B.Tech Project Report

EVs Landscape and Low Cost Add-Ons

under the guidance of

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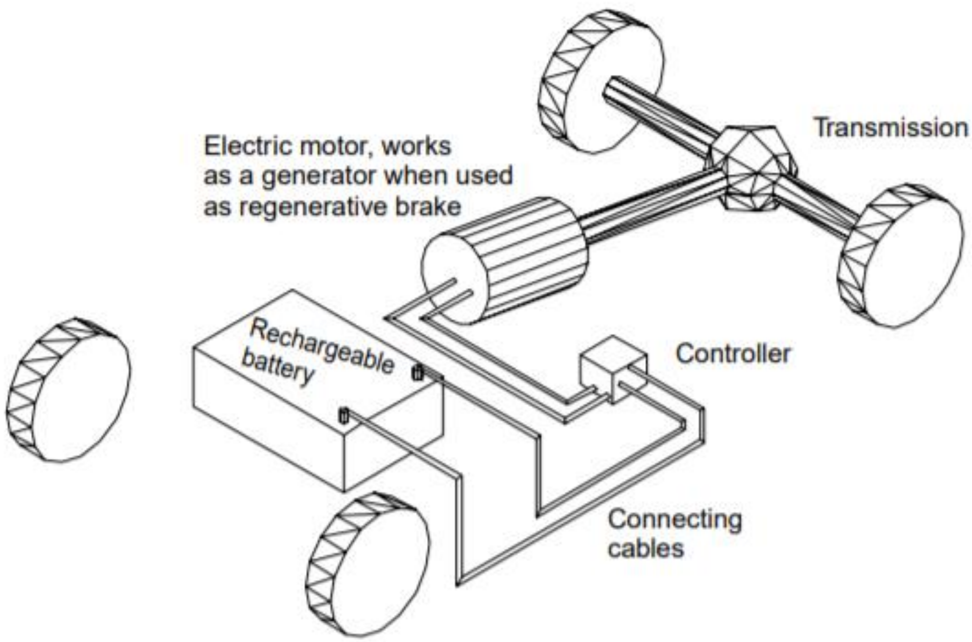
Introduction to EVs

Electric vehicles or EVs are the type of vehicles that operates on electrical form of energy, which is provided by the battery within the vehicle.

The rise of electric vehicles marked the beginning of the automobile industry. Petroleum-based fuels, on the other hand, have mostly superseded battery-operated vehicles due to their lower cost and superior performance. Electric vehicles are once again gaining popularity as a result of increased environmental concerns. When compared to conventional IC (internal combustion) engine-based vehicles, EVs emit significantly fewer greenhouse gases and are far quieter. As a result, standardizing the usage of EVs in place of IC-based vehicles could be an efficient way to reduce carbon emissions.



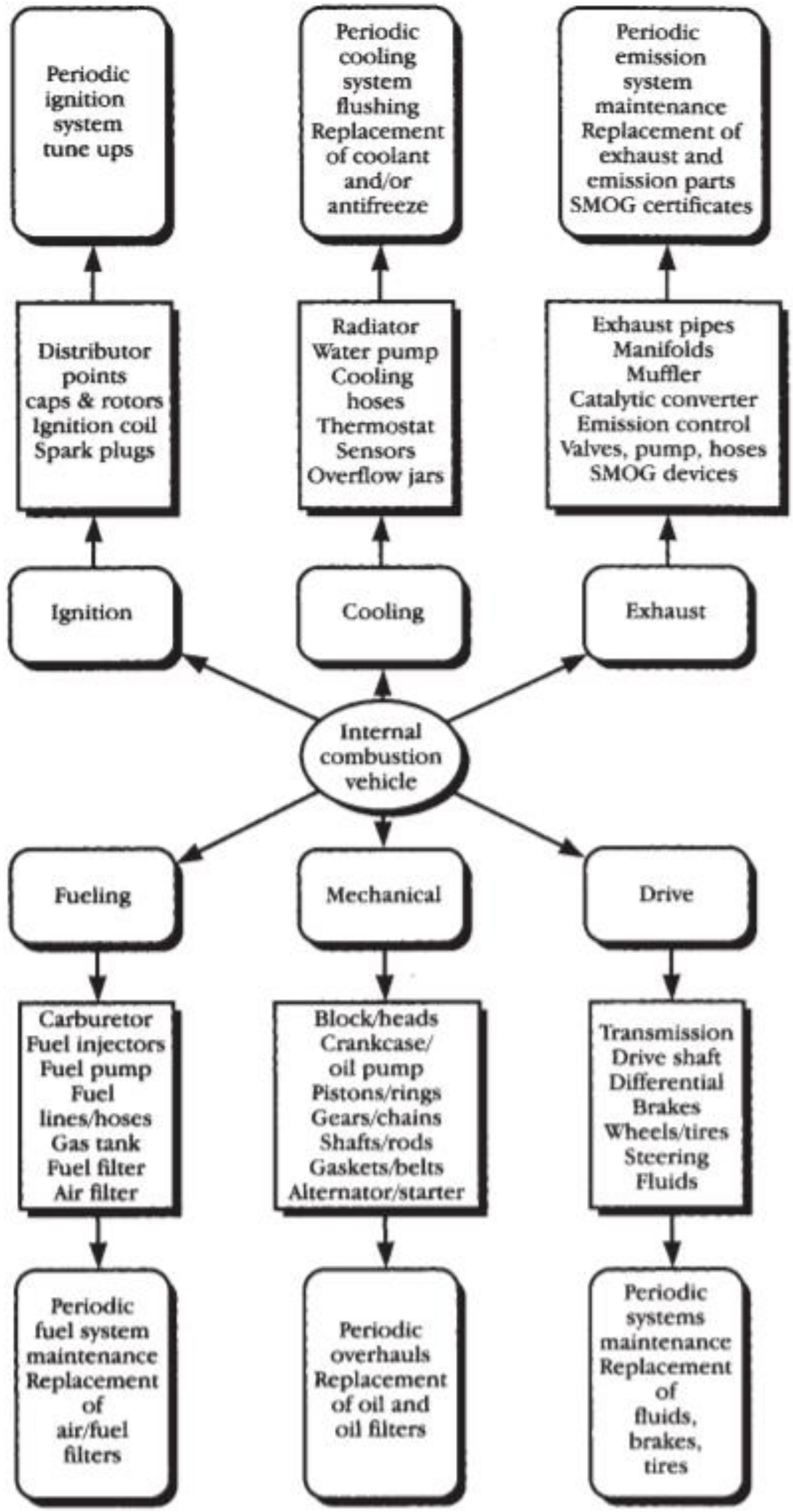
The principle of a battery electric car is relatively straightforward, as seen in the diagram above. An electric battery for energy storage, an electric motor, and a controller make up the vehicle. Normally, the battery is recharged from mains energy using a socket and a battery-charging mechanism that can be carried onboard or installed at the charging site. In forward and reverse, the controller will generally govern the power supplied to the motor, and hence the vehicle speed. Regenerative braking is frequently preferred as a means of recouping energy and as a frictionless braking method.

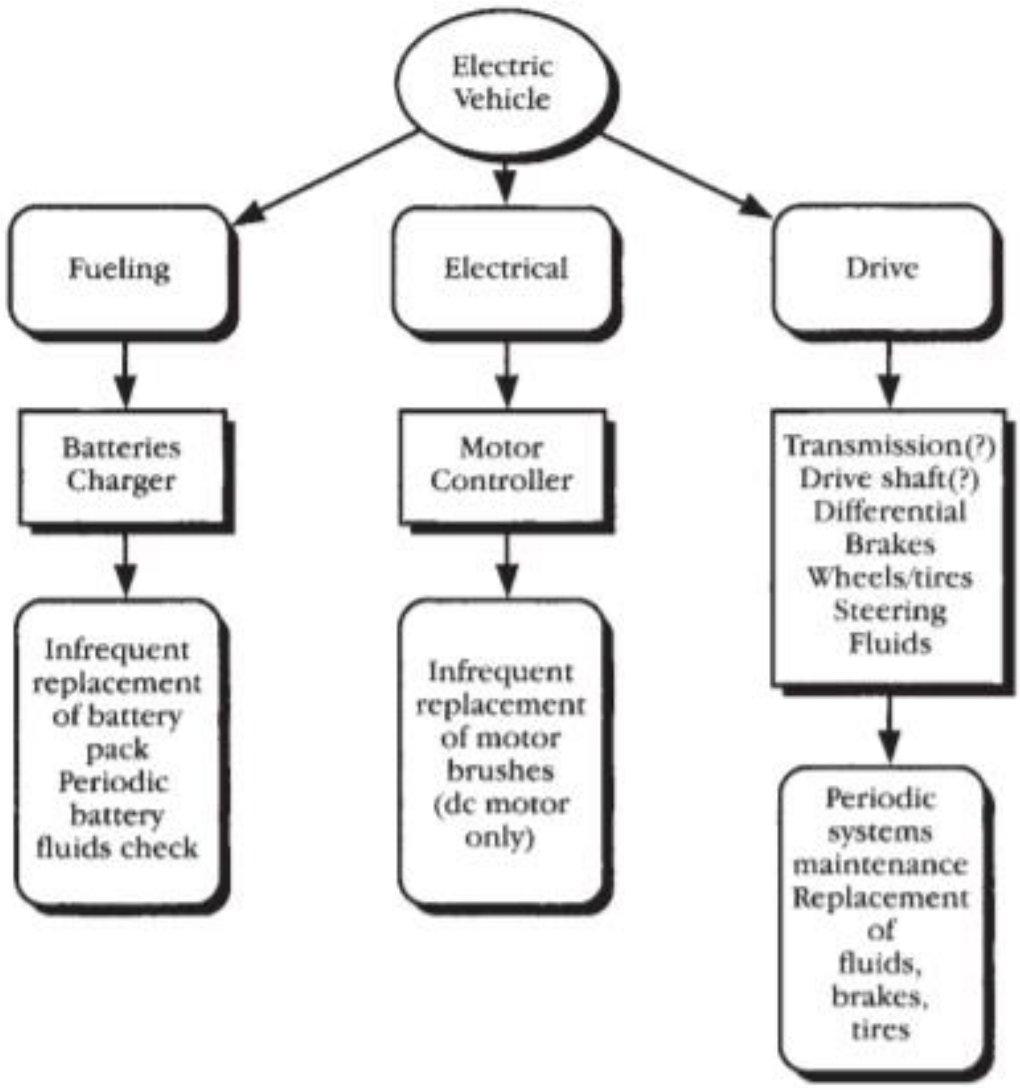
The fundamental difference between a regular petroleum-based car and an electric vehicle is that EVs acquire mechanical energy from the electricity stored in the battery via an electrically controlled motor, whereas IC vehicles obtain mechanical energy largely from the combustion of fossil fuels.

EVs have fewer moving parts than automobiles with internal combustion engines, resulting in lower maintenance costs. Due to the lack of spark plugs, fuel or air filters, and the usage of less lubricants, it has a minimal maintenance cost. Furthermore, the majority of EVs employ regenerative braking, which is more energy efficient.

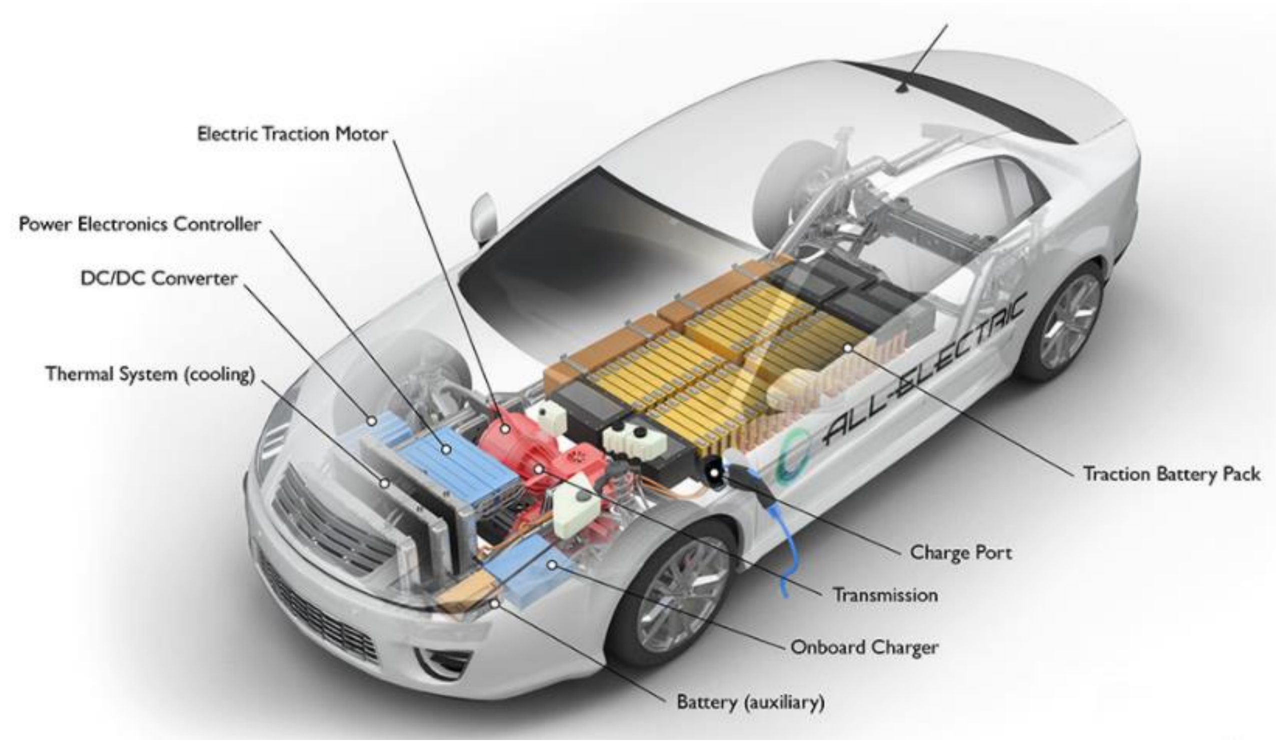
Furthermore, because the batteries are mounted on the car's floorboard, EVs have a low centre of gravity, which increases the vehicle's agility and stability, reducing the risk of it toppling. They can also provide instant torque (at 0 rpm), which most gasoline-powered cars can't. When compared to traditional vehicles, the energy generated to power EVs is up to 97 percent cleaner in terms of harmful pollutants.

However, charging time is longer when compared to vehicles with IC engines, whose tanks may be filled in minutes. EVs typically have a shorter range than vehicles powered by internal combustion engines. Because of the large batteries, they are more substantial, and to compensate for the weight, a person may have to forego other comforts. It may also necessitate repeated expenditures in the form of battery replacements over time. Last but not least, public charging facilities are not as numerous as gasoline stations, which limits the range of electric vehicles and eliminates the option of travelling to isolated places.


Periodic ignition system tune ups
Periodic cooling system flushing Replacement of coolant and/or antifreeze
Periodic emission system maintenance Replacement of exhaust and emission parts SMOG certificates
Distributor points caps & rotors Ignition coil Spark plugs
Radiator Water pump Cooling hoses Thermostat Sensors Overflow jars
Exhaust pipes Manifolds Muffler Catalytic converter Emission control Valves, pump, hoses SMOG devices
Ignition
Cooling
Exhaust
Internal combustion vehicle
Fueling
Mechanical
Drive
Carburetor Fuel injectors Fuel pump Fuel lines/hoses Gas tank Fuel filter Air filter
Block/heads Crankcase/ oil pump Pistons/rings Gears/chains Shafts/rods Gaskets/belts Alternator/starter
Transmission Drive shaft Differential Brakes Wheels/tires Steering Fluids
Periodic fuel system maintenance Replacement of air/fuel filters
Periodic overhauls Replacement of oil and oil filters
Periodic systems maintenance Replacement of fluids, brakes, tires


Electric Vehicle
Fueling
Electrical
Drive
Batteries Charger
Motor Controller
Transmission(?) Drive shaft(?) Differential Brakes Wheels/tires Steering Fluids
Infrequent replacement of battery pack Periodic battery fluids check
Infrequent replacement of motor brushes (dc motor only)
Periodic systems maintenance Replacement of fluids, brakes, tires

Working of EVs



Different pieces of the electric car that keep it going can be seen in the image above.

- **Motor:** It transforms the electrical energy in the battery into mechanical energy. Through the shaft, this mechanical energy is delivered to the wheels. This mechanical energy is what propels the car forward. When travelling downhill (in neutral gear), the engine in some EVs also acts as an electrical generator, converting the kinetic energy of the wheels into electrical energy. After that, the energy is stored in a battery (charging of battery). This is related to the notion of regenerative braking, which is employed while a vehicle is decelerating. Kilowatts are the units of measurement for its power (kW).

- **Power electronics controller:** It is made up of an inverter, a low voltage dc-dc converter, and a vehicle control unit (VCU). This component is in charge of all electrical power regulation and flow within the vehicle. The inverter's job is to convert the DC electricity from the battery to AC current and then distribute it to various components of the vehicle. LDU converts high-voltage electrical energy to low-voltage electrical energy so that it can be used by EV components, which only utilize low-voltage electricity. The motor control, regenerative breaking control, and power supply for the electronic systems are all managed by the VCU, which is a critical component of the EV.

- **Cooling system:** In electric vehicles, a cooling system is required to cool the battery and any other parts that may become hot. In general, the cooling system consists of a cooling pipe in the form of a loop that wraps around the battery pack and any electronics that are more likely to overheat. Coolants like ethylene glycol are used in the cooling pipe. With the help of the motor pump, the coolant is circulated within the pipe. Some vehicles also utilize cooling plates, which are more expensive but more efficient than cooling loops in terms of cooling (coolants).

- **Battery pack:** It is both the most crucial and the bulkiest portion of the EV. It stores the energy needed to operate the vehicle and is critical in calculating the maximum range that can be travelled without charging after the vehicle is completely charged. EVs typically stack numerous batteries into a single container rather than using a single huge battery. Individual batteries will then be connected in series or parallel to provide the ultimate output necessary. The battery pack also contains a number of relays and contractors that control the output as well as sensors (voltage, current, and temperature) that monitor the battery's health. The data acquired by these sensors is sent to a battery management system for transmission (BMS).

- **Charging port:** The fastest way to charge electric vehicles is to use a DC fast charging station. In an hour, it may charge the battery to 40-80 percent of its full capacity.

- **Transmission:** It's also known as a reducer, and it's in charge of sending the kinetic energy created by the engine to the wheel. Because electric motors generate consistent torque at every given RPM within a particular range, EVs often feature single speed transmission (i.e. only one gear instead of several gears as in IC engines).

- **Onboard charger:** The OBC converts Alternating Current (AC) from slow chargers or portable chargers plugged into household outlets to Direct Current (DC) (DC). It's a technology incorporated into the automobile that uses the AC grid to charge its high-voltage batteries while it's parked.

- **Auxiliary battery:** When the primary battery runs out of power, it is used to power electronics (excluding motors) such as lighting and control systems.

The EV works by hooking into a charging station and drawing AC electricity from the grid, which is then stored in DC form in the EV's battery pack. The inverter converts the stored DC electricity into AC, which is subsequently delivered to the motor and transformed into mechanical energy. This mechanical energy is subsequently transferred to the wheels through the transmission line, which moves the wheels and hence the vehicle.

Materials Used in EVs

To make electric vehicles more energy efficient, we need use lightweight materials. When picking a material for any part of an EV, make sure it has the essential attributes, such as strength and the capacity to tolerate high pressure, temperature, and so on. Instead of cast iron, steel, or other bulky metals, lightweight materials such as high strength steel, magnesium alloys, carbon fiber, polymer, and other composites are utilized to reduce vehicle weight.

Aluminum alloys, which are both strong and light, are used to construct the space frame. In order to reduce the weight of the EV, the steering wheels are likewise made of aluminum rather than steel. Magnesium alloy or another lightweight metal is used for the seat frames and the steering wheel's heart. The body is comprised of a recyclable impact-resistant composite material.

Copper is an important component of the electric vehicle because it is one of the best conductors of electricity. EVs have up to four times the copper content of gasoline-powered vehicles. The majority of copper is utilized in motor winding wire. Copper is also used in other devices and electric transmission lines. Permanent magnets made of neodymium are required in motors. Different types of composites are also finding their way into EVs, mostly for usage in battery enclosures due to their high strength-to-weight ratio. Materials like as acrylonitrile butadiene styrene (ABS), styrene maleic anhydride (SMA), polyphenylene ether (PPE), polycarbonate, and other fabrics are used to make dashboards, door linings, and seats. Tires are comprised of rubber and are designed to inflate to a high pressure in order to reduce tire-to-road friction. Self-sealing material is also included in tires to prevent air leakage. Windshields are solar glass that keeps the interior from scorching in the summer and from freezing in the winter. Thermal conservation materials are also utilized in EVs to limit the energy loss caused by heating and cooling impacts on batteries.

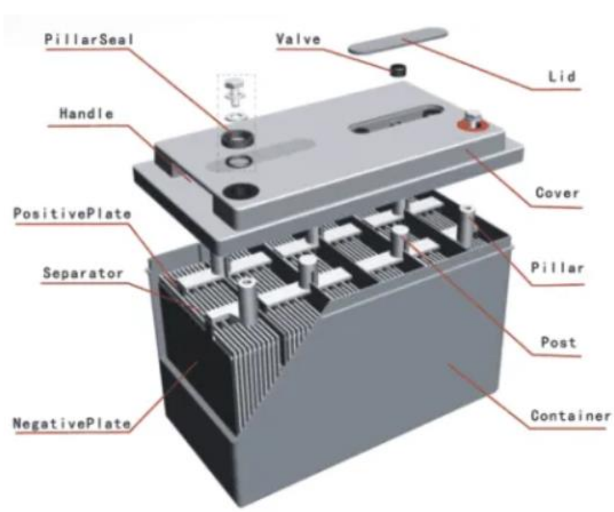
EV batteries are typically Li-ion, Li-polymer, or lead-acid batteries with a plastic covering and various transition elements such as cobalt, nickel, and aluminum, copper, lithium, among others.

Batteries for EVs

EVs are powered by batteries. These are rechargeable and were created with a high kwh capacity in mind. EV batteries are made to last for a long time and go through repeated charging and draining cycles. To reduce battery weight, these batteries offer a high power-to-weight ratio and energy density. Lithium-ion and lead-acid batteries are the most commonly utilized battery kinds nowadays.

- **Lead acid batteries:** These are the cheapest batteries on the market and the first secondary (rechargeable) batteries to be developed. Because of its familiar technology, high availability, and low cost, lead acid batteries were also the most commonly used batteries in the past. Other batteries, such as Li-ion batteries, are gradually displacing them.

  The chemical energy of the battery is stored in the potential difference between pure lead on the negative side and PbO_2 on the positive side, as well as the aqueous sulfuric acid, in the charged state. The energy released when the strong chemical bonds of water (H_2O) molecules are created from H^+ ions of the acid and O_2 ions of PbO_2 can be attributed to the electrical energy produced by a discharging lead–acid battery. During charging, the battery, on the other hand, serves as a water-splitting device. Multiple lead acid cells are connected in series or parallel to form a lead acid storage battery. The quantity of lead acid cells employed determines the capacity of the lead acid storage battery. It is made up of plastic housings with lead anodes and cathodes, as well as H_2SO_4 fluid as an electrolyte (diluted to one-acid: three-water ratio). Batteries store their liquid in absorbent pads that won't spill if they're punctured in an accident.



The lead acid battery consists of following parts:

1. **Positive and Negative plates:** Positive plate (cathode) is Lead oxide. Negative plate (anode) is pure Lead.

2. **Grid:** The grids are made of a lead-antimony alloy. The transverse rib, which crosses the sites at a right angle or diagonally, is typically used. The grids for the positive and negative plates are the same design, but the grids for the negative plates are lighter since uniform current conduction is not as important to them.

3. **Separators:** These separators, which are composed of wood, rubber, or glass mat, are placed between the positive and negative plates to prevent direct contact between the two plates. The smooth side of the divider is smooth, while the grooved side is grooved. Because the majority of the chemical reaction occurs on this side, the grooved side is placed near the positive side of the plate so that the electrolyte solution may readily move about.

4. **Electrolyte:** As an electrolyte, dilute sulfuric acid (H_2SO_4) is utilized. Electrolyte: H_2SO_4 fluid (diluted to 1 acid: 3 water ratio). Batteries store their liquid in absorbent pads that will not spill if they are punctured in an accident.

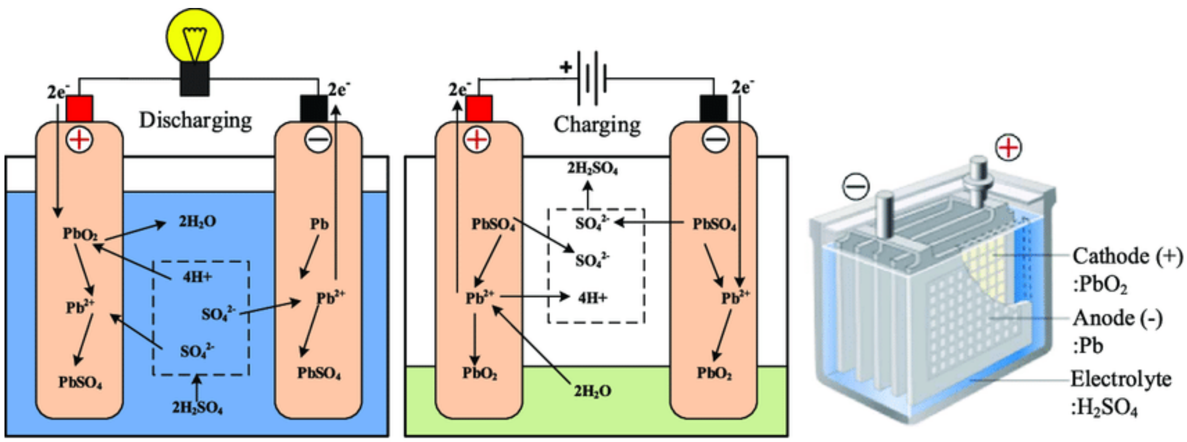
5. **Element:** The assembly of positive and negative plates is called an element.

6. **Container, Cell covers, and vent plugs:** Because the electrolyte of a lead acid battery is sulfuric acid, the materials used to create the container must be sulfuric acid resistant. It should also be free of sulfuric acid-sensitive contaminants. Iron and manganese, in particular, are unbearable. As a result, lead acid battery containers are typically built of lead lined wood, glass, ebonite, bituminous hard rubber, ceramic materials, and molded plastic parts. With the top cover, the container is tightly sealed. The top cover contains three holes: one at each end for the posts, one in the middle for the vent plug, and one in the middle for the electrolyte to be poured and gases to escape. The positive lead acid battery plates are held by two ribs in the bottom floor of the lead acid battery container, while the negative plates are held by two additional ribs. The ribs or prisms act as supports for the plates, insulating them from short circuits that would

otherwise occur due to the active material collapsing from the plates to the bottom of the container.

7. **Battery terminals:** Each lead acid battery has two terminals, which are referred to as the battery terminals. These battery connections have + and – markings on them. In most cases, the positive terminal is greater than the negative terminal.

8. **Cell connectors:** Cell connectors are used to connect the individual cells in series to achieve the desired voltage.



Discharging: The chemical energy of the battery is stored in the potential difference between pure lead on the negative side and PbO_2 on the positive side, as well as the aqueous sulfuric acid, in the charged state. The energy released when the strong chemical bonds of water (H_2O) molecules are created from H^+ ions of the acid and O_2 ions of PbO_2 can be attributed to the electrical energy produced by a discharging lead–acid battery. During charging, the battery, on the other hand, serves as a water-splitting device.

Negative plate reaction during discharging:
$Pb(s) + HSO_4^-(aq) \rightarrow PbSO_4(s) + H^+(aq) + 2e^-$

Positive plate reaction during discharging:
$PbO_2(s) + HSO_4^-(aq) + 3H^+(aq) + 2e^- \rightarrow PbSO_4(s) + 2H_2O(l)$

The total reaction for discharging can be written as:
$Pb(s) + PbO_2(s) + 2H_2SO_4(aq) \rightarrow 2PbSO_4(s) + 2H_2O(l)$

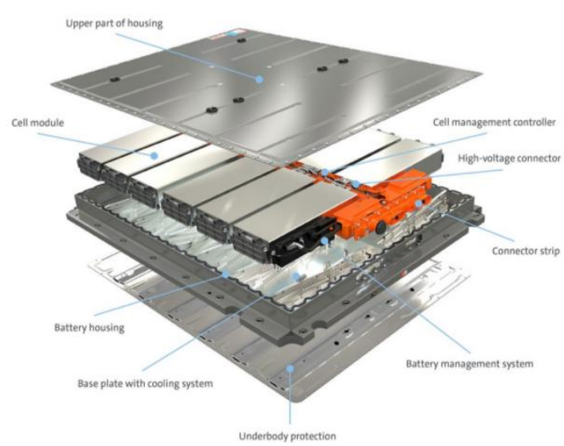
Charging: The procedure described in the discharge is reversed when charging a lead-acid battery. The lead sulphate ($PbSO_4$) is removed from the electrolyte and replaced (H_2SO_4). When acid is added to the electrolyte, the sulphate in the plates is reduced. This will continue until all of the acid has been pushed off the plates and into the electrolyte, as shown in the diagram below.

The total reaction for charging can be written as:

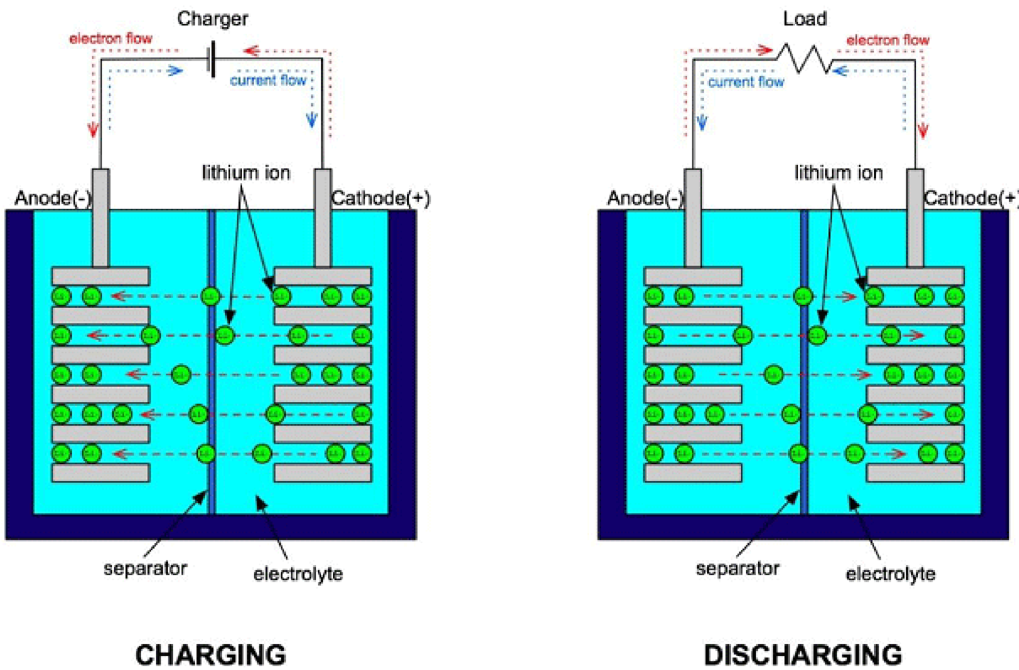
$$\mathbf{2PbSO_4(s) + 2H_2O(l) \rightarrow Pb(s) + PbO_2(s) + 2H_2SO_4(aq)}$$

Hydrogen (H_2) gas is liberated at the negative plate and oxygen (O_2) gas is liberated at the positive plate when a lead-acid battery charge nears completion. Because the charging current is usually greater than the current required to decrease the remaining amount of lead sulphate on the plates, this operation occurs. The electrolyte's water (H_2O) is ionized by the excess current. Because hydrogen is a very explosive gas, it's important to keep the battery well ventilated while it's charging. In addition, no smoking, electric sparks, or open flames are permitted in close proximity to a charging battery.

- **Lithium ion batteries:** Because of their high energy density and long life cycle, lithium ion batteries have become popular as a replacement for lead acid batteries. A battery pack for an electric vehicle contains multiple modules, each of which contains hundreds of individual Li-ion cells.



An anode, cathode, separator, electrolyte, and two current collectors make up a Li-ion battery (positive and negative). The lithium is stored in the anode and cathode. Through the separator, the electrolyte transports positively charged lithium ions from the anode to the cathode and vice versa. The movement of lithium ions causes free electrons to form in the anode, causing a charge to form at the positive current collector. The electrical current then passes from the current collector to the negative current collector, passing through a powered device (cell phone, computer, etc.). The separator prevents electrons from flowing freely inside the battery. Lithium ions travel from the negative electrode to the positive electrode through an electrolyte while discharging, and vice versa when charging. The positive electrode of a lithium-ion battery is made of an intercalated lithium compound, while the negative electrode is made of graphite. The batteries feature a low self-discharge rate and a high energy density.



Charging and Discharging: The anode delivers lithium ions to the cathode as the battery is discharging and delivering an electric current, resulting in a flow of electrons from one side to the other. When the gadget is plugged in, the cathode releases lithium ions, which are then accepted by the anode.

External shorts, runaway charging circumstances, and overcharging can generate potentially hazardous over-current and over-temperature conditions in lithium battery packs, making them particularly susceptible to failures. As a result, a standard battery management chip is placed into the battery pack to handle the charging and discharging processes of lithium-ion batteries in a smooth and safe manner. The battery management chip guarantees that the battery is not overcharged or drained, preventing harm to the battery.

LEAD ACID		LITHIUM
325+ LBS FOR SET OF LEAD ACID	WEIGHT	**72 LBS** FOR SET OF LITHIUM **1/4TH THE WEIGHT**
WATERING, CORROSION CLEAN UP, MONITORING 50% DISCHARGE LIMIT	MAINTENANCE	NONE
33% PER MONTH	SELF DISCHARGE RATE	**2-3%** PER MONTH LEAVE UNPLUGGED ALL OFF SEASON
SHOULD NOT GO BELOW **50% OF CHARGE**	MAX USAGE	CAN USE ALL **100% OF CHARGE**
8-10 HOURS	CHARGE TIME	**2-3** HOURS
500-750 CYCLES	LIFETIME CYCLES	**5000+ CYCLES** LASTS **5+** TIMES AS LONG AS LEAD-ACID

Motion of EVs

The energy in a battery is stored as chemical energy, which can be converted to electricity when needed. Because of the chemical potential difference between the anode and the cathode, ions migrate between the anodes and the electrolyte, resulting in electric potential (electricity). The battery provides DC electricity, which must be converted to AC. The inverter in the power control system performs this conversion. The power control system also ensures that the vehicle's motor receives the best possible supply of electricity. The motor rotates due to the electricity given to it. The wheel receives the kinetic power provided by the motor via a single ratio transmission line. The battery's energy was therefore converted into vehicle motion.

Indian Market for EVs

Major electric vehicle manufacturers in India: Because India's electric vehicle sector is still in its infancy, traditional automobile manufacturers are dominating the Indian EV market.

- **Mahindra Electric:** Front-runner in Indian EV market currently with various products like Reva, E2O, eAlfa mini, eSupro, eVerito etc.

- **Tata Motors:** Tata Nexon, Tata Tigor are some of the EV model manufactured by Tata.

- **Hyundai:** Hyundai Kona EV.

- **Ashok Layland:** Specialization in big vehicle production.

- **Lohia Auto:** Main products are 2/3-wheelers and e-auto.

- **MG Motors:** MG ZS electric car.

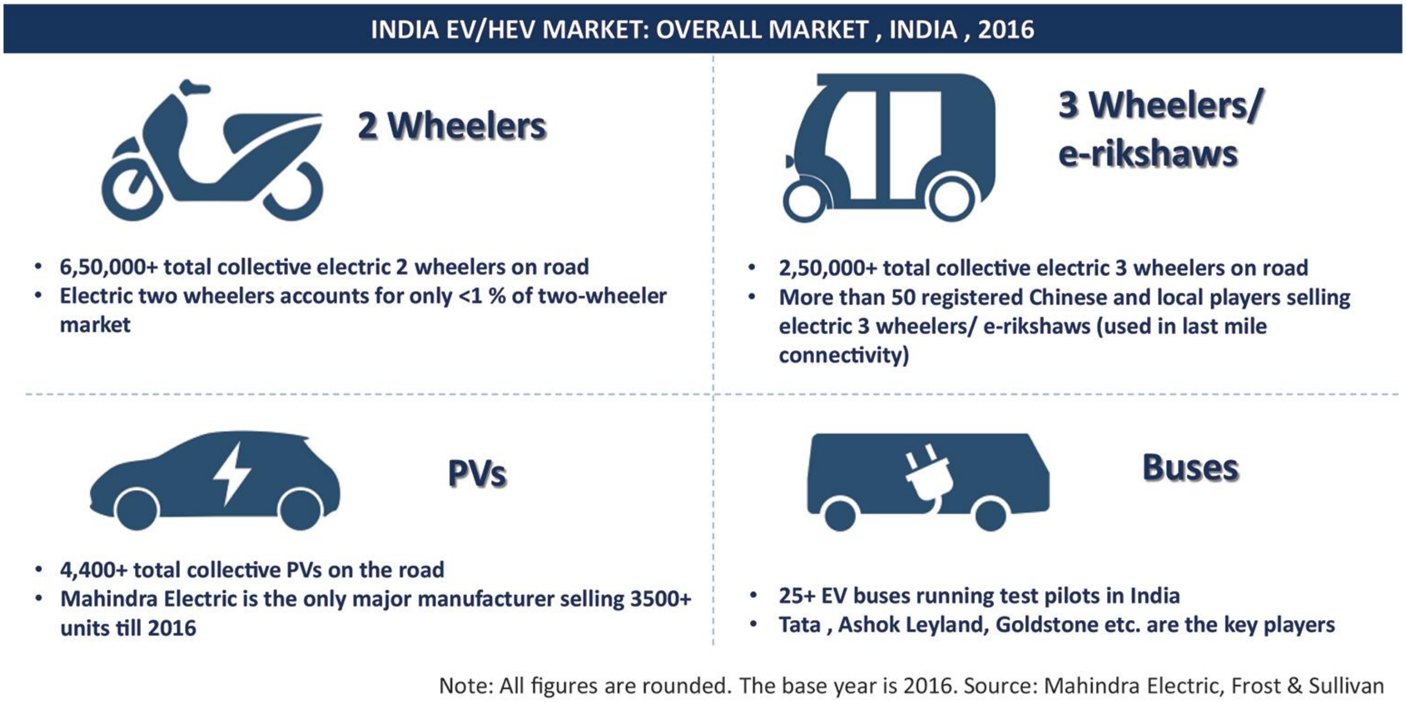
- **Ather Energy:** Scooters model 'Ather 450' and 'Ather 340'.

- **Hero Electric:** Mainly produces two-three wheelers.

The needs of citizens in different countries are obviously varied. People in the United States like pickup trucks, but we in India prefer mid-sized vehicles. A four-seater hatchback is the cheapest car in China. First and foremost, we must convert the two- and three-wheeler markets to electric vehicles. India is already looking to buy lithium and cobalt mines in nations other than China, and is negotiating a lithium import arrangement with Argentina. Lithium is also a limited resource, thus India can explore for alternatives.

The three largest EV manufacturers in India are Mahindra, Tata, and Hyundai. Tesla is also considering entering the Indian vehicle market.

1. India can currently manufacture the parts such as the chassis frame and the anodes and cathodes required for the batteries.
2. As mentioned before India is looking at the alternative source for lithium other than china.
3. Last year 1.5L vehicles were sold in India of which only around 4000 were cars and buses. The rest were two wheelers.



Government policies for EVs:

National Electric Mobility Mission Plan 2020 (NEMMP): The Department of Heavy Industry (DHI) launched it in 2013 as a roadmap for the speedier development and deployment of electric vehicles in India.

FAME Phase I: The Faster Adoption and Manufacturing of Hybrid and Electric Vehicles in India (FAME India) Scheme was notified in April 2015 as part of the NEMMP 2020, with the goal of promoting the manufacturing of electric and hybrid vehicle technology. Demand development, technological platform, pilot projects, and charging infrastructure have all been prioritized. Incentives for demand generation have primarily taken the form of lower purchasing prices.

FAME Phase II: This scheme, which was launched in 2019 for a three-year term and has a budget of US$1.36 billion, will be used to provide upfront incentives on the purchase of electric vehicles as well as promote the construction of charging infrastructure. FICCI has requested that FAME II be extended till 2025, with short-term boost incentives to encourage demand.

Ministry of Power: It has been stated that charging electric vehicles is considered a service, hence EV charging stations will not require a license to operate. It has also created a policy on charging infrastructure in order to facilitate the adoption of electric vehicles.

Ministry of Road Transport and Highways: It has stated that green license plates would be provided to both commercial and private battery-operated vehicles. All battery-operated, ethanol-powered, and methanol-powered transport vehicles will be excluded from the commercial permit requirement, according to the announcement.

Department of Science and Technology: It has announced a major competition to set Indian standards for electric vehicle charging infrastructure.

Niti Aayog: The cabinet has authorized the National Mission on Transformative Mobility and Battery Storage, and the mission's inter-ministerial steering group will be chaired by Niti Aayog's CEO. The Mission's goal is to develop a five-year Phased Manufacturing Program (PMP) to help India build large-scale, export-competitive integrated batteries and cell manufacturing mega facilities, as well as localize production across the full electric vehicle value chain.

Challenges faced by EV industry:

- **Insufficient charging infrastructure:** In 2019, India has only 650 charging stations, compared to 0.3 million in China. One of the main reasons why customers are hesitant to buy electric vehicles is a lack of charging infrastructure.

- **High costs:** Along with range anxiety (kms/charge), the current high price of EVs is a big worry among potential customers. Electric cars in the same segment tend to be more expensive than lower-end (internal combustion engine) ICE cars. This is primarily due to the increased expense of the technology used in EVs, which accounts for a significant amount of the cost, leaving little room for other features often seen in luxury vehicles. With improved R&D and market competitiveness, it is envisaged that the pricing factor will be rationalized in the future to fit price sensitivity, which is a primary factor affecting purchasing in India, particularly in the lower-end car category. With the latest announcement of incentives, EVs in the two-wheeler market are expected to become more affordable. Since the government's goals have shifted to sustainable, clean electric mobility, industry experts anticipate a similar effort to ease uptake of other electric vehicles such as cars and buses in the near future.

- **Limited options:** Customers in India have a relatively restricted choice of products to pick from because the business is still in its infancy. Increased investment in the sector will eventually make it more competitive, resulting in increased demand.

- **Lower mileage:** Because the sector is still young, there is a lot of room for R&D. EVs are currently not cost competitive for the average customer in India, as internal combustion engine (ICE) vehicles are more cost effective.

- **Higher dependency on imports:** One of the issues driving up the cost of EVs in India is the country's reliance on imported batteries and other components.

- **Grid challenges:** Another concern is the cost of charging electric vehicles at private charging stations once they become commonplace. According to Brookings India, even with a decent penetration of EVs, the increase in electricity demand is expected to be around 100 TWh (tera watt-hours), or roughly 4% of total power generation capacity, by 2030. As a result, expanding power producing methods is required to fulfil the increased demand.

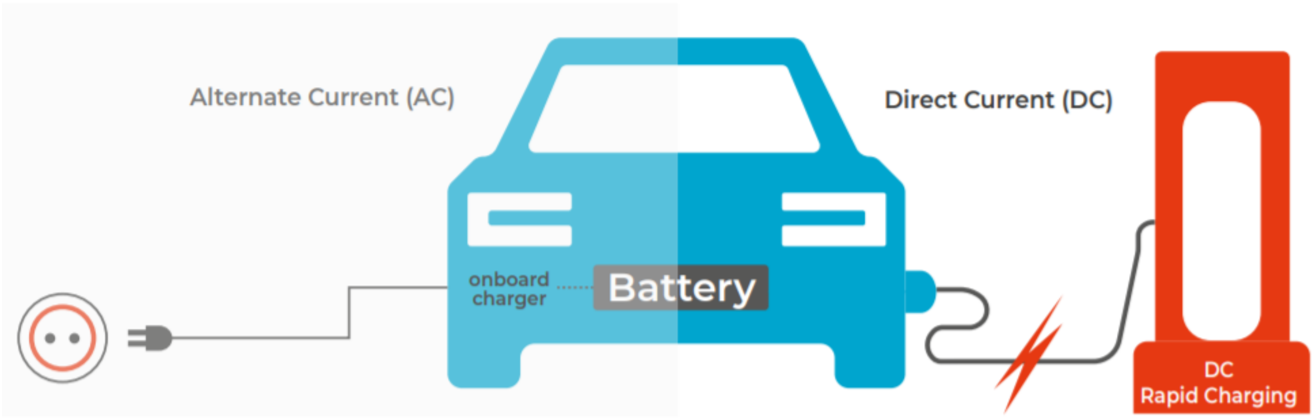
Charging of EVs

Charging is divided into two types: AC/slow charging and DC/fast charging. The grid's power is always alternating current (AC) (Alternating Current). Vehicle batteries, on the other hand, are always charged by DC (Direct Current).

- **AC/Slow Charging:** The electricity supplied by the grid is in the form of alternating current (AC). The power must be converted from AC to DC while charging portable electrical gadgets. A converter is responsible for this. In the case of electric vehicles, this converter/onboard charger is located within the vehicle. Here, AC is fed to the vehicle's onboard charger, which converts AC to DC and then charges the vehicle's battery. This charging technique is best for parking places or residences where the car will be parked for at least 20 minutes. Bharat AC-001, a low voltage charging technology that is the most cost-effective of all the standards, and Type 2 AC, which has a power output of 7.4 kW, are two sluggish charging methods. AC-001 is slower than Type 2 AC. Although a power output of up to 22 kW can be considered, no vehicle with this power output is currently available in India. OEMs such as Volvo and BMW, on the other hand, expect to release 22 kW compatible EVs by the end of 2021.

- **DC Charging:** DC charging is used in EV fast chargers. Before the power enters the car, it is converted. After conversion, the electricity is sent straight to the car's battery, bypassing the car's converter, which serves as an onboard charger. In India, however, electric 4-wheeler (4W) vehicles do not have an on-board charger capable of exceeding 7.5kW. This is done to save or reduce car costs. As a result, the majority of them use AC chargers. A DC system necessitates a significant amount of grid electricity (around 125 A). As a result, its costs (manufacturing, installation, and operation) are extremely expensive, resulting in higher pricing tariffs. It is, however, the favored charging technique for swiftly charging during long-distance trips because it allows for significantly faster charging. This form of pricing is more common along highways than at businesses or residences. Charge De Move (CHAdeMO), Bharat DC-001, and Combined Charging System are some of the fast charging standards (CCS). CCS (available in two versions: CCS1 with a 5-pin AC connector and a 2-pin DC connector, and CCS2 with a 7-pin AC connector and a 2-pin DC connector) is widely utilized by US, European, and South Korean automakers, whereas CHAdeMO is predominantly used by Japanese automakers.

AC Charging vs. DC Charging



Source: JMK Research

A 230V/15A single-phase plug with a maximum output power of 2.5kW is commonly used in home chargers. In addition, the electricity used is accounted for in the home-metering system.

Interoperability between EVs produced by different automakers and charging stations is enabled by public charging, also known as outside-home charging. Public Charging Stations (PCS) could be installed in gas stations, municipal parking lots, shopping malls, and government buildings. Countries with higher population densities have a more dense public charging network, as assessed by the number of vehicles per charging station (VCP). The Netherlands (450 people per square kilometre) has a VCP of 4, China (150 people per square kilometre) has a VCP of 6, and the United States (36 people per square kilometre) has a VCP of 79. As a result, in a country like India, where population density is high and space is limited, a public charging network is required. Furthermore, in places such as Delhi and Mumbai, where 70% of automobiles are believed to be parked on the roadways, just a small percentage of city people own a garage or parking spot for their vehicle. This needs the existence of a public space that can be shared by several cars.

EVs' Performance

The range of an electric vehicle is determined by the battery capacity, which is measured in kWh. It determines the amount of energy accessible to the motor and other vehicle components. The remaining range of an electric vehicle is thus determined by the amount of energy in the battery at any particular time.

Other factors that determine the rate at which energy is utilized affect the range of electric cars. Some characteristics, such as the car's energy efficiency or motor power, are inherent in the vehicle. Others have to do with how the vehicle is operated.

Factors that affect range:

- **Road topography:** Driving up a steep incline takes a lot of energy, especially if you're going fast. Riding at a higher altitude demands a lot more energy from the motor (and hence the battery) than travelling on flat roads, reducing the range. Driving downhill, on the other hand, provides some compensation because regenerative braking allows the vehicle to replenish its battery.

- **The weight of the car:** The more energy it takes to move a car, the heavier it is. When there are four passengers in the vehicle or a heavy weight in the trunk, the range is limited. When driving in a smooth manner, the effect on range is minimal.

- **Using interior equipment:** Although it's commonly assumed that an electric vehicle's range reduces in cold weather, most vehicles have measures in place to keep the lithium-ion batteries' chemical processes at an optimal temperature. Weather, on the other hand, can have an indirect impact on a vehicle's range because severe temperatures may prompt the driver to utilize the heating or air conditioning.

- **Condition of the tires:** It's one of the most significant cost advantages of electric vehicles: the absence of a clutch, transmission, and pistons eliminates the need for routine maintenance. Only a few consumables (brake fluid, coolant, and so on) need to be checked on a regular basis. As a result, maintenance is significantly easier and less expensive than with a combustion-powered vehicle. There are a few components, such as the tires, that should not be disregarded. Inadequately inflated tires will, of course, reduce the vehicle's range. During braking, regenerative braking also helps to reduce excessive tire wear.

- **Battery wear:** The age and quality of the battery that an electric vehicle is equipped with is a determining element in its range. Recent advancements in lithium-ion technology guarantee that your automobile battery will last a long time, even when used often. However, as a result of repeated charging cycles, there is a type of wear that can impair the battery's capacity and thus the vehicle's range over time. This is why the battery's capacity — and thus the range of kilometres it provides — degrades with time.

Disposal Challenges with Batteries

Electric vehicles are made up of a variety of metals and materials. The majority of it can be easily recycled, however batteries are not easily decomposable. Traditional automobiles used lead-acid batteries, which are very easy to degrade and recycle, with 90-95 percent of the battery's materials recovered.

Lithium-ion batteries are commonly used in electric vehicles, and while these batteries are relatively new on the market, their recycling technology is similarly new and inefficient (maximum recovery is around 70-80 percent of the battery material).

- **Recycling of Pb-Acid battery:** These are the batteries that are the most easily recycled. They are first shredded with a shredder, and then the acidic impact on these parts is neutralized. After that, the lead-containing components are separated from the remainder, and elemental lead is extracted. Other materials, such as plastics (battery case) and metals, can also be recycled and recovered to some extent and utilized to manufacture new batteries.

- **Recycling of Li-ion battery:** Li-ion batteries are more difficult to recycle than other types of batteries. Apart from graphite and polymers, these batteries contain many valuable, rare earth, and transition metals such as lithium, cobalt, nickel, manganese, copper, aluminum, and others. The recycling process is made up of several complicated phases. The battery is totally drained before being dismantled. After that, different components are destroyed in different shredders. Several hydrometallurgical and pyro metallurgical procedures are used for further recycling.

Scope of Recycling

Due to rising demand for key battery components like cobalt and lithium, as well as limited reserves, recycling these materials from old/used batteries is gaining traction. By 2030, India's annual recycling industry for outdated batteries is anticipated to be worth $1 billion. In India, recycling batteries is especially necessary because many crucial constituent elements of batteries, such as lithium, cobalt, and nickel, are scarce. Recycling them from spent batteries will be a significant step toward self-sufficiency, as we currently rely on other countries for these components, mainly China. The key reason for India's Li-ion battery manufacturing backwardness is said to be its reliance on imported metals. Furthermore, shifting geopolitical connections with the countries that have those mineral reserves, as well as the ever-changing demand-supply gap and, as a result, the changing price of batteries, might be a big impediment to the EV market's progress. As a result, it is imperative to invest in and grow up the Indian recycling industry in order to reduce imports and ensure the long-term viability of battery manufacture in India.

On the plus side, the recycling industry in India is predicted to increase dramatically starting in 2023, as the batteries currently used in EVs begin to reach the end of their useful life. Many automobile behemoths, such as Tata and Mahindra Motors, have begun or announced the construction of recycling plants. Many automakers have also partnered with other recycling companies to ensure that their batteries are properly disposed of and recycled. The government is also providing incentives to industry (such as tax exemptions) in order to speed up the recycling process. There are a variety of incentives available to consumers to ensure that used batteries are recycled rather than disposed of in landfills. Refundable battery deposits, sometimes known as the "buy back" option, are one such incentive. When spent batteries are returned to the manufacturer or a partner recycling company, a portion of the purchase price is repaid to the purchaser.

Recycling of lithium-ion batteries: As we know that Li-on batteries are better than lead acid batteries in almost every aspect but it is difficult to recycle these batteries.

The yearly lithium-ion battery market in India is expected to grow at a CAGR of 37.5 percent from 2.9 GWh in 2018 to 132 GWh in 2030. As the number of lithium-ion batteries grows, so does the number of used batteries in our ecosystem, which, if left untreated, would pose a health and environmental risk.

Furthermore, the valuable metals that make up these batteries would be lost for all time. The best approach to deal with such batteries is to use diverse mechanical and metallurgical procedures to recycle the metals and other natural resources from a discharged battery. These valuable extracts can be repurposed to make new batteries. Since, the natural reserves of most of these metals are outside of India, the Indian battery manufacturers are heavily dependent on imports. This dependence can be reduced only by recycling of spent batteries.

Some important materials used in these batteries are:

	Cobalt	Nickel	Lithium	Copper	Graphite
Uses	Used in cathode for all type of lithium-ion batteries except lithium iron phosphate battery	Used in cathode for Lithium Nickel Cobalt Aluminium Oxide (batteries)	Used in the cathode of all kind of lithium-ion batteries	Used in collector foil, electrical tabs, connections and functional items at cell and pack level	All lithium-ion batteries use graphite as anode
Abundance	Rare metal	Rare metal	Abundant	Abundant	Abundant
Reserves	Almost 55- 57% of the world reserves exist in Congo	Australia has the largest reserves (24%), followed by Brazil and Russia	75% of the world reserves exist in Argentina, Chile, and Bolivia	Chile (20.5%) has the largest reserves, followed by Australia and Peru	China accounts for almost 60% of the graphite reserves
Key characteristic	Most expensive metal in lithium-ion batteries	Most important metal by mass in lithium-ion battery cathode	Lithium is an essential part of these batteries, and hence the name lithium-ion batteries	Copper is used outside the battery cell, but it is one of the most important components in the battery pack due to its superconductivity	Quantity of graphite in the lithium-ion battery is 40 times more than lithium
Current prices (2019)	32,000 USD/ tonne	15,700 USD/ tonne	13,000 USD/ tonne	5,700 USD/ tonne	1,800 USD/ tonne

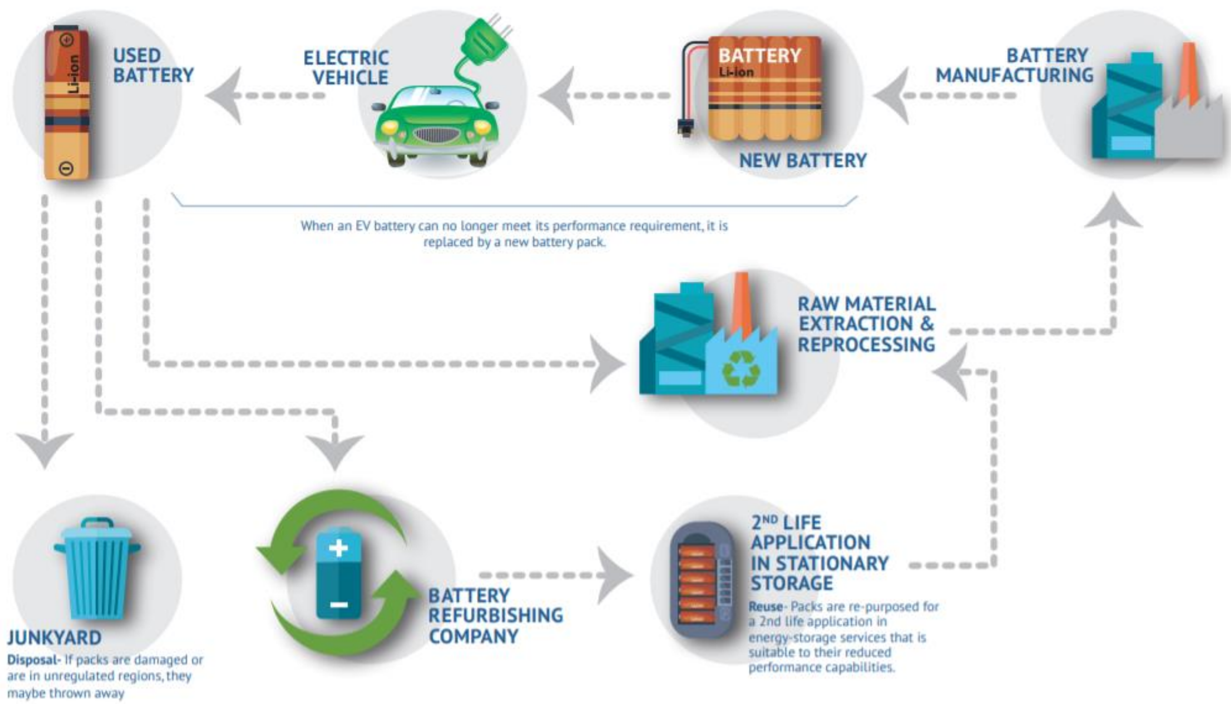
The two known solutions that help to re-use and recycle used lithium-ion batteries are:

1. **Second Life Use:** The shelf life of lithium-ion batteries used in electric vehicles is fewer than ten years. The power provided by the batteries is insufficient for an EV to attain the specified range after 5 to 8 years of use. As a result, these used batteries can be used for other secondary applications because they still have 70–80 percent of their original capacity and can last several years. Some of the potential second-life uses for lithium-ion batteries are:

(1) Electric power management for residential and commercial spaces

(2) Power grid stabilization (firming up the peak power)

(3) Renewable energy system firming by providing storage



2. **Closed Loop Recycling:** Because heavy metals are still present after use, a second-life battery cannot be labelled a sound-disposal device. It must then go through closed-loop recycling to remove the battery's valuable components. Closed Loop Recycling can be done through various process:

1. Direct Recycling (Mechanical process) - includes crushing and physical separation of components and recovery of the black mass.
2. Pyro-Metallurgical (with heat and flame) - requires the processing of spent lithium-ion cells at high temperature without any mechanical pre-treatment and loading batteries directly into the furnace.
3. Hydro – Metallurgical (With liquids and chemicals)- does mechanical pretreatment and metal recovery from the black mass by

means of leaching, precipitation, solvent extraction, ion-exchange resins, and bioleaching.

Challenges in closed loop recycling of lithium ion batteries:

- **Battery recycling is a highly complex procedure:** Lithium-ion battery technology is still in its infancy. Manufacturers' constant research and design updates to improve battery efficiency have resulted in batteries of various designs and compositions. The adoption of a standard recycling method is challenging due to these design variances, which affects process efficiency. The current recycling effectiveness of roughly 50% of the economic value, along with the high cost of recycling, makes the procedure expensive. Recycling may not be particularly cost-effective at this time.

- **High cost of recycling:** The cost of recycling a lithium ion battery in India is around INR 90-100 per kg, according to industry sources. While the profile margins are low, a Lithium-ion battery facility necessitates significant expenditures in technology for resource collection, shipping, and management. It takes at least 5 years for costs to be recovered and earnings to be booked.

- **Safety issues:** With waste lithium batteries, safety issues associated with collecting, transport, and storage may be an issue. If the discarded battery is pierced or short-circuited, the remaining energy can be discharged quickly, causing a fire.

- **Collection and transportation of waste lithium ion batteries:** It is a difficult task. At present, less than 5% of the lithium-ion batteries that are spent are being collected today

If cell-manufacturing units are set up in India in the near future, another 8-10% of the production waste from these units can be recycled. Many Indian corporations have already begun to consider this profitable prospect and have either begun or announced intentions to create recycling facilities. Some of them include:

• **Attero Recycling:** They have commercial lithium-ion battery recycling plant operational in India for more than 15 months.

• **Tata Chemicals:** In August 2019, they launched its lithium-ion battery recycling operations in Mumbai. The operations, launched at the pilot-scale, could recycle the spent batteries successfully. They now plan to scale their operations up; to recycle 500 tons of spent lithium-ion batteries.

- **Raasi Solar:** They have announced plans to set up a 300 MW plant focusing on lithium battery recycling along with battery assembling and cell manufacturing.

- **Mahindra Electric:** They also have expressed its plans to enable EV battery recycling, in a method similar to the recycling of cell phone batteries, with the help of a supply partner

Scope of Materials Used

- **Use of Light-Weight Materials:** The range of an electric vehicle is inversely proportional to its weight, as a larger vehicle consumes more energy (fuel). As a result, it's critical to choose materials that are both lightweight and sturdy. Although aluminum has typically met this requirement to a large extent. To meet the customer's ever-increasing appetite for greater variety, it has become increasingly important to seek out lighter and stronger materials.

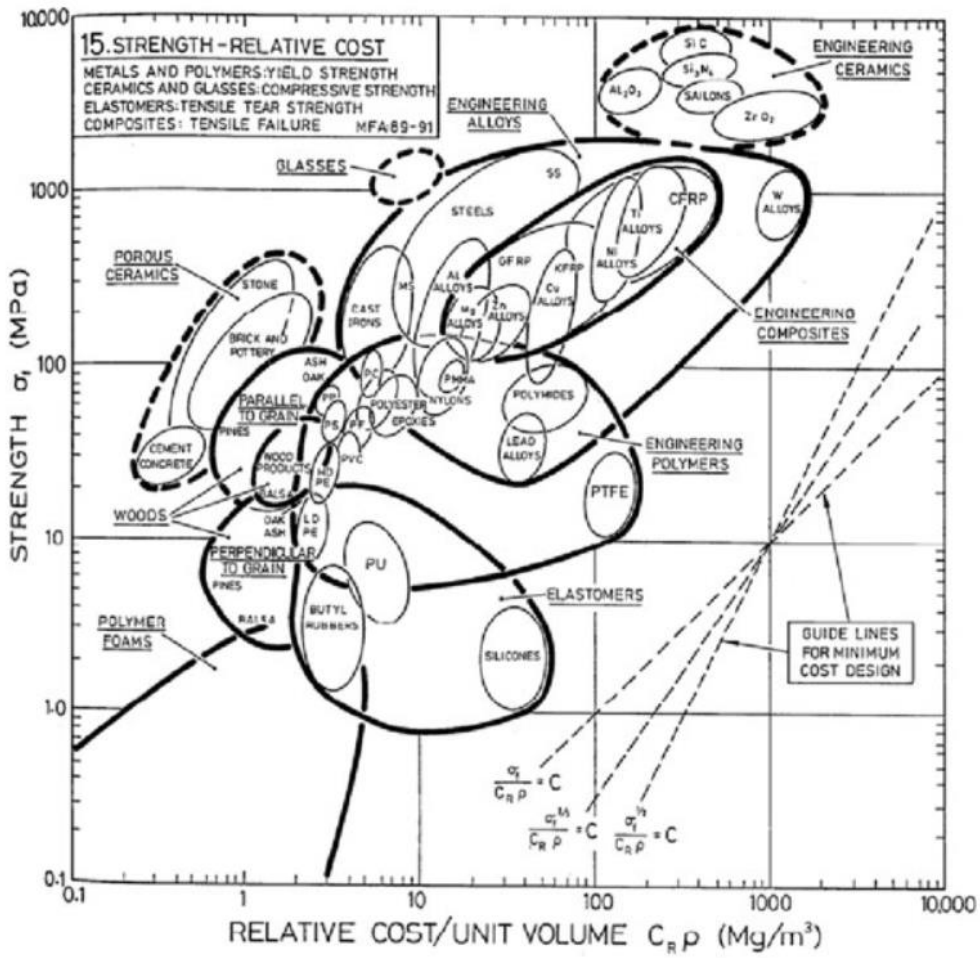
  Using materials such as glass fiber reinforced polymer composites or aluminum matrix composites, carbon fiber composites can reduce the weight significantly as compared to the metallic compound. Mass reduction by using given materials with respect to steel is,

  1. Magnesium: 30-70%
  2. Carbon Fiber Composites: 50-70%
  3. Aluminum Matrix Composites: 30-60%
  4. Glass Fiber Composites: 25-35%
  5. Advanced High Strength Steel: 15-25%

  South Korean scientists have produced a lightweight aluminum and steel alloy that is also very inexpensive and extremely strong. To combat the brittleness caused by aluminum alloying in steel, a little quantity of nickel and manganese is added, coupled with the proper heat treatment.

  The Fraunhofer Institute for Structural Durability and System Reliability LBF has developed a traction battery with thermal storage capacity with partners. The focus is on a novel sandwich battery housing made of continuous fiber reinforced thermoplastics (CFRTP), which helps to insulate stored heat in the traction battery for preconditioning. The sandwich construction has several advantages. It offers high light-weight potential and enables high specific bending properties and impact resistance. In addition, it provides a high level of protection against intrusion events, which play a major safety role in battery packs.

  The metal rotor shaft cab be replaced with a hybrid Carbon Fiber Reinforced Plastic shaft. Similarly, the laminated magnet carrier can be replaced with an injection moulded SMC (sheet moulded compound) part with functional separation of the torque transmission and the magnetically active part.



We can think along with these Ashby diagram to get an idea of appropriate material selection. As we can observe composites and metallic compounds are placed quite higher in strength and low in density as required for used in EVs. Composites can also be a very good alternative to the metallic alloys as they have low density and demonstrate high tensile strength. we need to be cautious about the cost of these materials. Composite are costly as compared to steel, so it should be ensured that additional cost of these materials is well compensated by increased range. Otherwise, there is no point of using these materials. Again, on a positive note, it is expected that as the research and development of composites speeds up, the prices will only come down.

Scope of Charging

We know that DC charging is better than AC charging (via on-board charger) due to many reasons. For DC charging, we can either use a charging station or implement a swapping station concept.

- **Charging Station:** Setting up of charging station requires

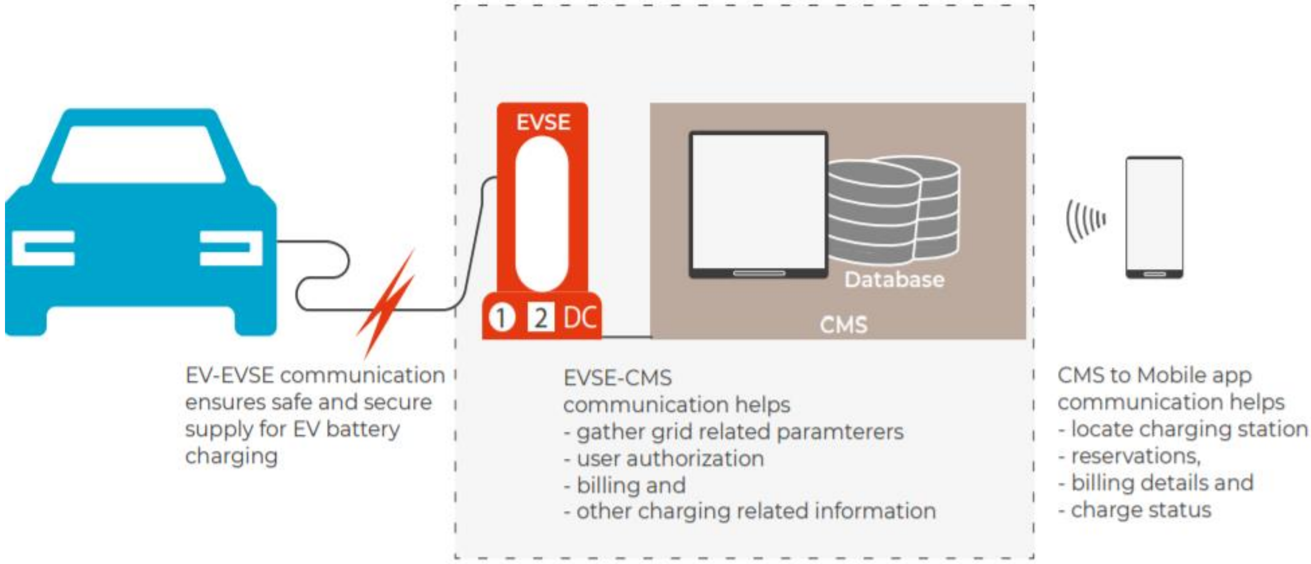
  • Hardware (charger/EVSE)
  • Software (Central Management System/mobile app)
  • Service (maintenance of charging stations and other hardware/software)

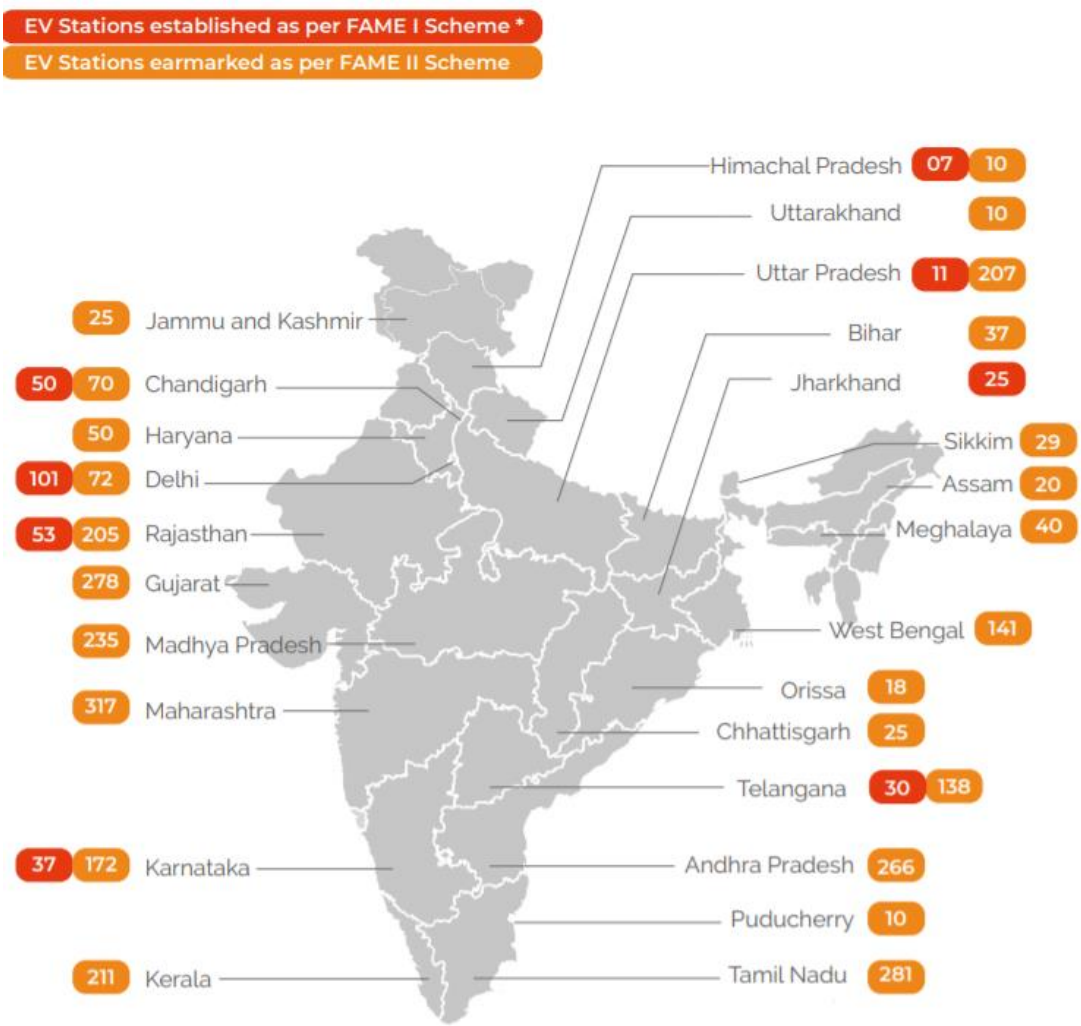
  An EV Charging Infrastructure, in essence, includes the following:

  • Charging station that contains several EVSE (Electric Vehicle Supply Equipment)/charge points. So, a charge point can be considered as equivalent to a refueling hose of a gas station/petrol pump. A charge point in turn contains several connectors/outlets however, per charge point, not more than one connector can be active at a time. This connector, through which the electricity is delivered, can be a socket or even a cable. A charger is then connected to one of these connectors basis requirement, which then goes directly to the vehicle's socket.

  • Central Management System (CMS) is a cloud-based backend system managed by the company operating the charging station. The CMS manages user authorization, billing, and rate of charging.

  • Mobile Application enables end-users in finding nearest charging stations, reserving a charging slot, and paying. Digital infrastructure availability in the form of charging location finders, IoT infrastructure for multiple cars, online charging reservation platforms, and online payment platforms completes the value chain of charging infrastructure efficiently.





*Delhi-Chandigarh Highway: 16 ; Mumbai-Pune Highway: 15; Jaipur-Delhi-Agra: 29; Goa: 6

Source: Department of Heavy Industry, JMK Research

- **Swapping Stations:** The main problem associated with the charging of EVs is the time taken to fully charge a flat/empty battery, which is usually in hours. Comparing to the conventional cars whose empty tanks can be refilled in the matter of seconds, EVs may not look tempting to customers due to this time delay. To address this problem, companies can introduce swapping stations for batteries.

  The idea of Swapping stations is almost similar to charging stations, except that the discharged batteries of EVs will not be charged itself at the station, instead they will be swapped with the charged one.

  Following procedure is suggested in this whole swapping process:

- When the battery in the EV is about to get fully discharged, the EV should be taken to nearby swapping station.

- Discharged batteries are exchanged with the charged ones. The EV owner pay the service charge (consisting of charging and maintenance of batteries) to the station owner.

- The exchanged discharged batteries will then be charged at swapping stations for further use.

- To avoid the mixing of batteries of different brands it is also suggested that the batteries should be maintained as the property of swapping station companies, not of the EV owners themselves.

  This process will greatly reduce the time taken to refill the energy as swapping the batteries will hardly take 10 minutes instead of hours taken in charging at charging stations. Our idea is to rent out batteries instead of customers actually buying them. If the owner of the company can give an incentive by giving the first battery free of cost with the help of government, citizens will be more preferably buy EVs. The idea is to charge the rent and electricity fees every time the battery is swapped instead of charging the petrol fees.

Cost-Benefit Analysis for swapping stations:

Our main goal is to prove that electric vehicles with swapping stations would be a better option for India than internal combustion Engine vehicles.

We will make the following assumptions:

- The power of engine in both the EV and ICE vehicle are same
- The Engine lasts for the same time in both the variants
- The service costs for both the vehicles will be same
- We take the mileage data from real products in the market
- Another important assumption we must make is that roads are flat as electric vehicles can travel at lesser speed on uphill roads. Since we are talking about Indian market, we can focus on auto rickshaws as they are one of the most important and popular modes of transport in India. According to a study, it is seen that e-rickshaws comprise of more than 80% of the electric vehicles market share in India.

Let us start with the cost of e-rickshaw and a conventional rickshaw. An e-rickshaw costs in the range of anywhere between 0.6-1.1 lakh rupees. Whereas, a conventional one costs in the range of 1.5-3 lakh rupees. In this case, there is a clear difference in the cost of the rickshaw.

The average mileage of a e-rickshaw is 13km/kwh.

An average e-rickshaw has four 12V 100 Ah batteries.
Which means 12 x 100 = 1200 VAh = 1.2 kWh. So an e-rickshaw has a capacity of 1.2 x 4 = 4.8 kWh. But, We also know that not all 100% will be used as a battery is never 100% charged or 100% discharged. Hence, we will assume that it is 85% efficient.

Hence the effective capacity of the battery is around 0.85*4.8= 4.08 kWh

Since the mileage is around 13 km/kWh, the total distance it can go on one charge is 13 x 4.08 = 53 km.

Vehicle type	Average distance between destinations (km)	Average number of trips per day	Average distance covered per day per vehicle (km)
Bus	20	4	160
Taxi	n/a	n/a	150
Auto-rickshaw	5.03	10	100

Source (Dutta 2012)

The average distance that is travelled by a typical rickshaw in one day is 100km. Which means that an e-rickshaw finish an average day of travelling with approximately two charges. But since charging may take a lot of time we can introduce swapping system instead of charging system.

In this, the customer will be charged for renting out batteries as well as the electricity cost required to charge the battery.

Will this be profitable to the customer?

In India, electricity cost is Rs.6 per kWh. Therefore even to fully charge the e-rickshaw it will cost 4.8*6 = Rs. 28.80.

Now if we consider this battery as being rented out by the company to the customer, we can include the rent cost as Rs. 5 per battery (Rs. 20 approximately as there are 4 batteries) and charge the customer Rs. 50 per swap, it will still be cheaper than a conventional auto rickshaw.

A conventional auto rickshaw gives a mileage of 20 km/kg of LPG.
Which means on an average, it requires 5 kg of LPG per day. The cost of LPG is approximately Rs.36 as of today.

Hence, it will cost approximately Rs.180 per day.

Whereas in case of swapping batteries in e-rickshaw it will cost less than Rs.100 per day including the rent.

Can company that is renting out batteries make any profit from this?

A single rickshaw battery can cost approximately Rs.9000.

According to research by a battery manufacturing company (Cadex Electronics), it can be charged upto 500 times in an intense situation before the battery life starts depreciating. Now if we consider the rent per charge is Rs 5 per battery charging, the company can make Rs 2500 per battery before it can be stopped from electric vehicle usage.

But it does not end there. The battery still has approximately 80% of its life left. Hence, it can be used in UPS battery. The company selling the battery can also manufacture UPS with these batteries. A typical UPS can sell for up to Rs. 10000. Hence the company can easily make lots of profits from just one battery.

Even after the battery becomes a scrap, it can be sold for up to Rs.90 per kg as a scrap waste. The scrap is usually processed to extract the valuable metals present in the battery such as lithium.

This Rs. 3000 is the profit that the company can make in worst case scenario as the battery can be charged more than 500 cycles if the situation is not extreme.

The only problem is that the company needs to make an initial investment and there should be enough EVs on the road to keep the company in business.

If all the batteries are being rented out, the battery cost can also be subtracted from the cost of the rickshaw and hence it will be available for an even cheaper price.

Scope of Low-Cost Innovations

The key issue that must be addressed initially in order for EVs to become mainstream in India is their cost, as well as charging infrastructure and equipment. EVs are currently substantially more expensive than conventional cars. Few ways in which the price can be reduced to some extant are:

- **Conversion of existing conventional vehicles to Electric vehicles:** Electrical motors and batteries are used to replace internal combustion engines. This will save money in the long run because most of the parts from the prior automobile will be reused instead of being recycled. As we migrate from conventional to electric vehicles, it will also solve the problem of dumping existing petroleum-based vehicles.

  It has already been implemented by E-Trio, an ARAI-certified firm situated in Hyderabad. They take outdated petroleum-based automobiles like the Maruti Wagon R and Tata Swift and entirely convert them to electric vehicles with the right modifications. They even offer a warranty on it, which includes both manufacturer and component warranties.

  However, the biggest drawback is that this conversion is only possible for a limited number of vehicles, as each vehicle model necessitates distinct hardware modifications to accommodate the additional components. Another consideration is the documentation, which must be reissued/re-registered because the chassis/engine numbers may differ after conversion.

- **Use of cheap materials:** There are a few instances where different low-cost materials can be used without compromising the build quality. Battery-packing, battery enclosure, motor envelops, insulators, heat exchangers, and other components It is possible to minimize the ultimate cost by using low-cost polymers and metals. Application of a cooling tube The need of expensive plate heat exchanging materials between the stacks of batteries can be reduced by using refrigerant. Similarly, battery enclosures, which are typically built of metals (aluminum alloys or extrusions), are large and expensive. As a result, various composite materials, resins, and polymers might be explored and promoted in order to overcome this difficulty. 'TRB lightweight structures' designed and manufactured a battery enclosure utilizing composite materials as an example.

- **Cheap chargers:** Manufacturing and marketing low-cost charging equipment could be a crucial step toward normalizing EVs in the Indian market, given that many customers will not choose the expensive chargers provided by the vehicle manufacturer. Though cheaper charging devices may be of inferior quality and take longer to fully charge the battery, they can be constructed in such a way that they provide the best performance at a low cost.

- **Manufacturing of smaller/lightweight cars**: With lower number of seats for those people with few family members who prefer cars over bike to commute.

- **More charging/swapping stations:** At this time, India has over 70,000 petroleum gasoline stations. If the government can ensure that each station has a few charging ports for EVs as well, the charging infrastructure problem will be greatly alleviated.

Since comparing all the countries in the world with ours, it is best to analyze the markets of the two major electric vehicle markets in the world, China and USA.

In USA, as we all know the major manufacturer of electric vehicles is TESLA. Tesla started producing stylish and high performance electric vehicles since 2008. They built a nation wide charging infrastructure to help people to charge their vehicles anywhere they travel in the country.

US Government policies:

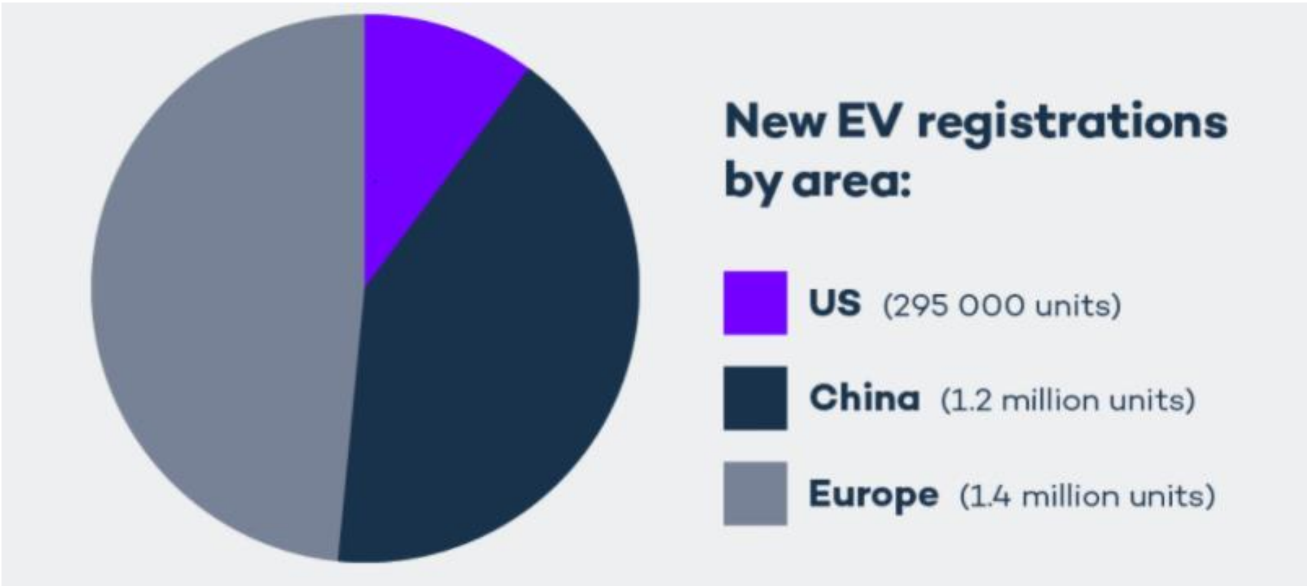
While researching about electric vehicles, it is also important to study how the government of the country is promoting its citizens to shift to using electric vehicles from conventional vehicles. The government gives tax credits to anyone who owns an electric car which ranges between $2500 to $7500 depending on the battery capacity of the vehicle.

Over half of the states in the United States are using rebates, tax exemptions, and tax credits to motivate EV purchases. For instance, California offers rebates to light-duty zero emission vehicles and plug-in hybrid electric vehicles (PHEVs); low-income families are eligible for an extra $2,000. Washington and New Jersey exempt EVs from motor vehicle sales and use taxes. Louisiana and Maryland provide tax credits of up to $2,500 and $3,000 per vehicle, respectively.

Difference between Indian and US Government:

Now, the main question is can Tesla come to India as a Electric Vehicle brand? Yes they can. But can they use the same models they used in the USA? No they cannot. This is because of the difference in requirements of the US and Indian auto market. In USA, they like sedan and pickup truck kind of vehicles. Whereas in India, we prefer two wheelers and medium sized cars.

Also, the cost of the vehicle plays a major role. Tesla's cheapest electric car model costs $40000 which is close to 30 lakh rupees. According to a study, Indians usually prefer car in the range of 5 lakh - 15 lakh rupees. This is because India mainly has a middle-class population. So a car in the range of 30 lakh is considered to be a luxury. For Indian citizens to start using electric cars, it must be sold at a price which is a lot less compared to the US market.



China is currently the world's second largest EV market after Europe. Since buying an EV costs more than buying a conventional internal combustion engine (ICE) vehicle, in 2009 the government began to provide generous subsidies for EV purchases. But the price differential and the number of buyers were both large, so paying for the subsidies became extremely costly for the government. There are many policies that the Chinese government implemented in order to push people into buying electric vehicles.

China Government Policies:

Due to the excessive pollution caused due to vehicles in China, the government restricts the movement of conventional vehicles from 7am to 7pm on a given day. There are also some days when conventional vehicles are not allowed to ply on the roads. But an electric vehicle does not have these kind of restrictions. They are free to ply at anytime of the day.

China also has an incentive where in, if you buy a gasoline car, the buyer must pay a tax of close to $12000 just to get the license plate. But this tax can be exempted if you buy an electric car.

The manufacturers also have to produce certain quantity of electric vehicles per year or else they are heavily fined by the government.

This clearly goes to show that the growth of Chinese electric vehicle market is mainly because of the subsidies offered by the government.

What can India learn from the Chinese market?

Even though the subsidies and incentives may seem a little extreme, it cannot be denied that it is because of these incentives that the electric vehicle market in China has grown so big. India also should implement some strict policies in order to promote the electric vehicle market.

Waste Generation

The process of creating a car begins with the extraction, refinement, transportation, and manufacturing of raw materials into various components that will be integrated to create the car itself. Both conventional and electric cars go through the same process. Electric cars, on the other hand, produce greater carbon emissions at the end of the production process. The process of creating a car begins with the extraction, refinement, transportation, and manufacturing of raw materials into various components that will be integrated to create the car itself. Both conventional and electric cars go through the same process. Electric cars, on the other hand, produce greater carbon emissions at the end of the production process.

For instance, to produce 1 ton of REE, 75 tons of acid waste (that isn't always handled in the right way) and 1 ton of radioactive residues are also made, according to the Chinese Society of Rare Earths*. In spite of these pollution issues, research tells us not to worry about the availability of these rare earth elements and when it comes to lithium, there is data estimating enough worldwide reserves for the next 185 years, even if the EC market triples, according to the Deutsche Bank. As for cobalt, graphite, and nickel, they also seem to be in a comfortable situation, since the demand for the years to come is expected to stay far away from the reserves Earth has to offer. Although it looks like everything will work out just fine, let's not forget the negative environmental impact of extracting REEs.

Apart from the weight of the REE, the energy used to manufacture the batteries accounts for roughly half of their environmental impact, as most of this energy is not derived from low-carbon sources. Nonetheless, forecasts show that power generation is improving, and more renewable sources are entering the grid, which will help reduce pollution generated by battery manufacturing.

If the production of electric vehicles increases, the waste that is generated would also significantly increase.

To put the scale of EV battery trash in perspective, China recycled over 60 metric tons of lithium-ion batteries in 2019, accounting for more than 70% of the global battery recycling market. South Korea is the second-largest recycler of spent batteries, with little under 20 metric tons recycled.

Because of the high cost of energy and the growing problem of e-waste, China has focused on battery recycling. CATL, BYD, and Guoxuan High-Tech dominate China's battery recycling sector.

German multinational BASF is also a major player in lithium-ion battery recycling, while Belgian mining company Umicore also recycles EV batteries for Tesla and Audi cars.

India has not yet prioritized battery recycling, which could represent a significant market gap. India must prepare for the first wave of used batteries and those upgrading to newer EV models as EV sales are projected to increase.

To tackle this dilemma, Indian battery producers and startups must stand up and collaborate. Even as India's electricity demand rises, the operating expenses of electric vehicles will rise in the coming years. By recycling battery materials and reusing batteries, India can keep electric energy costs under control.

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