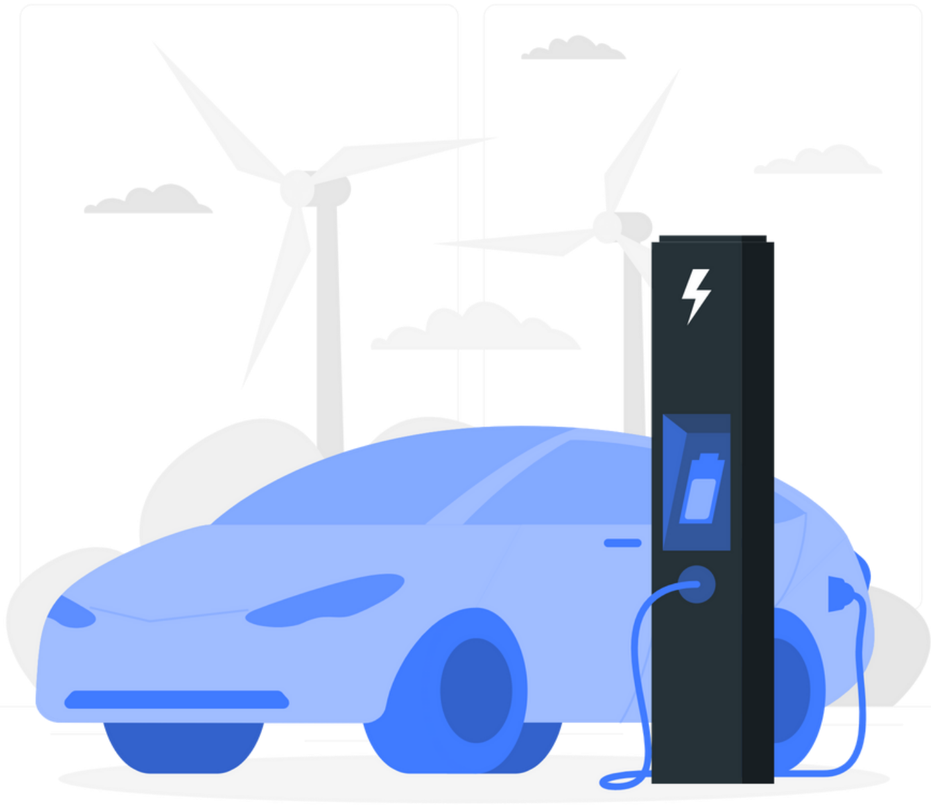
ELECTRIFYING THE FUTURE



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EV charging infrastructure

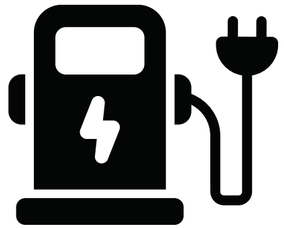
Is India's infrastructure ready to be electrified?

India is taking the lead in the global shift to electrification by introducing several electric vehicles or hybrid vehicles.

According to market research firm Jato Dynamics, Electric vehicle (EV) sales grew 112% YoY to 50,284 units during April-September 2023.

What is the present status of EV charging ecosystem (including home stations) in India and the projected demand?

The key barrier on the path of adoption of EV or Hybrid Vehicles is the lack of public charging infras-tructure in India.



The highest number of EV charging stations was in Delhi (1845) and then in Maharashtra (660) followed by Uttar Pradesh (406).

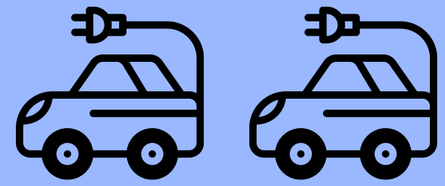
It is reported that there were a total of 6,586 public charging stations by March 2023 out of which 419 were on National Highways.

The Confederation of Indian Industry (CII) report on ‘Changing Infrastructure for Electric Vehicles’, states that India might require a minimum of 1.32 million charging stations by the end of 2030 to meet the rapid demand for electric vehicles.

Confederation of Indian Industry

To meet the demand for charging stations, India requires ideally 1 charger for every 40 EVs, thus it demands for over 4 lakh charging stations annually. Cumulative charging stations annually are expected to be 1.32 million by 2030.

It also has stated that it is projected that by 2030 around 106 million EVs are going to be sold each year.



Now another question arises: What will happen to the end-of-life EV batteries (about 10-15 years)?

One way to use the batteries after their shelf life is to recycle them. According to Niti Ayog, by 2030 EV battery recycling market is going to expand to 128 GWH from 2 GWH in 2023.

Recycling enables the extraction of valuable resources from spent batteries, reducing reliance on raw materials and cutting manufacturing costs.

Benefits of Battery Reuse:

- Electric vehicle (EV) batteries contain reusable materials like plastic, iron, aluminum, silver, and gold.
- Reusing these materials reduces both mining and manufacturing expenditures.
- This lowers the overall cost of EVs, as batteries are the most expensive component.

Regulatory Measures and Industry Initiatives:

- The European Union proposed holding EV manufacturers accountable for recycling batteries after their useful life.
- -Volkswagen has opened a recycling plant for its EV batteries, contributing to increased recycling efforts.

Environmental Hazards of Improper Disposal:

- Improper disposal of EV batteries can lead to environmental hazards such as water and soil contamination.
- Burning EV batteries releases toxic chemicals, deteriorating air quality.

Importance of Proper Recycling and Disposal:

- Proper recycling and disposal methods are crucial to mitigate environmental impact.
- Ensuring sustainable use of EV batteries is essential for long-term environmental health.

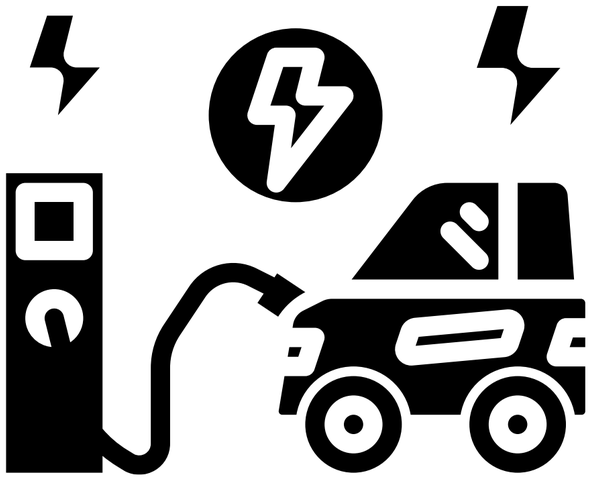
What are the supply chain issues in Lithium manufacturing?

One of the main components of EVs is lithium, which is not easily available in One of the main components of EVs is lithium, in February as per the Ministry of Mines, more than 5.9 million tonnes of lithium is found in Jammu and Kashmir. This comes as a hope for India, to manufacture its own lithium-found batteries, it will not only reduce the cost of lithium material thus making EVs more affordable but also increase employment.

What are the supply chain issues in Lithium manufacturing?

- The development of local capacities and capabilities for manufacturing lithium battery cells and recycling batteries is an ongoing process.
- These projects are still in their initial stages, and it's imperative to recognize that implementing such technologies from the drawing board to mass production is a complex and time-consuming journey.
- However, the industry remains committed to seeing these projects through to fruition.

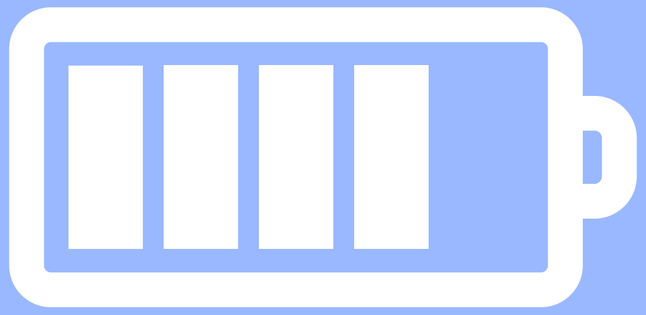
Charging availability can make or break EV fleet operations!!!!



- Surveying vehicle operators reveals that their biggest anxiety operating an EV is the scarcity or lack of charging availability. As an example, in a 2022 EY-conducted survey of more than 200 National Grid fleet drivers

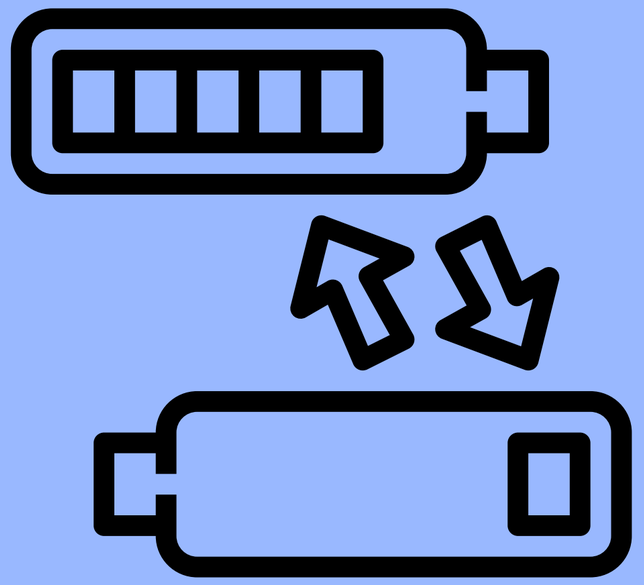
- the top three concerns focused on charging rather than EV capability or suitability. Indicating that a successful transition strategy needs to address the charging plan.

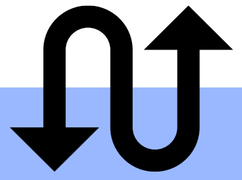
Battery Infrastructure:
Charging vs Swapping!!!



What is Battery Swapping?

Battery swapping is the process of replacing a depleted battery in an electric vehicle with a fully charged one, allowing for a quick exchange instead of waiting for a recharge. This can reduce downtime for electric vehicle users.





List of some Notable Companies use Battery Swapping in India

Sun Mobility: A 50:50 joint venture between Maini Group and SUN Group, the most prominent player in India's battery swapping space for electric 3VVs and e-buses. In Sep 2020, Bosch acquired a 26% stake in the company. It aims to power 1 million EVs by 2025 and save 8.5 million tons of C02.

Battery Smart: has 650+ Live swap stations across 15 cities and works with 25000 Customers

List of some Notable Companies use Battery Swapping in India

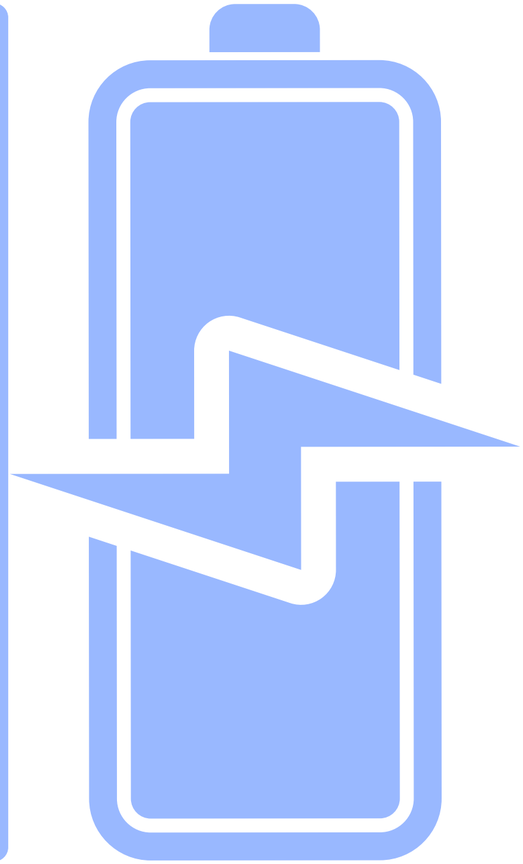
Gogoro: 6 operational BSS in Delhi NCR

Voltup: Provides a battery swapping and smart charging technology platform for EV owners, Logistics Players, and OEMs, working on a pay-as-you-go model.

Technology:

Charging: charging stations involve connecting the EV to a power source through a cable. There are different charging levels, including

- Level 1 (standard household outlet)[3.3kw],
- Level 2 (dedicated charging brick)[7.2Kw],
- Level 3 (fast chargers, DC fast charging).



LEVEL 1

- The slowest Form of Charging
- The charger is included with the vehicle
- This is suitable for overnight charging but is not practical for quick charging needs.3.3KW

LEVEL 2

- Household charge
- Not Included with the vehicle
- Faster than the Standard household charge
- Have to earthed properly
- 7.2KW

LEVEL 3

- known as DC fast charging, is the fastest public charging option.
- Its the Fastest Charging option
- it uses direct current (DC) and is suitable for quick pit stops during long journeys.

Battery Swapping

Battery swapping involves replacing a depleted battery with a fully charged one. This process is typically faster than charging.

Standardization: For battery swapping to be practical, there needs to be a degree of standardization in battery pack design. This includes the physical dimensions, electrical connections, and communication protocols to ensure compatibility across different vehicle models.

Battery packs must be designed for easy removal and replacement, with standardized interfaces to facilitate a seamless swapping process.

Battery swapping stations often incorporate automated systems to efficiently replace the battery packs. Because it will hard to lift the heavy batteries.

Infrastructure Cost

Charging:

- Setting up charging stations involves the installation of charging equipment, including charging points, and power distribution units.
- Space Req: Charging stations, especially in public areas, require dedicated parking spaces with access to power. This can impact the availability of suitable locations and influence land costs in urban areas. But as seen in some areas the charging station can be set up in super marketing Parking, mall parking, underground parking, etc.
- O&M: Ongoing maintenance of charging equipment, software updates, and addressing technical issues contribute to operational costs.

Infrastructure Cost

Swapping:

- Establishing a battery swapping station involves constructing a facility with the necessary infrastructure to accommodate the storage, maintenance, and swapping of battery packs.
- If the swapping process is automated, the robotics and other automated systems adds to the initial infrastructure costs but as seen in india the BSS has been there for 2 wheelers and 3 wheelers. In this type of BSS there is no need of automation but in case of 4 wheelers automation is must.

Convenience

Charging

- Time: The charging time for electric vehicles at charging stations can vary widely depending on the charging level. Level 1 and Level 2 chargers are slower, requiring hours for a full charge, while Level 3 (fast chargers) offer quicker charging times.
- Availability: Depending on the location, the availability of charging stations might be a concern, especially in less densely populated areas. Users may need to plan their routes carefully to ensure access to charging infrastructure. Even when the charger is available, In busy charging stations, users might need to be considerate of others waiting for a charging spot.
- For long-distance travel, users need to plan their routes around the availability of charging stations, considering the time needed for charging stops.

Convenience

Swapping

- Battery swapping offers a significantly faster process compared to charging. Users can quickly exchange a depleted battery for a fully charged one, reducing downtime considerably. This efficiency is particularly beneficial for users with time-critical needs or those who want to minimize waiting times during their journeys.
- User felt it hard to lift the battery due to the weight
- Battery swapping can be advantageous for long-distance travel, Swapping allows users to resume their journey quickly.
- No Need to Wait for Full Charge: Unlike charging, where users might wait for a full charge to continue their journey, battery swapping allows users to swap a partially charged battery for a fully charged one without waiting for a complete charge cycle.
- Due to the smaller area requirement of BSS(2 and 3-wheelers), users find them available in a more widespread and accessible manner.
- Users need to familiarize themselves with the battery-swapping process, including locating and using swapping stations. However, with user-friendly interfaces, the learning curve can be minimized.

SMART BATTERIES

Components of smart batteries:

Lithium

Cobalt

Nickel

Manganese

Major suppliers of cobalt

Democratic Republic of Congo

Cobalt reserves: 4,000,000 MT

Australia Cobalt reserves:

1,500,000 MT

Cobalt reserves: 600,000 MT

Major suppliers of lithium

argentina

chile

bolivia

EV CHARGING PRICING MODELS

Energy-based – based on how much electricity is charged during a charging session

Hybrid pricing - combination of time and energy based

Time based - with a time based pricing model ev drivers pay eg- per minute of their charging time. This model can be unfair as ev models differ not only based on battery capacity but also battery design and drivivng range

Energy-based-The energy-based pricing model is the most suitable in offering transparent and fair rates. This pricing model makes it fair for two EV drivers with different EV models.

ADVANCED PRICING MODELS

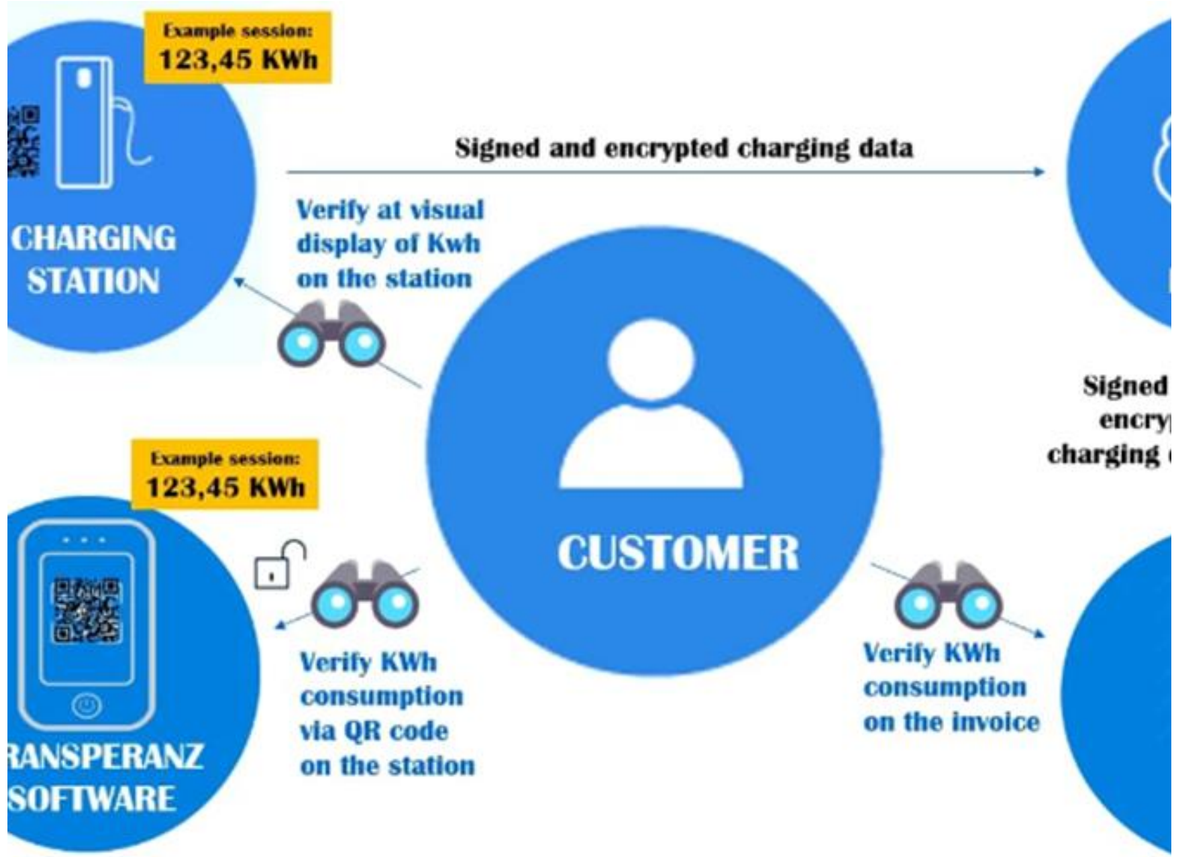
• Charging at off-peak / peak hours: You can also choose to set up pricing based on peak or off-peak hours. This pricing model can encourage EV drivers to charge outside of peak hours to get a lower price which will help not to overload the energy system.

• Pricing based on the type of EV charger: Fast and ultra-fast DC charging are premium services that allow EV drivers to charge quickly. And as a premium service, you can set higher prices on your DC chargers.

THE GERMAN CALIBRATION LAW: EICHRECHT

Germany passed a law providing a regulation for the measurement meters used for billing EV charging sessions. These meters must be calibrated regularly and fully visible to EV drivers. Measurement meters that are not correctly calibrated are prohibited under this law.

Eichrecht provides transparency to the customer, ensuring they are only paying for the amount of kWh they charged. This avoids any changes made by the CPO or the EMP to the invoiced amount.



Optimal Scheduling model of emergency power supply for important loads :

(1) An optimal scheduling strategy for EVs participating in emergency power supply of important loads is proposed. By optimizing the discharge plan of EVs, the proposed strategy can increase the duration of continuous power supply for important loads, reduce disaster losses, and ensure EV users discharge revenue.

(2) The grid and EVs determine the bidding range based on the idea of cost pricing through their own cost accounting and estimation of the cost of the other party, which increases the rationality of the negotiation.

Optimal Scheduling model of emergency power supply for important loads :

3) In order to increase the adaptability of negotiation, a bidding function is established based on Q-learning theory. Considering the transaction possibility and the competition/learning relationship among participants, a one-to-many two-stage discharge pricing strategy between the grid and EVs is established to achieve the balance of interests.

CURRENT PLAYERS IN EV INDUSTRY IN INDIA

The imperative shift towards electric vehicles (EVs) in India is propelled by the urgent need to address climate change, with the country ranking 168 out of 180 in the Environmental Pollution Index (EPI) 2020.

The government's ambitious target of achieving 100% electrification by 2030 is commendable, albeit challenging given the current adoption rate of less than 1%, as indicated by a McKinsey&Company report

Recognizing the barriers hindering EV ownership, some state governments, such as Maharashtra, have proactively addressed the issue of high initial costs by offering substantial subsidies,

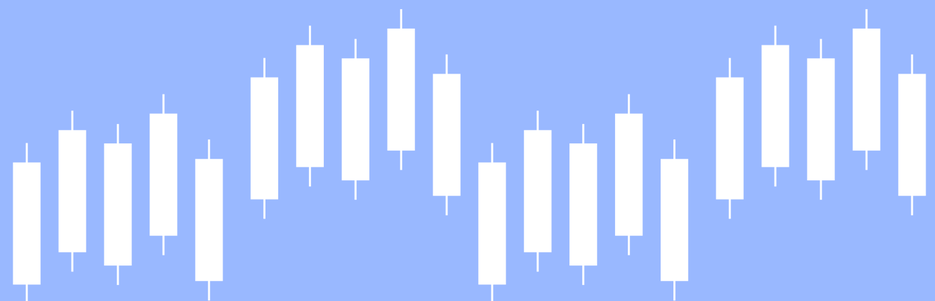
Maharashtra's initiative, providing a subsidy of 1 lakh for electric vehicles, has proven successful, making it a frontrunner in the Indian electric car market since 2017.

Top EV Stocks In India

Mahindra is the pioneer of EV in the Indian space. Being the first major EV manufacturer it launched Mahindra Reva, its first EV as early as 2001. The Mahindra Reva was India’s first electric car

Tata Motors, India's largest automobile manufacturer, boasts a diverse portfolio spanning cars, utility vehicles, buses, trucks, and defense vehicles, with notable subsidiaries like Jaguar Land Rover and Tata Daewoo.

move with meaning



GEMPL is a key player in the electric vehicle industry, contributing to the design and manufacturing of electric mobility solutions for over 13 years. In the electric two-wheeler segment (e-scooter), GEMPL has launched the “Ampere” brand, which has a strong presence in both business-to-consumer and business-to-business markets.

Ather Energy is India’s fifth largest player in the segment. Founded in 2013, it is a recognized electric two-wheeler maker, headquartered in Karnataka. It has two production facilities, one in Bengaluru, Karnataka and the other at Hosur, Tamil Nadu, which is 25 miles southeast of Bengaluru. The EV plant at Hosur is set up across 400,000 sq ft at an investment of about US$99 million and can manufacture 110,000 e-scooters and 120,000 battery packs annually.

HERO ELECTRIC

plug in. plug out. ride!

Present in the electric two-wheeler segment, with a strong focus on producing high-quality, energy-efficient electric scooters for the Indian market. The company is now seeking to create differentiated brands and hopes to enter the premium e-bike segment under the A2B brand. It is opening a new manufacturing facility near Ludhiana, Punjab with an annual production capacity of 200,000 units

The carmaker has made slow but steady strides in the Indian auto market, with two of its five offerings being EVs. The company has a manufacturing facility at Halol in Gujarat, which has an annual production capacity of 120,000 units.

MORRIS GARAGES

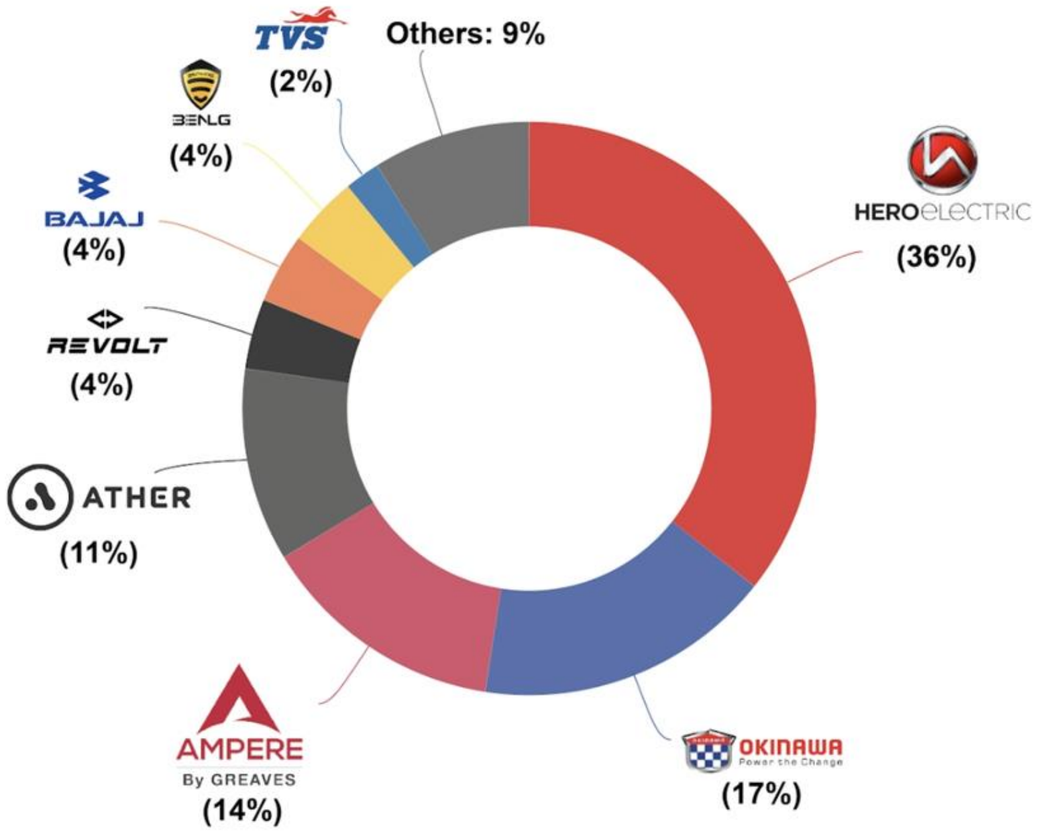
Since 1924

. Interestingly, in September, leading two-wheeler brand Hero MotoCorp said it will be investing INR 5.5 billion in Ather Energy. The company hopes to increase annual production capacity to 1.5 million from the current 420,000 units. Ather Energy is eyeing a 30-40 percent increase in market share in the next few years

ATUL Auto Limited:

A prominent name in the electric vehicle market, specializing in the production of a diverse range of electric vehicles, including electric rickshaws and three-wheelers. Its manufacturing plant is located at Shapar, 18km from Rajkot, Gujarat, with an annual production capacity of 60,000 units on a single shift basis per the company.

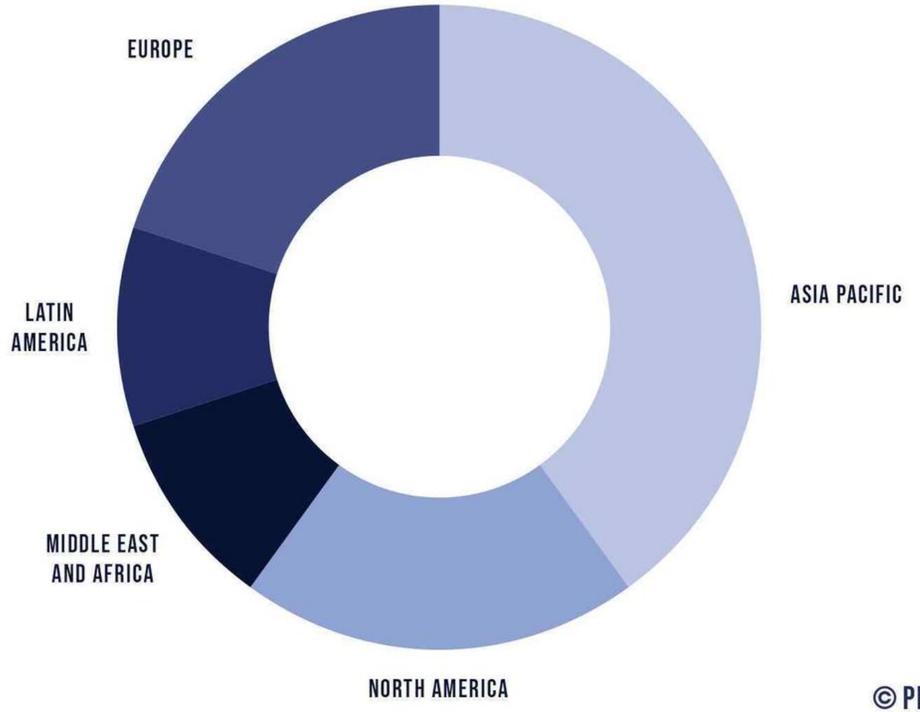
Current Market share in EV Industry in India



TYPICAL BATTERY SPECIFICATIONS FOR DIFFERENT EV SEGMENTS

VEHICLE SEGMENT	BATTERY CAPACITY	BATTERY VOLTAGE
 **E-2W**	1.2-3.3 kWh	48-72V
 **E-3W** (passenger/ goods)	3.6-8 kWh	48-60V
 **E-cars** (1st generation)	21 kWh	72V
 **E-cars** (2nd generation)	30-80 kWh	350-500V

ELECTRIC VEHICLE BATTERY MARKET SHARE, BY REGION, 2021 (%)



Government Initiatives

- FAME India & PLI Schemes:
  - The Faster Adoption and Manufacturing of Hybrid and Electric Vehicles (FAME) initiative, coupled with Production-Linked Incentive (PLI) schemes, demonstrates the government's commitment to fostering local production of EVs.
  - These schemes offer substantial incentives to both manufacturers and customers, aiming to accelerate the growth of the EV sector.

Government Initiatives

Industry Developments:

- Market Projections vs. Current Sales: While projections for the Indian EV market estimate substantial growth by 2030 (17 million units), the current sales figures fell short of expectations, reaching only a million units. However, the industry's potential remains evident, attracting both domestic players like Tata Motors, Mahindra, and Hero Electric, as well as international giants like Hyundai and Foxconn.

- Investment Influx: Significant investments from global and local automotive manufacturers, driven by the supportive policy framework, are fueling the momentum in India's EV production landscape.

Factors Driving India's EV Growth:

- Policy Support: The government's commitment to reducing carbon emissions, along with robust policy measures, has been instrumental in creating an enabling environment for the EV sector's growth.

- Charging Infrastructure & Renewable Energy: India's focus on developing charging infrastructure and promoting renewable energy sources like solar and wind power aligns with the requirements of a thriving EV ecosystem. The government's efforts to establish a network of charging stations across the country make EVs more accessible and convenient for consumers.

- Manufacturing Prowess: India's strong manufacturing capabilities, combined with an expanding market for EVs, position the country as a potential global leader in EV production.

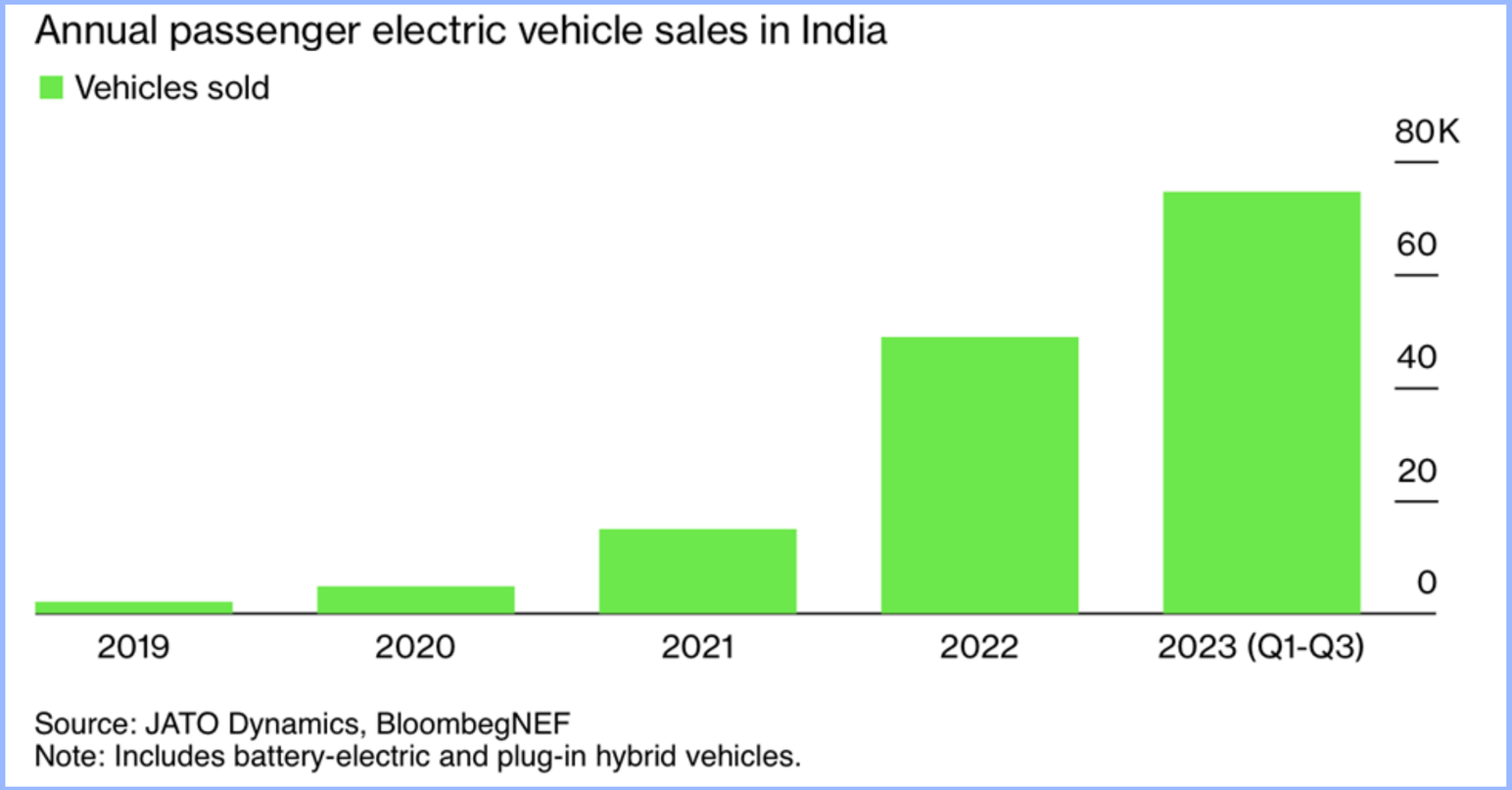
Historical Evolution:

- EVs have been present in India for several years, with the first electric three-wheeler, Vikram Safa, invented by Scooters India Private Limited in 1996.

- Several EV models, including cars and vans, were introduced in India by companies like Mahindra & Mahindra, BHEL, and Reva Bangalore in the late 1990s and early 2000s. Historical Challenges:

- Adoption challenges in the past included high battery costs, limited speed and range, inadequate service centers, and the use of bulky lead-acid batteries, which were environmentally harmful. Government Initiatives:

- The Indian government, through the Department of Heavy Industry, launched the National Mission for Electric Mobility in 2012, aiming to promote EV adoption. Efforts have been made to establish charging stations in cities, along highways, and at public places to support EV charging infrastructure.



the cheapest — MG's Comet mini car that sells for less than $10,000.
Tata Motors' best-selling Tiago compact EV accounted for 39% of EV shipments and retails for around $10,500.

Challenges in Charging Infrastructure:

Urban Concentration: Public charging stations are predominantly concentrated in major cities like Delhi, Mumbai, and Bengaluru. Moreover, many of these stations cater primarily to electric two- and three-wheelers.

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Current Challenges:

- Limited availability of EV models for purchase compared to internal combustion engine (ICE) vehicles.
- Factors impacting driving range, including battery capacity, driving conditions, and weather.
- Varied charging times, longer for home chargers compared to public ones.
- Lack of public awareness about EVs, their benefits, charging methods, and related tariffs.

Recent Achievements and Developments:

- Fame initiative supporting EV adoption:
- Registration of numerous EV models by manufacturers.
- Incentives provided by the government for EV sales and deployment of electric buses.
- Installation of charging stations across Indian states.
- Significant CO2 reduction due to EV adoption.

COST OF EV AND ICE

EV Sales Surge in India:

- Remarkable surge in EV sales in India, surpassing 100K EVs sold per month in the current year.
- Over 1.1 million EVs have been registered in the calendar year 2023, with more than 500K two-wheelers and 350K three-wheelers

Advantages of EVs:

- Simplified mechanics of EVs with around 200 moving parts compared to over 1,000 in traditional petrol/diesel vehicles lead to potentially lower repair costs.
- Setting up charging stations at showrooms and service centers incentivizes dealers under schemes like FAME II, boosting EV infrastructure.

SWOT ANALYSIS

Strengths

- Environmental Benefits
- Technological Advancements.
- Government Support
- Cost Savings
- Diverse Vehicle Options

Weakness

- Range Anxiety:
- High Initial Cost
- Charging Infrastructure
- Battery Technology Limitations
- Consumer Awareness and Education

Opportunities

- Infrastructure Investment:
- Collaboration and Partnerships
- Policy Support
- Market Expansion
- Sustainable Supply Chain

Threats

- Competition from Traditional Automakers
- Regulatory Uncertainty
- Supply Chain Disruptions
- Economic Factors
- Technological Risk

PORTER'S 5 FORCES ANALYSIS

Threat of New Entrants:

- High Initial Investment: For example, Tesla's Gigafactories requires massive investments
- Regulatory Hurdles
- Established Brand

Bargaining Power of Suppliers:

- Battery Suppliers:
- Rare Earth Minerals
- Charging Infrastructure Providers

Bargaining Power of Buyers:

- **Increasing Consumer Demand:**
- **Price Sensitivity**
- **Information Availability**

Threat of Substitutes:

- Internal Combustion a (ICE) Vehicles:
- Hybrid vehicles
- Public Transportation

Competitive Rivalry:

- Intense Competition
- Product Differentiation
- Partnerships and Collaborations

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