Comparative Study of Normal Vehicles and Electric Vehicles Using Regression Model

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Abstract — The automobile industry faces two significant challenges that hinder its development: environmental pollution and energy storage. To address these issues, Hybrid Electrical Vehicles (HEVs) have been developed to achieve energy savings and emission reductions. Unlike conventional vehicles that rely solely on internal combustion engines (ICE), HEVs use two motors and ICE to improve the efficiency of the power train, which is essential for enhancing fuel economy. HEVs offer four modes of operation, including Electric Vehicle (EV) mode, Range Extending (RE) mode, Hybrid mode, and Engine mode. However, despite continuous development in HEVs, their short range, long recharging time, and high cost still act as barriers to their widespread adoption. The interest in HEVs has resulted in the development of new designs, including Series Hybrid Electrical Vehicles, Parallel Hybrid Electrical Vehicles, Battery Electrical Vehicles, Plug-in Hybrid Electrical Vehicles, and Range Extending Hybrid Electrical Vehicles. This paper reviews the technology used in HEVs, their types, the effects of different technology mixes for efficient battery recharging, and their development towards sustainable, efficient, and environmentally friendly transportation. The purpose of this study is to compare the trend of conventional vehicles vs electric vehicles using regression models. The automobile industry faces two significant challenges that hinder its development: environmental pollution and energy storage. To address these issues, Hybrid Electrical Vehicles (HEVs) have been developed to achieve energy savings and emission reductions. Unlike conventional vehicles that rely solely on internal combustion engines (ICE), HEVs use two motors and ICE to improve the efficiency of the power train, which is essential for enhancing fuel economy. The results indicate that the demand for electric vehicles will increase in the future due to the increasing number of hybrid electric vehicles on the road today.

Keywords: Environmental Pollution, Regression, Challenges Faced By Automobile Industry

I. INTRODUCTION

According to the 2021 statistics, the automotive industry in India stands fourth in the world. By 2022, India became the fourth-largest country in the world by the valuation of its automotive industry. As of 2020, India holds the fifth position in the world's automobile market, surpassing Germany in terms of sales.

Presently, India's auto industry is valued at more than US$100 billion and contributes 8% of the country's total exports. It accounts for 2.3% of India's GDP. India's major automobile manufacturing companies include Tata Motors, Ashok Leyland, Mahindra & Mahindra, Force Motors, Tractors and Farm Equipment Limited, Eicher Motors, Royal Enfield, Sonalika Tractors, Hindustan Motors, Hradyesh, ICML, Kerala Automobiles Limited, Reva, Pravaig Dynamics, Premier, Tara International, and Vehicle Factory Jabalpur.

The beginning of the 1970s saw no growth potential, and most of the collaboration license agreements came to an end. But, with the option to continue manufacturing with renewed branding, cars were still meant for the elite, and Jeeps were used by government organizations and in some rural regions. By the end of the decade, some developments were made in the commercial vehicle segments to facilitate the movement of goods. The two-wheeler segment remained unchanged except for increased sales to the middle class in urban areas. There was emphasis on having more farm tractors, as India was embarking on a new Green Revolution. Russian and Eastern bloc imports were brought in to meet the demand.

After 1970, with restrictions on the import of vehicles set, the automotive industry started to grow, driven by tractors, commercial vehicles, and scooters. Cars remained a luxury item, and in the 1970s, price controls were finally lifted, inserting a competitive element into the automobile market. However, by the 1980s, the automobile market was still dominated by Hindustan and Premier, who sold outdated products in limited numbers. The rate of car ownership in 1981 was about one in every thousand citizens, understandable when the annual road tax alone cost about half of an average Indian's income at the time.

During the 1980s, a few competitors started to arrive on the scene. Of the 30,487 cars built in India in 1980, all but six came from the two main players Hindustan and Premier. Standard led a shadow existence in the latter half of the 1970s, producing only a handful of cars to keep their license active. A new contender was tiny Sipani, which had tried building locally developed three-wheeled vehicles since 1975 but introduced the Reliant Kitten-based Dolphin in 1982. Nonetheless, all eyes were on Maruti, which caused a significant upheaval in the Indian automobile industry.

Overall, the global automotive industry is in better shape than it was five years ago, especially in the US, where profits and sales have recovered following the recent economic crisis. China's growth remains strong, and this progress is expected to continue. By 2020, global profits for automotive OEMs are expected to rise by almost 50 percent. The new profits will mainly come from growth in emerging markets and, to a lesser extent, the US. Europe, Japan, and South Korea will experience stagnant profit growth.

II. METHODOLOGY

There are a variety of different designs and segments available in four-wheelers, including all-terrain vehicles (ATVs), utility terrain vehicles (UTVs), and four-wheel drive vehicles. ATVs are designed for off-road use and feature four

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low-pressure tires and handlebars for steering. UTVs are also designed for off-road use, but have a steering wheel instead of handlebars and offer a side-by-side seating arrangement. Four-wheel drive vehicles are designed for on-road use and feature four-wheel drive capabilities, allowing them to traverse difficult terrain.

A. Different Designs/Segments available in Four Wheeler

Available Electric Vehicles based on segments

Fig. 1: Tata Tigor EV

The most affordable of the lot, the Tata Tigor EV is the electric-powered version of the standard Tata Tigor. The electric sedan packs a decent selection of upmarket features, and ample space for five occupants making it as comfortable as the standard Tigor. Moreover, the standard Tigor's 4-star Global NCAP safety rating also holds true for the Tigor EV, making it the safest compact sedan EV in India. Coming to the most prominent attribute of an EV, its range. A 306 km range makes it a reasonable choice for urban usage, making it an ideal car to consider for daily commutes.

B. Features of Tata Tigor EV

- 7.0-inch touchscreen infotainment system with Apple CarPlay and Android Auto
- Four speakers & four tweeters
- Multi-functional steering wheel
- Automatic climate control
- Digital instrument cluster
- Dual airbags
- ABS with EBD
- Rear parking sensors
- Rear parking camera
- Seat belt reminder

Fig. 2: Tata Nexon EV Prime

The all-electric version of the ever-popular Tata Nexon, the Tata Nexon EV is by far the most successful EV in India, covering around 74 percent of EV sales. Featuring a lengthy list of upmarket perks, spacious interiors, a 5-star G-NCAP safety rating, and a range of 312 km makes the Tata Nexon EV an immensely comfortable and reassuring electric compact SUV. What's more, in its more than 2 years of age, it has testified itself as the most value-for-money EV on sale and has accelerated the adoption of electric cars in India.

C. Features of Tata Nexon EV Prime

- 7.0-inch touchscreen infotainment system
- Auto headlamps
- Semi-digital instrument cluster
- Sunroof
- Cruise control
- Multi-level regenerative braking
- Automatic climate control
- Cornering stability control
- Dual front airbags

Available Hybrid Vehicles based on segments Maruti Suzuki Brezza

Fig. 3: Maruti Suzuki Brezza

Along with a 4-star Global NCAP safety rating, the Maruti Suzuki Brezza has the SHVS technology among its highly attractive perks. Just like the Maruti Ciaz, the mild-hybrid system in the Brezza consists of a Lithium-ion battery connected with an electric motor. The SHVS technology assists Brezza's functionality with idle start-stop, regenerative braking, and applying extra torque when required. The hybrid system is limited to the automatic variants and helps Maruti Brezza deliver a mileage of 19.80-20.15 km/l.

D. Features of Maruti Suzuki Brezza

- 9-inch TFT,Apple CarPlay and Android Auto,Rain-sensing wipers
- Interior Ambient Lighting
- Cruise Control,Auto Climate Control
- Dual front airbags,ABS with EBD +Brake Assist
- Rear View Camera,Rear Parking Sensors With Infographic Display
- Electronic Sunroof
- Next Gen Suzuki Connect,Smart Play Pro +, 360 Degree View Camera With Surrounded Sense powered by ARKAMYS
- ESP With Hill Hold Assist, ISOFIX

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Fig. 4: Maruti Suzuki Ciaz

The elegant Indian sedan, Maruti Suzuki Ciaz has an edge over its rivals, the Honda City and Hyundai Verna, due to its Smart Hybrid Vehicle System (SHVS) technology. The technology consists of a Lithium-ion battery connected with an electric motor. Recharging itself with regenerative braking, the battery assists the car in idle start-stop and complements the torque when needed in starting the car from idle or going uphill. The SHVS technology dramatically helps Ciaz in delivering impressive mileage figures of 21.56 kmpl with 6-speed manual transmission and 20.28 kmpl with the 4-speed torque converter automatic.

E. Features of Maruti Suzuki Ciaz

- 7-inch touchscreen infotainment system with Navigation System of Live Traffic Updates
- Apple CarPlay and Android Auto, Suzuki Connect
- Multi-Information Display, Automatic Climate Control
- Leather upholstery, Cruise Control
- Dual Front Airbags,Reverse Parking Camera,ESP With Hill Hold,Rear Parking Sensors
- ABS with EBD, ISOFIX

III. MODELING AND ANALYSIS

Modelling and analysis are essential tools used across various industries to understand complex systems and make informed decisions. Modelling refers to the process of creating a simplified representation of a real-world system, while analysis involves examining the model to gain insights into the system's behavior.

A. Source/s of Data

1) Source of Data's are as below

- https://cars.usnews.com/powersports/atvs
- https://boostatv.com/atv-utv-types/
- https://www.truecar.com/best-cars-trucks/four-wheel-drive/
- https://www.mordorintelligence.com/industry-reports/off-road-vehicle-market
- https://www.alliedmarketresearch.com/atv-and-utv-market
- SIAM(Society of Indian Automobiles),Government Websites,Suppliers of the Market
- Customer reviews/ Data from Zighweels, cardekho,Market Research for the different new technologies, also by the applicants and cross reference of different competitors.Market Survey,Communication from Vendor's, Suppliers.

2) Data Collection Method

- Main Competitors, Kaggle Datasets, Market Surveys
- Automobile exhibition, Creating Polls over Social Media

3) Sampling Method

- Random, Systematic, Cluster

4) Sampling Frame

a) Regressors:
   - Linear Regression
   - Multilayer Perceptron (MLP)
   - Random Forest
   - AdaBoost
   - Deep Multilayer Perceptron (Deep MLP)

b) Classifiers:
   - Support Vector Machines (SVM)
   - Multilayer Perceptron (MLP)
   - Random Forest
   - Deep Multilayer Perceptron (Deep MLP)

5) Date Collection Instrument

- Power BI
- Python
- Excel
- Visio

B. Data Analysis:

Hybrid and electric vehicles are becoming increasingly popular as environmentally-friendly alternatives to traditional gasoline vehicles. These vehicles utilize one or more electric motors for propulsion and rely on batteries as their primary source of energy. The report covers three main categories of electric vehicles: electric passenger cars, electric commercial vehicles, and electric two-wheelers.

Electric passenger cars are designed to transport no more than nine passengers and operate solely on electric power. These vehicles can be charged by plugging them into a charging point, and their batteries have a range of up to several hundred miles on a single charge.

Electric commercial vehicles are used for transporting passengers or goods and include a variety of vehicle types, such as buses and trucks. The report covers battery electric vehicles (BEVs), hybrid electric vehicles (HEVs), plug-in hybrid electric vehicles (PHEVs), and fuel cell electric vehicles (FCEVs).

Electric two-wheelers, including scooters, motorcycles, and mopeds, are designed for two riders and are propelled by batteries and electric motors. These vehicles can be charged from traditional wall outlets and are either plug-in or fully battery-operated.

Overall, the report provides a comprehensive analysis of the electric vehicle market, covering a range of vehicle types and applications that are increasingly important in the transition to more sustainable transportation options.

C. Current EV Manufactures in India.

Till 31st July 2021, there were 380 electric vehicle manufacturers in India. With the increasing adoption of electric vehicles in the landscape, this number is only expected to increase further. The models approved by FAME-II along with their manufacturers are as follows:

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Analysis of EV in Indian Market (As per Government of India)

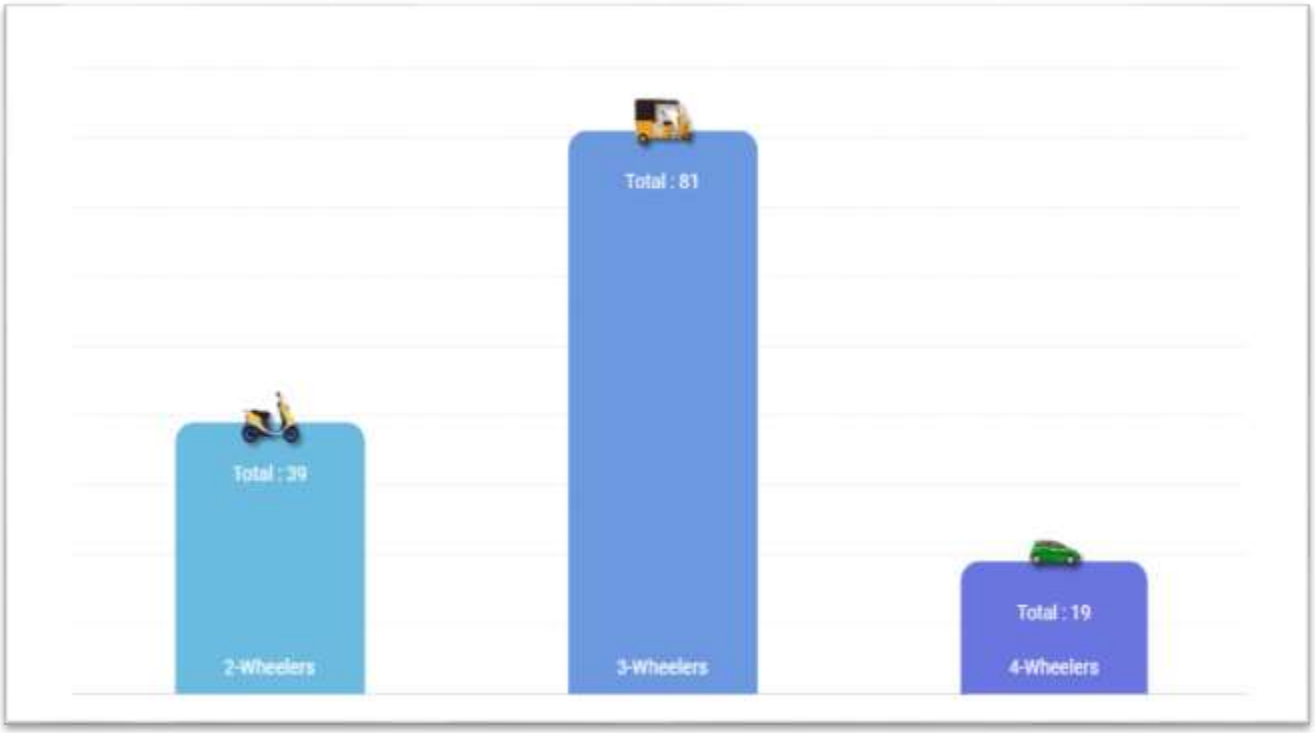

Fig. 5: Total EV available in India

2 Wheeler EV in India(As per Government of India)

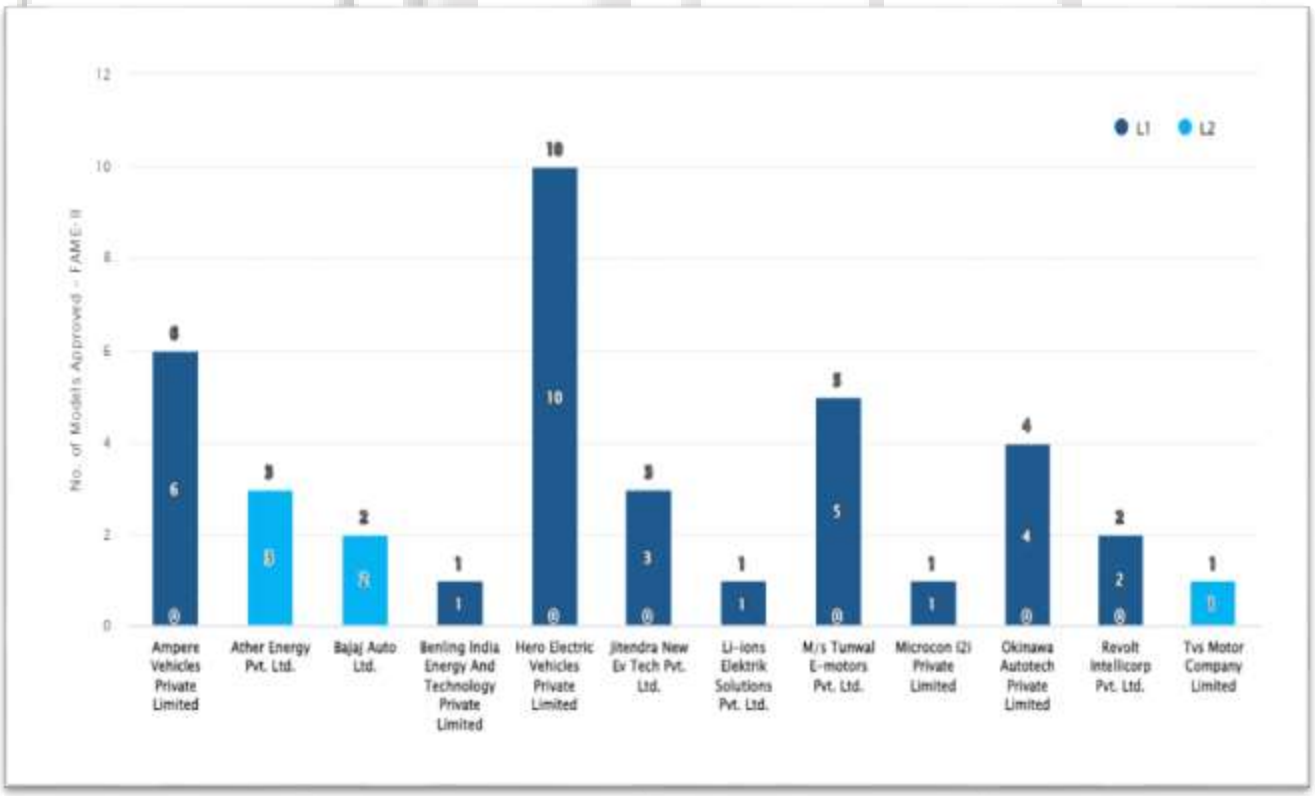

Fig. 6: 2 Wheeler EV in India

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3 Wheeler EV in India (As per Government of India)

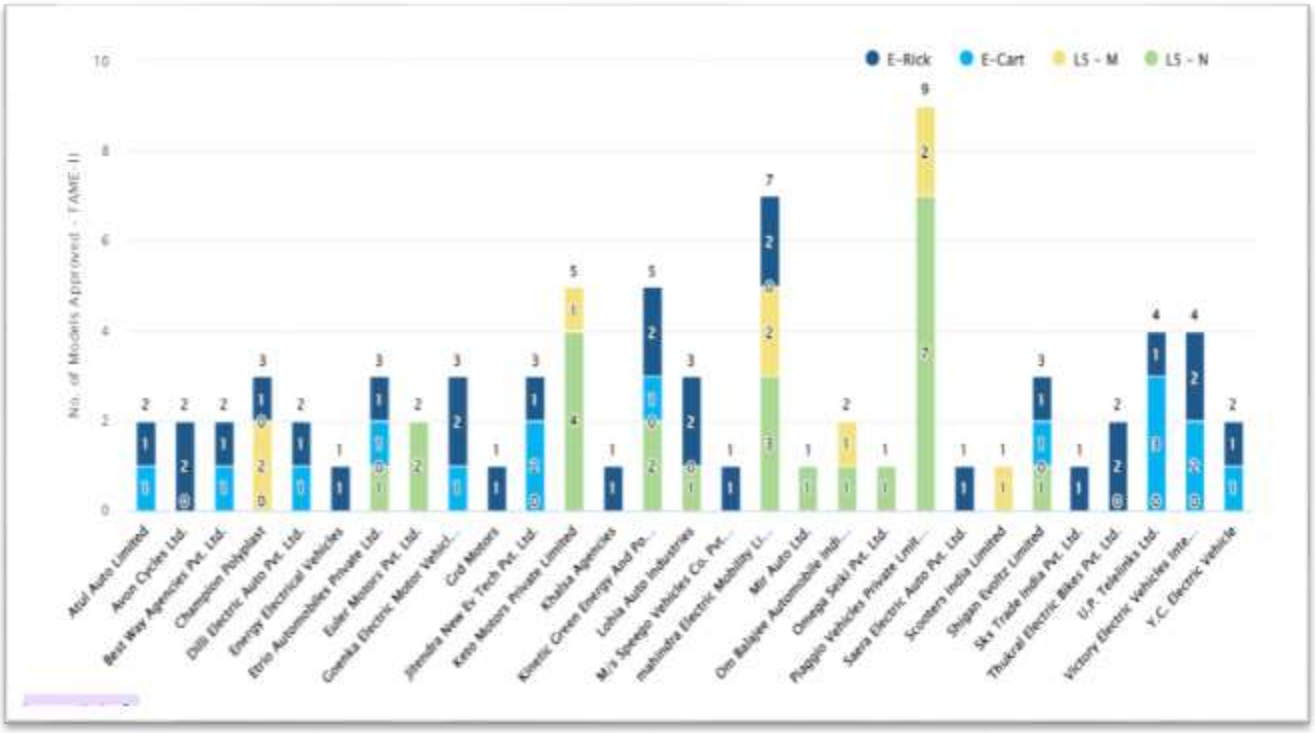

Fig. 7: 3 Wheeler EV in India

4 Wheeler EV in India (As per4 Wheeler EV in India Government of India)

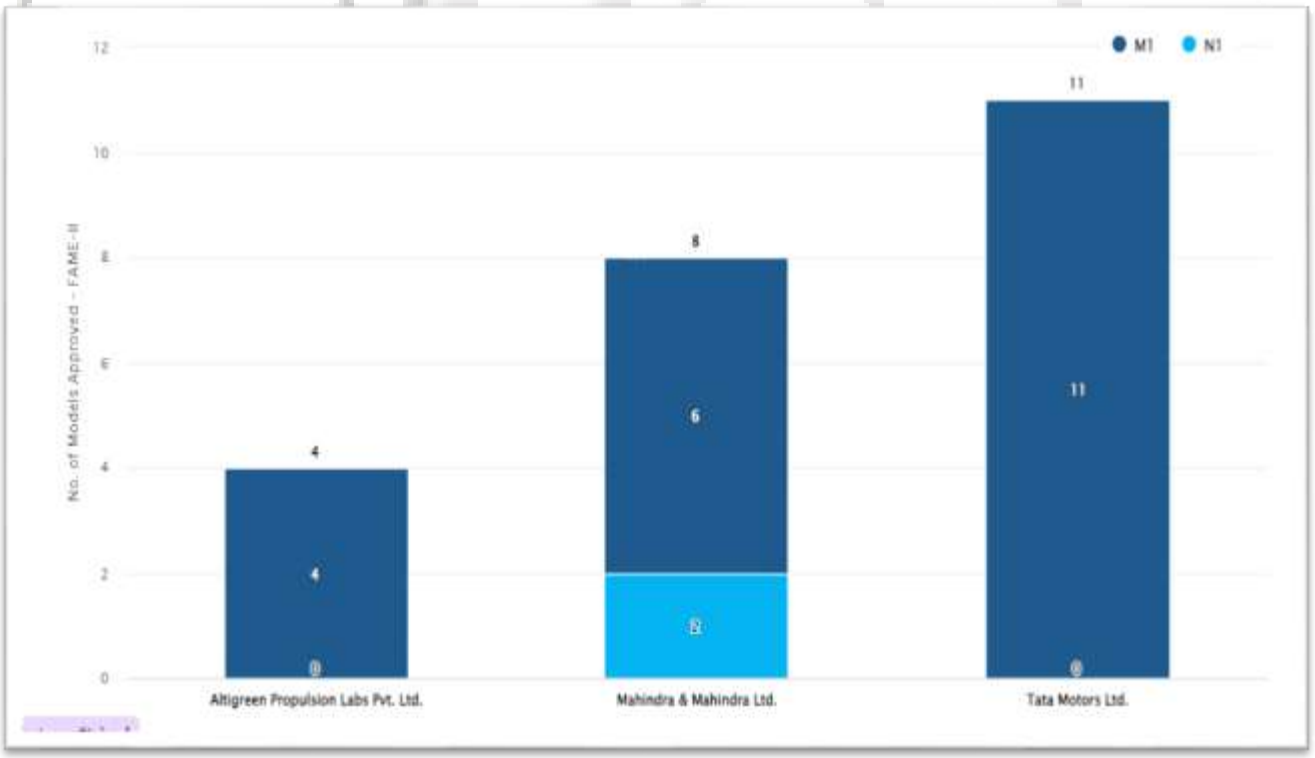

Fig. 8: 4 Wheeler EV in India

D. Charging Stations Deployment

There are 1128 EV charging stations in India spread across 149 cities. Of these, Maharashtra has the highest number with 410 charging stations while Jammu and Kashmir has the least with 1 charging stations.

E. Upcoming Charing stations in India

– The Department of Heavy Industries (DHI) has so far approved 2,636 electric vehicle charging stations in 62 cities across 24 states and union territories (UTS) under the second phase of FAME India (Faster Adoption and Manufacturing of Electric Vehicles in India) program.

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– According to the government's statement, nearly 106 proposals were received from the public and private entities for the deployment of approximately 7,000 EV charging stations.

– After the evaluation of these proposals, the government has approved 2,636 charging stations for 24 states. Out of these, 1,633 charging stations will be fast-charging stations, and 1,003 will be slow charging stations

Approved List of Charging Stations Across States/UTs Under FAME II Program

States/UTs	No. of EV Charging Stations Allocated	States/UTs	No. of EV Charging Stations Allocated
Maharashtra	317	Chandigarh	70
Andhra Pradesh	266	Haryana	50
Tamil Nadu	256	Meghalaya	40
Gujarat	228	Bihar	37
Rajasthan	205	Sikkim	29
Uttar Pradesh	207	Jammu & Kashmir	25
Karnataka	172	Chhattisgarh	25
Madhya Pradesh	159	Assam	20
West Bengal	141	Odisha	18
Telangana	138	Uttarakhand	10
Kerala	131	Puducherry	10
Delhi	72	Himachal Pradesh	10
Sub-Total	2292	Sub-Total	344
		Total	**2636**

Source: DHI — Mercom India Research

Fig. 9: Approved EV Charging Station State Wise

– With this, about 14,000 charging stations are expected to be installed, the government said in a statement

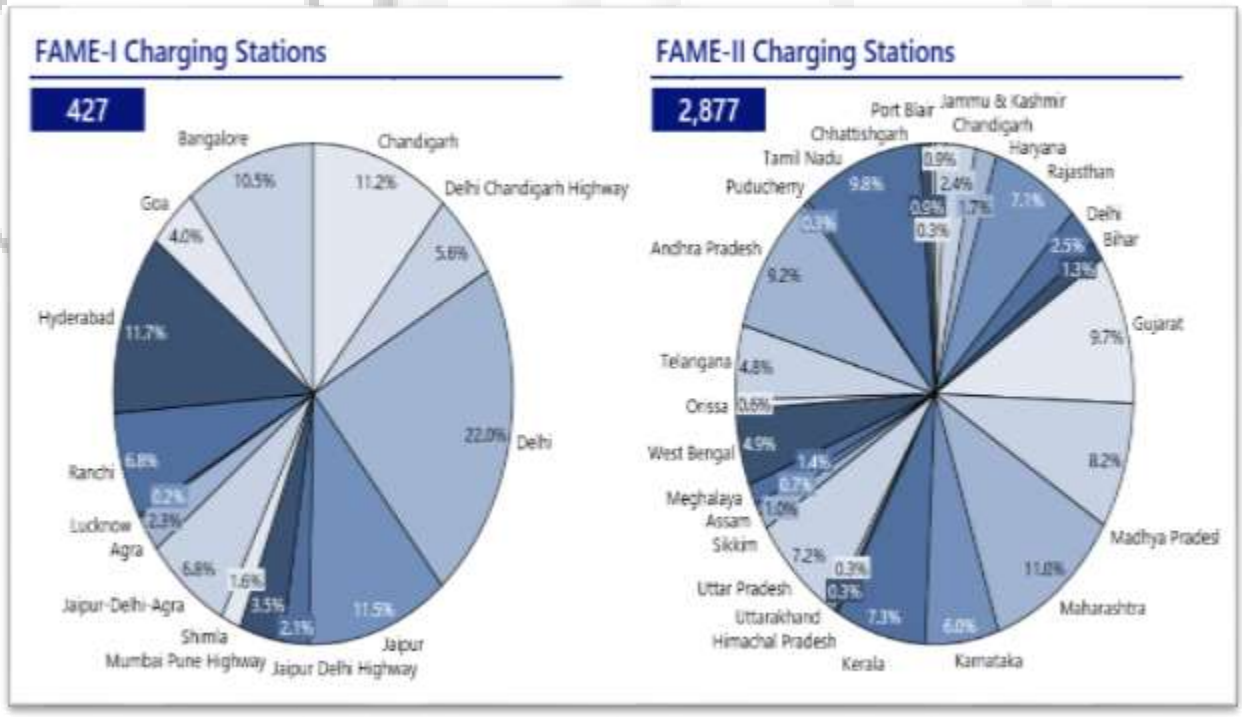

Fig. 10: Upcoming Charging Station Phase Wise

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EVSE POWER RATINGS

	Power level	Current type	Compatible EV segments
Normal power charging	P ≤ 7kW	AC & DC	E-2Ws, e-3Ws, e-cars, other LCVs (up to 1 ton)
	7kW < P ≤ 22kW	AC & DC	
High power charging	22kW < P ≤ 50kW	DC	E-cars, LCVs and MCVs (1-6 tons)
	50kW < P < 200kW	DC	

Fig. 11: Battery Charging Capacity

F. Current Scenario

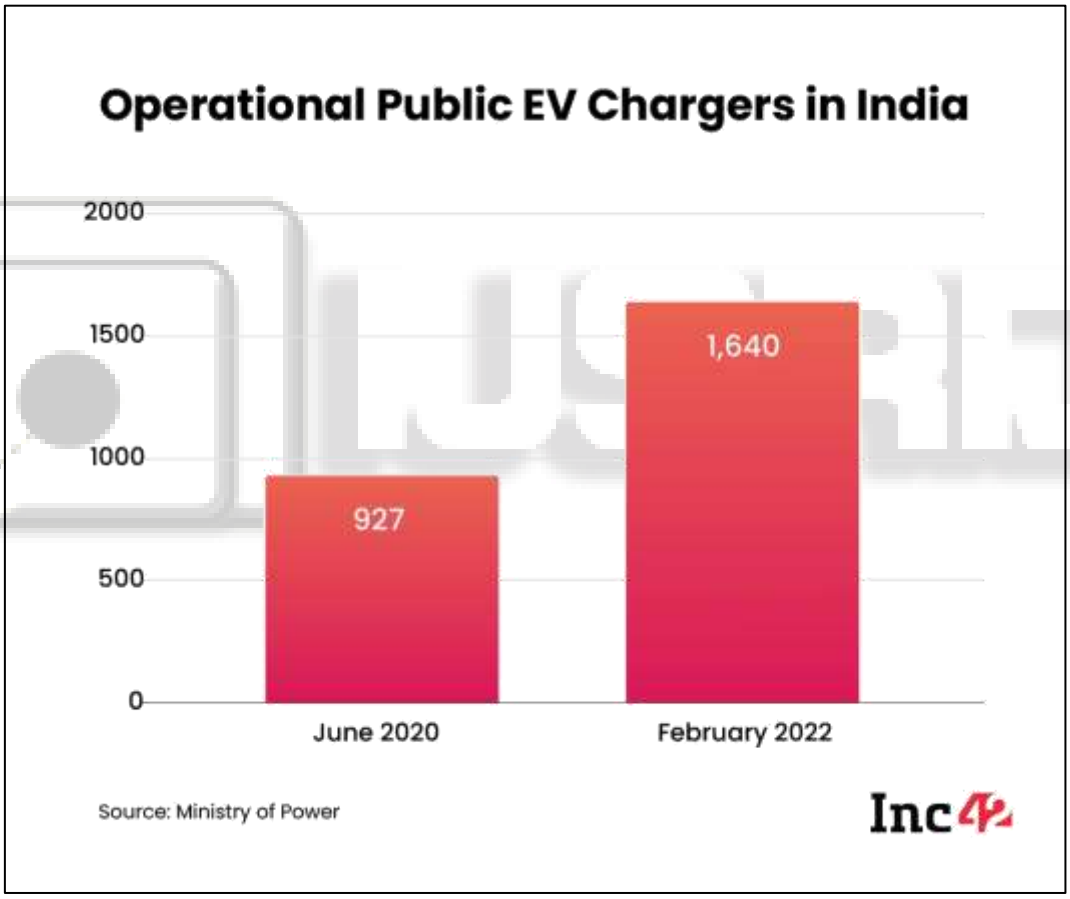

Fig. 12: Operation EV Charging Station

G. India Electric Vehicle Charging Station Market Competitor Analysis

India Electric Vehicle Charging Station Market Top Players

1) Tata Power Company Limited
2) Charzer Tech Pvt Ltd.
3) Mass-Tech Controls Pvt Ltd.
4) ABB Ltd.
5) Exicom Telesystems Ltd.

IV. Results and Conclusion

A. Comparative study of Conventional Vehicle vs EV Vehicle (Home Charging)

Home charging calculator helps in calculating the charging time of the electric vehicle and how much it costs. Most of the electric car owners would rely on home charging, given that the private cars would be parked overnight, in order to ensure that their EV is available for use each morning. In most cases, charging overnight at homes will be the cheapest method to recharge.

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Fig. 5: Home Charging Rate Input(Demo)

B. How much will I save?

You will save approximately ₹72.62 with this electric vehicle. As a conventional petrol or diesel vehicle costs around ₹1.62 per km.The total cost for the same journey with a conventional petrol or diesel vehicle would be around ₹80.83.

Fig. 6: Home Charging Rate Output(Demo)

C. Comparative study of Conventional Vehicle vs EV Vehicle (Public Charging)

Want to find out how long will it take to charge your electric vehicle with a slow, fast or rapid charger at a public place along with its cost? The public charging calculator will help you estimate the time as well as the expenses.

Fig. 7: Public Charging Rate Input (Demo)

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D. How much will I save?

The cost of electricity at home ranges from ₹4/kWh – ₹11.82/kWh. Therefore, the total cost for the same charge at home would cost approximately ₹ 6.32 to ₹ 18.68.

Fig. 16: Public Charging Rate Output(Demo)

E. Analysis Using Regression Model(Python)

```
In [21]: # make for loop for Regression

model = [LR,DTR,RFR,KNR,XGB]
d = {}
for i in model:
    i.fit(X_train,y_train)
    ypred = i.predict(X_test)
    print(i,":",r2_score(y_test,ypred)*100)
    d.update({str(i):i.score(X_test,y_test)*100})

LinearRegression() : 86.84533550517865
DecisionTreeRegressor() : 86.39184746373215
RandomForestRegressor() : 90.38804430727467
KNeighborsRegressor() : 79.18292621690438
XGBRegressor(base_score=None, booster=None, callbacks=None,
             colsample_bylevel=None, colsample_bynode=None,
             colsample_bytree=None, early_stopping_rounds=None,
             enable_categorical=False, eval_metric=None, feature_types=None,
             gamma=None, gpu_id=None, grow_policy=None, importance_type=None,
             interaction_constraints=None, learning_rate=None, max_bin=None,
             max_cat_threshold=None, max_cat_to_onehot=None,
             max_delta_step=None, max_depth=None, max_leaves=None,
             min_child_weight=None, missing=nan, monotone_constraints=None,
             n_estimators=100, n_jobs=None, num_parallel_tree=None,
             predictor=None, random_state=None, ...) : 88.18881275219054
```

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