%	0%	2%	1%	24%	6%
2035	0%	0%	20%	5%	48%	12%
2040	0%	0%	40%	10%	72%	18%
2045	0%	0%	60%	15%	80%	20%
2050	0%	0%	80%	20%	80%	20%
2055	0%	0%	80%	20%	80%	20%
2060	0%	0%	80%	20%	80%	20%
2065	0%	0%	80%	20%	80%	20%
2070	0%	0%	80%	20%	80%	20%

Note: Green cells represent 100% ZET sales share in the given years.

Results: Without policy interventions TTW carbon emissions rise to 2.5 times than 2021 levels in the Baseline scenario.

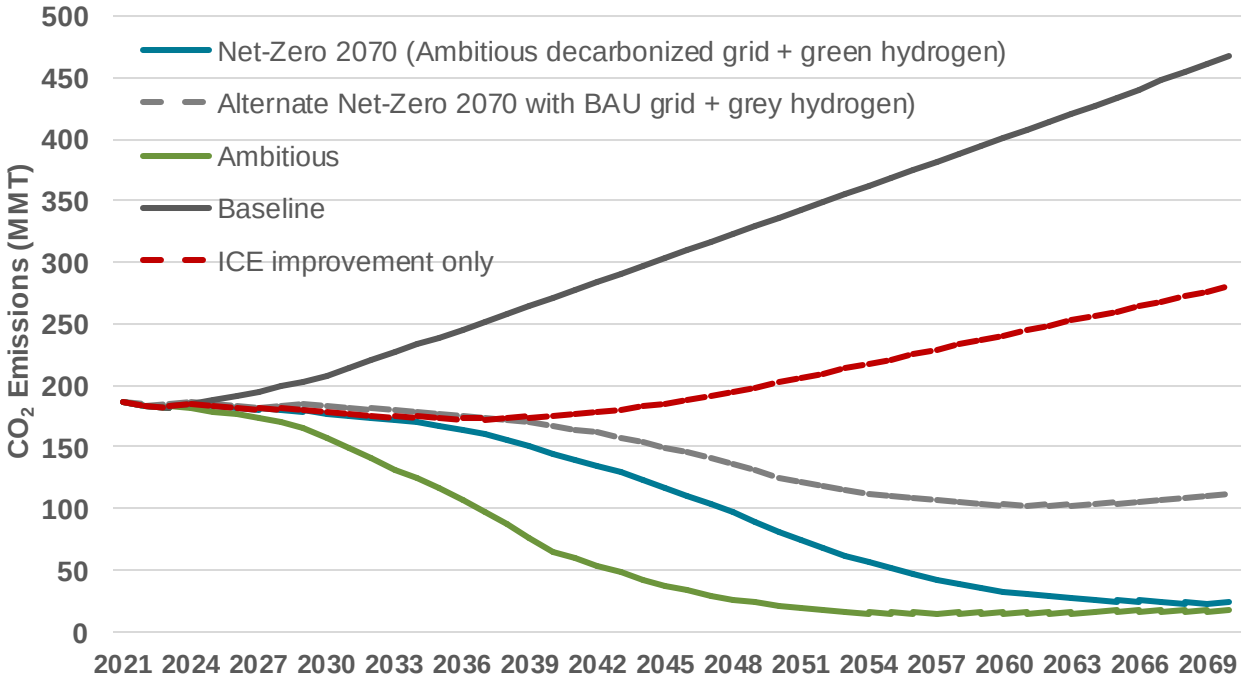


With different policies:

- **ICE efficiency improvement** of Diesel HDT: 40% reduction by 2070
- **Net-Zero 2070**: 100% reduction by 2070
- **Ambitious**: 100% reduction by 2060

Results: Decarbonized grid and green hydrogen lead to significant WTW carbon emissions reduction

Annual WTW CO_2 emissions by scenarios



- **ICE efficiency improvement** of Diesel HDT: 40% reduction by 2070
- Alternate scenario (ZET penetration without Decarbonized grid+ green hydrogen): 76% reduction by 2070
- **Net-Zero 2070**: 96% reduction by 2070
- **Ambitious**: 97% reduction by 2070

Results: ZET penetration with the clean grid in parallel with additional policies to achieve decarbonization in the long run

Cumulative WTW CO_2 Emissions	Net-Zero 2070		Ambitious	
Policies	ZET+ decarbonized grid	ZET+ decarbonized grid+ additional policies	ZET + decarbonized grid	ZET+ decarbonized grid + additional policies
2021-2030	- 0.1%	- 5%	- 1.7%	- 9%
2021-2050	- 20.7%	- 38%	- 38.4%	- 57%
2021- 2070	- 55.5%	- 66%	- 67.1%	- 77%

*Negative sign indicates the reduction in CO_2 emissions
*Additional policies include: ICE efficiency improvements and scrappage in **Net-Zero 2070** and ICE efficiency improvements, scrappage and Avoid-and-shift in VKT in an **Ambitious scenario**

Conclusions

- To align with the 2070 net-zero target, India would need to achieve **100% ZETs for new sales by no later than 2050**.
- To align with a **global pathway** to limit warming to well below 2 °C, ZET sales would need to be further accelerated to reach **30% by 2030 and 100% by 2045**.
- **Grid decarbonization** is vital in all scenarios to meet India's 2070 climate goal.
- The study underscores the critical importance of the pace of decarbonization through **ZET penetration**, **grid decarbonization**, and the implementation of other strategies, such as **efficiency improvements**, **vehicle scrappage and logistics optimization**, for attaining emissions-reduction objectives.

Please post your questions in the chat

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