

India's E-bus Initiatives: Job Creation, Adoption Challenges, and Policy Pathways

Authors: Anannya Jha, Divyanshu Yadav, Aditya Swarankar, Saoni Sanyal, Krishna Khanna, and Himani Jain

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Annexure 1 : Transportation Fuel Forecasting Model

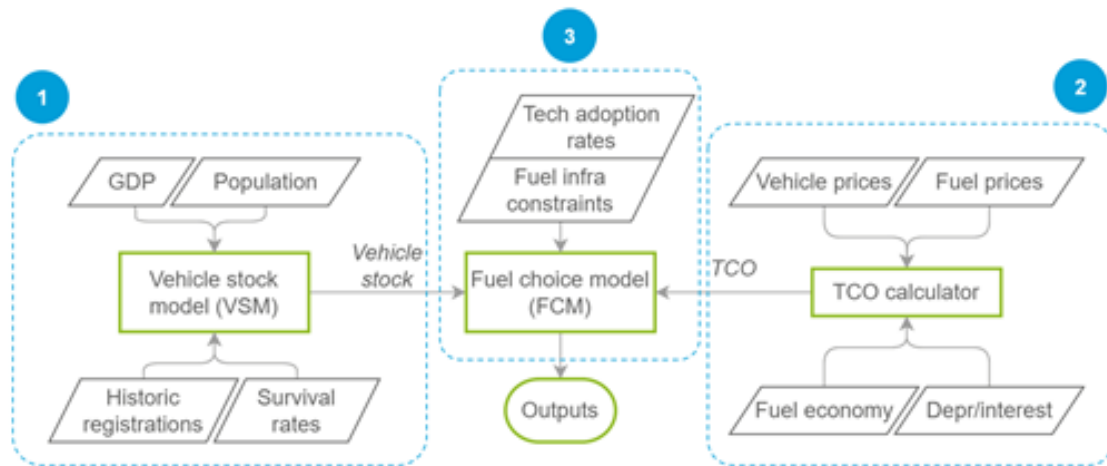
1. Methodology

The TFFM projects energy demand from 8 fuels and 10 vehicle segments at a district level by combining three components, as shown in the figure A1.

- **Vehicle stock model (VSM)**, for district-level projections of vehicle stock in the 10 vehicle segments till 2050 (Mohan et al. 2025).
- **Total cost of ownership (TCO) calculator**, for comparing the purchase and ownership cost for different fuel types available to each segment (43 different combinations of segment and fuel types evaluated) in each projection year till 2050 (Elango, Mohan, et al. 2025).
- **Fuel choice model (FCM)**, that divides the stock in each vehicle segment into different fuel types based on TCO data along with survey-based technology adoption rates (i.e., expected consumer willingness to adopt EVs and hydrogen vehicles) and refuelling infrastructure constraints (i.e., the number of new vehicles than can be supported by new CNG/LNG and H₂ refuelling and EV charging stations). The decision-making process employed by the FCM assigns fuel types to newly registered vehicles in each segment by following three steps:
 - **TCO:** Find the cheapest fuels for each projection year and district for a given vehicle segment in ascending order of cost.
 - **Adoption rate:** Check the adoption rate of the given fuel (if electric or hydrogen) in that year (based on anticipated consumer preference) for the cheapest fuel and allocate registrations to that fuel. We obtained anticipated consumer preferences only for EVs and hydrogen vehicles (as they are markedly different in design and operation) from a survey of transport sector experts from academia, think tanks, industry, and government.
 - **Infrastructural constraints:** Check the availability of refuelling infrastructure capacity for that fuel in that district and year and adjust registrations accordingly (except for petrol and diesel, for which infrastructure is widespread). We projected infrastructural growth for CNG, LNG, and EV charging stations based on past trends, regulatory authorisations, and assumed growth rates to account for infrastructure deployment lagging behind the adoption of, or the intent to adopt, newer fuel types.

The steps then repeat for the next cheapest fuel option, and so on, till all new registrations in that vehicle segment are allocated to the available fuel types.

Figure A1: The three components of the Transportation Fuel Forecasting Model



Source: CEEW

2. Key assumptions underlying the TFFM

- The primary assumption is that vehicle ownership grows in direct relation to the gross domestic product (GDP) per capita growth.
 - Vehicle ownership growth is estimated at the district level based on the gross district domestic product (GDDP) and district population growth using the Gompertz equation (the GDDP and the population are the parameters).
 - Population growth assumptions:
 - o A 2019 report from the Ministry of Health and Family Welfare (MoHFW) provides state-level population projections until 2036. It also provides expected urban vs rural population growth in each state. We used this data to prepare district-level population projections. For all years beyond 2036, we extrapolated the growth trends observed in the MoHFW data, such that the state-level population projections merged with the population-peaking estimations by CEEW.
 - GSDP and GDDP growth assumptions:
 - o We projected the gross state domestic product (GSDP) for different states based on the expected growth of the national GDP by 2047; we assumed that states with lower GDPs in the present year would grow faster than the national average growth rate as compared to states with higher GDPs.
 - o We collected all the available historical data and calculated the GDDP per capita in that year, using our district-level population estimates. We then calculated the ratio of GDDP per capita to GSDP per capita for that year; all future years' projections used this ratio multiplied by the projected GSDP and population to

partially account for mismatched base years (assuming that population is somewhat correlated to GDP).

- o For those states/UTs with no data, we only made state-level stock projections. These include the Andaman and Nicobar Islands, Jammu and Kashmir, Delhi, Goa, Sikkim, Nagaland, Tripura, and Meghalaya. Gujarat is the only exception, for which we assumed the GDDP per capita distribution to be similar to Tamil Nadu (as the latter has a similar GSDP).
- Gompertz function assumptions:
 - o We calibrated the Gompertz parameters for each district by minimising the sum of errors squared (known as the least squares method) with the historic growth in ownership levels.
 - o We calibrated the Gompertz curves (by changing the saturation level and speed of adjustment) at a state level using four sets of historical stock data: 2011–2019, 2011–2022, 2013–2019, and 2013–2022.
 - o We chose the 2013–2019 scenario as the projections more closely matched the actual data for more than 70 per cent of states and vehicle categories (i.e., the sum of the squared differences between actual vs calculated data was lowest, below 10 per cent). Using this scenario, we repeated the calibration process for each vehicle category in every district, allowing us to determine the saturation levels and speeds of adjustment based on the historical patterns and growth rates observed in each district.
 - o The shape parameters (α and β) cannot be directly estimated due to the solver’s recursive nature. We use the shape parameters of the curve (α and β) as estimated by previous CEEW studies.
 - o We assume that the public transport system will continue to expand at its historical growth rate. However, any increase or decrease in public transport availability can directly impact the overall vehicle stock.
- Since Telangana is missing from the Vahan portal, we applied the same ownership levels seen in Andhra Pradesh over the entire state of Telangana.

Table A1 - Assumptions considered in TFFM model : bus (9–12 m)

Fuel/Parameters	Average CAPEX (ex-showroom price, Delhi) ¹	Fuel economy ²	FE unit	Annual running (km) ³

Diesel		31,25,000	5.5	Km/l	74,250
CNG		35,15,625	6.5	Km/kg	
LNG		44,64,286	6.5	Km/kg	
Diesel hybrid		42,18,750	6.9	Km/l	
EV (Li-ion) ⁴	2024	91,68,946	1	Km/kWh	
	2030	97,61,811			
	2040	85,44,107			
	2050	75,07,655			
Hydrogen-ICE ⁴	2024	64,20,512	10	Km/kg	
	2030	43,37,006			

	2040	37,80,136		
Hydrogen-FCEV ⁴	2024	Not considered	16.6	Km/kg
	2035	1,41,50,210		
	2045	91,26,984		
	2050	71,42,857		

Remarks

¹Approximate prices reported by online platforms for a 12-m 40–50-seater bus.

¹EV subsidy of INR 25,00,000 is applied to 2024 and 2025, INR 12,50,000 to 2026, INR 6,25,000 to 2027 prices.

²Average fuel economy values reported by state transport corporations (for diesel), research papers (EV), or manufacturer claims (for H₂). In some cases, the fuel economy differences with respect to diesel buses have been considered based on values given in the [AFLEET tool](#).

³Assuming a daily distance of 225 km for 330 days per year (approximations based on state transport corporation data and news reports).

⁴Price decline for EVs based on battery cost (and proportionately, drivetrain cost) decline. For hydrogen vehicles, based only on assumptions.

Annexure 2 : Stakeholder details

Table A2: Details and contact info all different stakeholders from various case study

Case study	CTU/STU/Private company name	Website	Contact info
1	<p>Assam State Transport Undertaking (ASTC) ASTC, a state government owned road transport corporation of Assam, provides bus services within Assam and adjoining states. Currently ASTC manages 10 divisions, 135 bus stations and 3 Inter State Bus Terminals (Guwahati, Jorhat and Silchar) across the state.</p> <p>ASTC is responsible for operating and managing city bus services in the capital city Guwahati.</p>	https://astc.assam.gov.in/	astccontrol@gmail.com
2	<p>Surat Sitalink Ltd., a Special Purpose Vehicle (SPV), is formed by the Surat Municipal Corporation (SMC) as a fully-owned subsidiary company, to manage mass public transportation.</p>	https://www.suratsitalink.org/PlanYourTrip.aspx	+91-261-2300500
3	<p>Chartered Speed, one of India's largest bus operators, provides services across various states in India, including Gujarat, Maharashtra, Madhya Pradesh, Odisha, Rajasthan, and Assam. It operates across the B2B, B2C, and B2G segments. Chartered Speed offers a range of transport solutions, such as city buses, BRTS, school buses, staff buses, airport buses, taxis, and bike-sharing services. Established in 2010 with an initial fleet of 50 buses, the company has grown significantly and now manages a fleet of 2,200 buses.</p>	https://www.charteredbus.in/about-us.html	support@charteredbus.in , 9993288888
4			
5	<p>Kalyani Powertrain Ltd, a subsidiary of Bharat Forge DNA, has been driving the electrification of two-wheelers, buses, and trucks since 2021, focusing on commercial, environmental, and operational benefits. With a strong</p>	https://www.kalyanimotive.com/business3.html	Info@kalyanimotive.com 020-67042403

	emphasis on retrofitting ICE vehicles to transform them into EVs, the company is ambitiously targeting a significant global market share.		
7	NueGo is India's first inter-city e-bus service, operating in over 100 cities across the country. It was launched in 2022 by Greencell Mobility. NueGo aims to provide clean, quiet transportation for all. It aims to integrate and create powerful connected platforms/ecosystems across the products and services in the value chain, offering a robust e-mobility infrastructure in the B2G, B2C, and B2B domains.	https://www.nuego.in/about-us	support@nuego.in
8	Directorate of Urban Transport , under the Urban Development Department, Govt. of Uttar Pradesh is the nodal agency of 14 SPVs operating city bus services. It is responsible for planning, management and financing of bus based urban transport for the cities across the state. It is also manages the Dedicated Urban Transport Fund (DUTF) for the state.	https://uputd.gov.in/en	jdutdgoup@gmail.com
	Prayagraj Mela Authority is constituted for organizing Maha Kumbh Mela, Kumbh Mela and Magh Mela	-	dmail@nic.in
	Prayagraj City Transport Service Limited (PCTSL) is a public company operating in Prayagraj, Uttar Pradesh, India, providing city bus services. It operates under the JnNURM scheme of the Government of India and aims to provide public transportation to the city's commuters	https://uputd.gov.in/allahabadctsl	-