

# Electric Vehicle in India: Strategy to Enhance Penetration Level of E-trucks using Analytical Hierarchical Process

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## Abstract

Electric vehicles are the future of transportation emerged as the critical solutions to reducing greenhouse gas emissions and addressing the global warming challenges. In India while, the EV market has experienced significant growth. India compared to global market is limited in terms of EV while still lagging in terms of electric truck. This lagging can be popularly attributed to factors such as high upfront costs, limited maintenance and operation facilities, variance in govt. policies and subsidies, limited servicing facilities and safety concerns. The study uses an Analytical Hierarchical Process to identify and prioritize the criteria influencing the trucking community for purchasing decisions. For AHP 37.5 % response rate was obtained giving 60 responses among which 30 were truck driver cum owner of single truck and 30 were logistic firm owner. Few open-ended responses were also recorded during the survey which provides actionable insights for government and private stakeholders.

## Introduction

Developing Nation Like India with growing traffic, adoption of Electric Vehicle (EV) is crucially important for a sustainable development and emission controls. As third largest of the largest crude oil importer worldwide India's, EV promises a future with reduced carbon footprint and combat climate change. The transportation sector worldwide accounts for 24% of the CO<sub>2</sub> emission from fuel combustion. In addition to environmental impact switching to EVs helps in decreasing the country's reliance on oil imports and improvised energy scrutiny. Even from an economical perspective EVs offer economic ride compared to internal combustion (IC) vehicles. As India continues to urbanize, EVs are poised to transform energy sector, development of cleaner energy generation and more sustainable future.

Government and private sector both are focused on development of EVs in India. While several new industries launched EVs into the market, the government focused on subsidizing the EVs. The heavy industry ministry under government of India introduced FAME scheme to subsidize EVs to promote the users to shift from IC vehicles to EVs. Fitness and Mobility Exercise Program (FAME) scheme was executed in India in two phases by ministry of heavy industries.

Globally India stands at less than 1% of total EV sales worldwide in the calendar year 2023 Figure 1. Despite government subsidies the share of EV sales in India is relatively low however, EVs efficiencies, changes in infrastructures and battery cost and PowerGrid technologies shows promising growth in Indian EV market. Inclusion of latest technologies and policy adoption are particularly relevant in India for growth of EVs in India.

Currently only four major variety of vehicle class EV are available in India those are E-bike, E-three-wheeler, E-cars and E-bus. A major sector is of transportation is truck traffic in which India is still lacking in EV sector. Truck being an important and integral part of road freight transport dedicated truck related research are being carried out (Sahoo et. al., 2025; Sahoo et. al., Sahoo et. al., 2022). A perception survey is carried out from truck driver's single vehicle ownership and logistics agency owners about their preference of selecting a truck type based on multiple

criteria. An analytical hierarchy process is conducted for better understanding of truck drivers' preferences and open ended responses were collected for obtaining the more preference towards shifting to EV.

## Literature review

The development of EV in India is in growing nature (Singh et. al., 2021). Multiple modes of EV running in India two-wheeler shares highest shares of EV in India (Saxena et. al., 2014), while truck mode still lacks in the sector (JMK research analytics, 2024). The Ev penetration level (Kumar et. al., 2015), and strategies on EV (Das & Bhatt, 2022; Sharmili, 2021). The total ownership between diesel and electric trucks compared (Madichetty, et al., 2022), predicted about 2030 more battery operated trucks than IC engine trucks and zero emission achieved in 2070. While charging facility plays a key role in EV development its location is optimized by various methods like AHP (Guler & Yomralioglu, 2020). The government is putting effort by locating of charging station on highways which is extremely essential (Szumska, 2023), for truck modes presence of charging station on National Highways are important. Despite government efforts India still lacking in EVs sector analyzed (P. Goel., 2021).

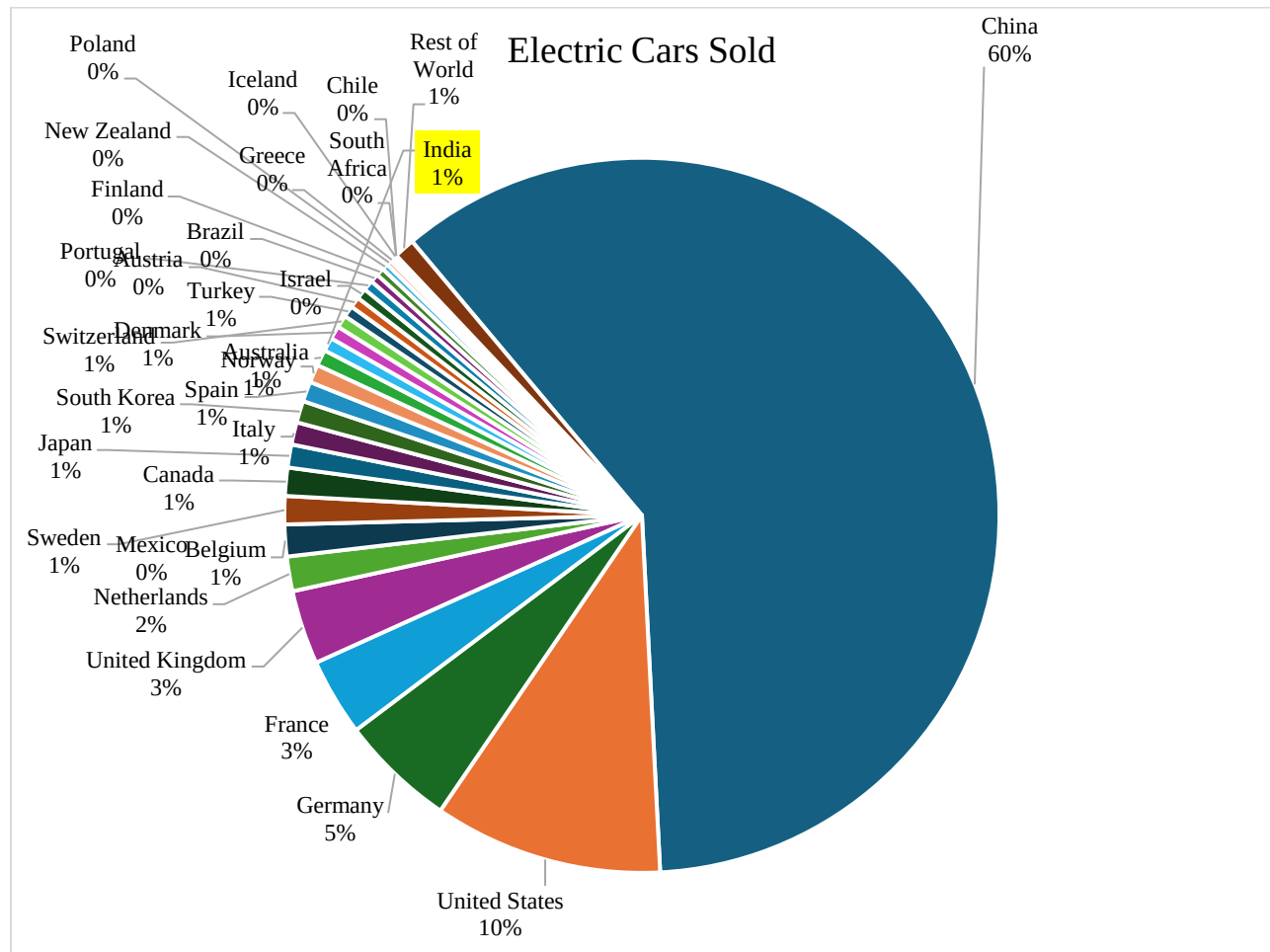


Figure 1: Worldwide share of EV sales in calendar year 2023.

## Methodology

Analytical hierarchical process (AHP) is a decision-making tool to find the weight of criteria for selection of a reaching a goal between different alternatives. The responses for selecting a specific type of truck based on fuel type is selected

based on up-front cost (UPC), operation cum maintenance cost (OMC), safety (S), government policies cum subsidies (GPS) and servicing quality (SQ). The respondents were truck driver's single vehicle ownership and logistics agency owners, the responses were collected from question survey by personal interview. Further AHP was conducted using the following steps.

**Step 1:** Evaluation of priority vector preferences indicated by users.

**Step 2:** Comparison matrix by using pairwise responses from questionnaires Eq (1).

$$A_i = \begin{bmatrix} \frac{C_{i1}}{C_{i1}} & \frac{C_{i1}}{C_{i2}} & \frac{C_{i1}}{C_{i3}} & \frac{C_{i1}}{C_{i4}} & \frac{C_{i1}}{C_{i5}} \\ \frac{C_{i2}}{C_{i1}} & \frac{C_{i2}}{C_{i2}} & \frac{C_{i2}}{C_{i3}} & \frac{C_{i2}}{C_{i4}} & \frac{C_{i2}}{C_{i5}} \\ \frac{C_{i3}}{C_{i1}} & \frac{C_{i3}}{C_{i2}} & \frac{C_{i3}}{C_{i3}} & \frac{C_{i3}}{C_{i4}} & \frac{C_{i3}}{C_{i5}} \\ \frac{C_{i4}}{C_{i1}} & \frac{C_{i4}}{C_{i2}} & \frac{C_{i4}}{C_{i3}} & \frac{C_{i4}}{C_{i4}} & \frac{C_{i4}}{C_{i5}} \\ \frac{C_{i5}}{C_{i1}} & \frac{C_{i5}}{C_{i2}} & \frac{C_{i5}}{C_{i3}} & \frac{C_{i5}}{C_{i4}} & \frac{C_{i5}}{C_{i5}} \end{bmatrix} \quad (1)$$

Where  $C_{12}/C_{ij}$ = score of  $C_{12}$  over  $C_{ij}$

**Step 3:** Eigenvector  $[X_{ik}]$  for each criterion.

**Step 4:** Normalized matrix computation. And Consistence Index and Consistence Ratio estimation.

**Step 5:** Global priority matrix computation.

## Data collection

Data is collected from different publicly available online sources to represent the trend and growth of EVs in India and globally. Some of the important sources are –

- 1> IEA (2024), Global EV Outlook 2024
- 2> Vahan.parivahan.gov.in
- 3> data.gov.in

Further a questionnaire survey was carried out for from total of 60 participants truck driver's single vehicle ownership and logistics agency owners comprising of demographic data, pairwise comparison and an open ended suggestion box for further improvement.

## EV trends

### Current and future trends

India has fourth largest automobile industry in the world. With a compounded annual growth of more than 7% exclusive of two-wheelers. With about 25 million units of vehicles produced per year India showed less trend for EVs. This is due to short term and unclear policies of government for EVs. Successful countries in EV sector like China has provided significant subsidies and incentives to promote EVs. The important infrastructure associated with EVs are public charging stations that are closely related with the GDP of the state are presented in Figure 2.

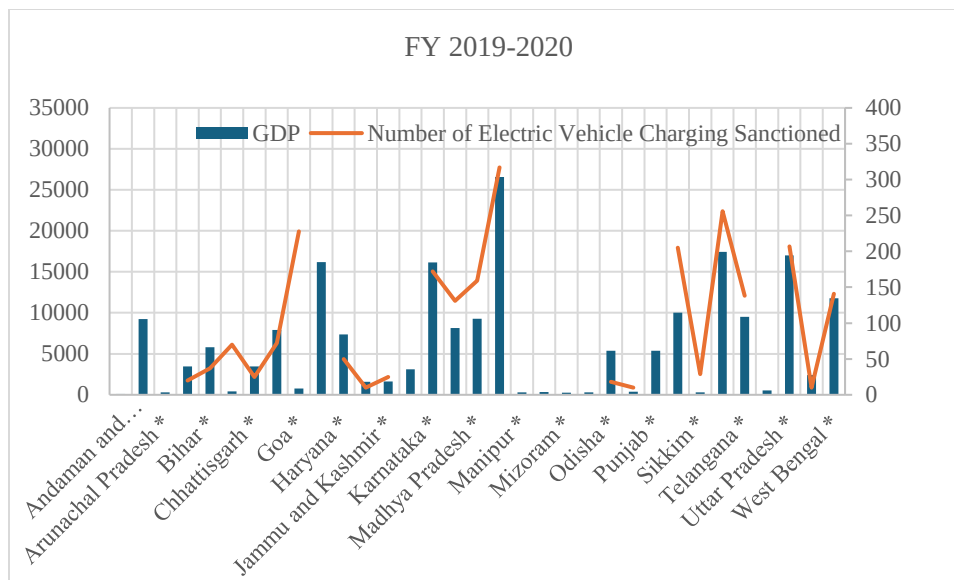


Figure 2: GDP and number of EV charging stations of different states.

While only few states and union territory focusses on having public charging stations on NH from the total number of charging station in the corresponding states. It is an important feature for a truck to have a charging station on NH since, moment of trucks are mostly redistricted in urban areas. A comparison of total number of charging station to the number of available charging station on NH is presented in Figure 3.

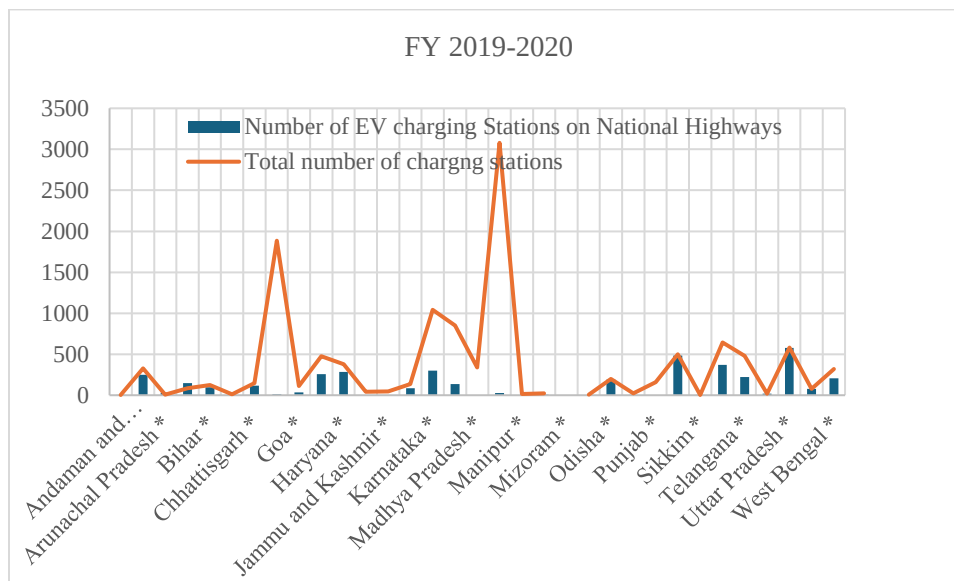


Figure 3: number of EV charging stations on NH and number of EV charging stations of different states

## FAME scheme

Government of India launched National Electric mobility mission Plan which subsequently led to FAME-I and FAME-II schemes under which subsidies were provided to EVs. The schemes were initially planned for two years each with the subsidy amount varied over time. For example, FAME-II scheme initially subsidized ₹ 10,000 per kilowatt-hour

which later increased to ₹ 15,000 per kilowatt-hour with capped 40% of vehicle cost. Different, subsidies for different modes of transportation 15% for two-wheeler ex-factory price and 20% for three-wheeler and four-wheeler ex-factory price. Some details of FAME scheme are shown in Table 1.

Table 1: Specification of FAME scheme

| Scheme name    | Duration                                                  | Extension                                  | Initial budget (in crore ₹) | Extended budget (in crore ₹) |
|----------------|-----------------------------------------------------------|--------------------------------------------|-----------------------------|------------------------------|
| FAME-I scheme  | 1 <sup>st</sup> April 2015 to 31 <sup>st</sup> March 2019 | 2 years extended from initial planned date | 795                         | 100                          |
| FAME-II scheme | 1 <sup>st</sup> April 2019 to 31 <sup>st</sup> July 2024  | 2 years 5 month extended                   | 10000                       | 1500                         |

## Mode wise growth

EVs sales in India has shown significant growth, while the major sector of the EVs is limited to the two-wheelers while Table 2. There are few dedicated two-wheeler studies in heterogenous traffic which suggest the ease of driving (Biswal et. al., 2022) and other reasons related two-wheeler growth in India. It is significant that truck mode shows very little sales compared to other modes. There are many private companies dedicatedly producing heavy duty electric trucks like Omega and Olectra. In order to understand the lacking of the EVs sales in truck mode AHP is conducted.

Table 2: EV sales and share of different modes

| EV Sales in India since FY2014 |           | EV Sales split in FY 2024 |          |
|--------------------------------|-----------|---------------------------|----------|
| Fiscal Year                    | EVs sold  | Segment                   | Units    |
| 2014                           | 2,627     | Two-wheeler               | 9,44,082 |
| 2015                           | 2,340     | Three-wheeler             | 6,32,485 |
| 2016                           | 16,182    | Four-wheeler              | 90,379   |
| 2017                           | 55,864    | Buses                     | 3,693    |
| 2018                           | 96,507    | Heavy duty trucks         | 240      |
| 2019                           | 1,46,970  | Light duty trucks         | 4,699    |
| 2020                           | 1,73,611  | Other                     | 122      |
| 2021                           | 1,42,409  | ---                       | ---      |
| 2022                           | 4,59,293  | ---                       | ---      |
| 2023                           | 11,83,418 | ---                       | ---      |
| 2024                           | 16,75,800 | ---                       | ---      |

## Result and Discussion

Three alternatives were provided during the survey as fossil fuel-based trucks, Electric Trucks and hydrogen powered trucks. The pair wise comparison matrix is present in Table 3. Similarly, all the data were sorted for two groups both truck driver single ownerships and logistic firm owners for all five criteria's those are UPC, OMC, S, GPS, SQ.

Table 3: Pairwise comparison for UPC from truck driver's single ownerships

|                | E-truck | Hydrogen truck | IC truck |
|----------------|---------|----------------|----------|
| E-truck        | 1       | 6.234          | 4.961    |
| Hydrogen truck | 0.160   | 1              | 1.567    |
| IC truck       | 0.201   | 0.638          | 1        |

The validation of the rating obtained is verified by using Consistency Index (CI) and Consistency ratio (CR). The random Index for 5 criteria is 1.12 used for estimating the CI and CR which is presented in Table 4. All the ratios were found to be satisfactory CI and CR.

Table 4: CI and CR of AHP conducted

| Criteria | $\lambda_{\max}$ | $CI = \frac{\lambda_{\max} - n}{n - 1}$ | $CR = \frac{CI}{RC}$ |
|----------|------------------|-----------------------------------------|----------------------|
| UPC      | 5.0013           | 0.00032                                 | 0.029                |
| OMC      | 5.0024           | 0.00062                                 | 0.055                |
| S        | 5.0045           | 0.00127                                 | 0.100                |
| GPS      | 5.0031           | 0.00077                                 | 0.065                |
| SQ       | 5.0038           | 0.00095                                 | 0.084                |

The final composite score for each criterion will be the matrix multiplication of the normalized matrix and the priority vector as shown in Eq. (2).

$$[Norm.] \times [Priority\ vector] = [composite\ score] \quad (2)$$

## Conclusions

EVs sector is showing growth rapidly in India and the growth is expected to continue. However, there are certain lacks in the trucking industry in the case of the EVs. Current research shows that trucking industry preference towards EV can be modified by making important changes in the SQ, GPS, OMC, UPC and S in decreasing order. Further the AHP shows that while single truck owners are more concerned about UPC logistic firm owners are less concerned over UPC but more concerned on OMC. While the open-ended repores showed multiple additional criteria which need further development. For instance, the regional policies and subsidies changes over different states like UP green hydrogen policy which not only subsidies on capital and fuel but also rebates interstate taxes also. Another important conclusion is single owner truck drivers are ready to invest on higher up front cost for newer trucks if when the truck is older than eight or more years when they are facing difficulty in approval of fitness certificate. The most important criteria found in AHP analysis indicates that servicing facility such as charging stations on NH and local availability of vehicle maintenance services is the most important factor of a decision of choosing a specific type truck. The research output will be helpful to both the policy makers and private companies involved in making strategic decisions for improving scopes of electric vehicles in truck domain.

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