# Electric Vehicles for India: Overview and Challenges

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**Abstract**

The global pollution is on rise and every effort made, being to reduce the CO2 emissions and save the planet. One such effort is the introduction of Electric Vehicles (EV). The transport sector is one of the biggest emitter of CO2 and hence it is very important to convert the sector to a green sector. Indian government has come up with ambitious plans of introducing the EVs to Indian market and keep in pace with the development of EVs globally. The National Electric Mobility Mission Plan 2020 (NEMMP 2020) has come with a detailed report on the EVs.

## 1. Charging Infrastructure

At present, India needs to provide adequate charging infrastructure to boost the adoption of EVs by Indian customers. The lack of charging infrastructure will put the customers under range anxiety, as the vehicle may not run long without charging infrastructure at regular intervals on the roadways. Charging infrastructure classified into following:

### 1.1 Home Charging:

This is the most common type of charging. The customer needs to have a 230V/15 A single phase supply in order to charge the EVs. They can deliver a maximum of 2.5 KW. The charging process takes time and it is expect that the customers will charge the EVs at night. The metering is connect directly with home metering and hence there is no separate billing for it. However, there may be soon a policy emerge to regulate the home charging also with separate metering and guidelines for builders to mandatorily include EV charging stations in flats and apartments.

### 1.2 Public Charging:

Public charging maintained by the government or its any of delegated bodies. Public places such as parking lots, malls, offices may be target to offer public charging. They are meter separately.

a) AC Charging: AC charging can be a slow or fast charging. They will employ a power converter to convert the ac power into dc power to charge the batteries. The slow charging will charge at 2.5 kW to 3 kW while fast charging will charge at the rate of 7.7 kW to 22 kW. The IEC 60309 Industrial Blue connector prescribed as the Bharat EV standard to be use in AC charging.

b) DC Charging: In this method, the output of the charging port directly provides high current DC power to directly fed to the batteries. The charging rates are very high upto 50 kW. The voltage rating of them is 48V/72V. DC fast charging infrastructure is very important for buses and cabs, which usually travel long distances. The connector recommended is GB/T connector standard.

## 2 Research and Development in Electric Vehicles

### 2.1 Battery Cell:

The battery cell forms the basic unit of the battery pack that is employed in the EVs. The battery cells together constitute a module and several such modules collectively form a battery pack. The batteries form the major cost in EVs. Their cost is nearly half of the cost of EVs. Hence, if the cost of batteries brought down, then cost of EVs will come down. The prices of electrodes and electrolytes needs to bring down to affordable prices. The research on battery cell involves increased thermal protection, higher power density, increasing the lifespan and coming with lightweight materials.

There are various battery technologies available for EVs. They are summarize as follows:

**a) Lead-acid Battery:** These batteries employ lead oxide as positive active material; spongy lead as negative active element and sulphuric acid used as the electrolyte medium. The advantaged of lead-acid batteries are that are very commonly available and cost very less. The technology has been around fifty years and has matured now. The disadvantages are that they have a limited life cycle and low power density. They also weigh heavier.

**b) Nickel-Metal Hydride Battery:** These batteries carry nickel hydroxide as positive electrode and titanium or nickel as negative electrode. The electrolyte solution is alkaline solutions. These batteries are resistant to wide temperature changes and their life cycle are long. They are also recyclable. However, they suffer from lower charge-discharge cycles.

**c) Lithium ion (Li-on) Battery:** Currently the lithium ion (Li-on) batteries developed for running the EVs. There are three main variants of Li-on batteries. They are

***i) NMC (Lithium Manganese Cobalt Oxide)***

These batteries employ graphite as anode. NMC batteries very commonly used because of less cost. The other features of the battery is that they carry the highest specific energy and they are lightweight. This gives a significant edge over other variants. The disadvantage with these batteries are that they cannot be charged very fast (less than an hour) and typically requires 6 hours of charging time for normal usage of EVs. They also cannot exposed to ambient temperature of 40 degrees or above. These batteries carry 80% DoD and last up to 2500 charge-discharge cycles. The normal discharge rate of battery is 2 hours.

***ii) LTO (Lithium Titanate)***

The LTO batteries can address the disadvantages of NMC batteries. These batteries can be charged fast (less than 30 minutes) and they are resistant to high ambient temperatures of 45 deg. They also can last up to 10000 charge-discharge cycles and hence they seem to be a very attractive. However, the downside of the LTO batteries are that that specific energy is lesser than NMC and they weigh more. However, there cost that is the main disadvantage. They cost around 3 to 4 time higher than NMC.

***iii) LFP (Lithium Phospate)***

The LFP batteries occupy an intermediate position between the NMC and LTO batteries. Compared to NMC batteries, there are more temperature tolerant, but lesser than LTO. They can also charge and discharge faster.

India's approach towards battery cell should be a collaborative research with the global players and not entirely on its own. Many countries such US, Japan, China, Korea have advanced battery technologies and hence it will be wiser for India to collaborate with them. This can be done by many ways. One way is to let the global players invest their infrastructure in India. This will help the country in gaining the needed much knowledge in battery technology. Another way is to let the OEMs (Original Equipment Manufacturers) and national labs to collaborate with global players. In either way, the need for India is to scale up the battery manufacturing on quantity scale.

**3. Battery Management System:**

Battery Management System (BMS) is the electronics that deals with binding the cells of a battery pack together and constantly monitoring the status of each cell. The temperature of each cell, charge-discharge status, short circuit protection carried out by BMS. The BMS leads to efficient use of the battery pack. The BMS is highly dependent on local weather conditions and hence it is very important of India to develop their own BMS rather than outsourcing them. An indigenous BMS will keep in pace with the cost affordability of Indian Customers. An EV suitable for EU nations may not be suitable for Indian conditions because of the differences in the weather conditions. In this case, the BMS plays the key role to make the EV suitable for Indian weather conditions.

**3.1 Power Electronics:**

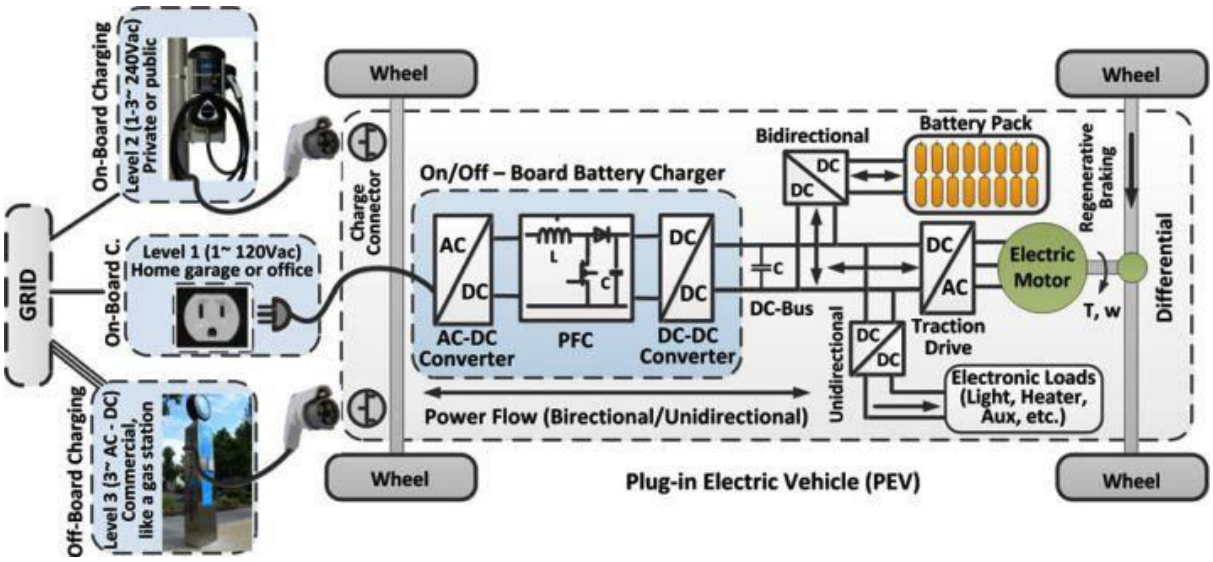


Figure 1: Power Electronics employed in a EV [2].

Power electronics takes care of the various power conversion process from the plug to wheel. The various power electronics converters employed in EVs are

**a) AC-DC converter:** The EVs conventionally charged from an ac outlet. However, but the batteries charge only with dc power. Hence, the AC-DC converter helps in converting the ac power to dc power, not only batteries, dc power is required by many electronics loads such as lights, heater within the EVs and hence it is a big network of power.

**b) DC-DC converter:** The dc power from the AC-DC converter is often variable and fluctuating. Hence, it is necessary to make the dc power constant and stable. In a DC-DC converter, it is important to provide the isolation between input and output. This makes sure that the power electronics converter are safe from any reverse flow of current.

**c) DC-AC converter:** The ac power is necessary to drive the electric motors in EVs. Hence, another DC-AC converter is necessary to convert the dc power from DC-DC converter to ac power. The ac power could be single-phase or three-phase depending upon the type of motor used.

**d) AC-AC converter:** This converter used for the purposes of changing the frequency of ac power. The electric motors when required to operate with variable speed based on frequency could employ this converter

There are wide areas of research in power electronics for use in EVs. The converters need to be compact and occupy very less space. This helps in providing more interior spacing within the vehicle; the converters also need to be lightweight. A heavier converter burdens the electric motors to carry more current to achieve high speed. The heat management in power electronics is also very important and process ventilation facility needs to provide.

## 4. Electric Motors

The electric motors convert the electrical power to mechanical power and drive the EVs. The electric motors also help in regenerative braking where the electric motor acts as generator and converts the mechanical energy into electrical energy. There are many types of electric motors and they classified as follows:

**a) Brushed DC motor:**

The stator of these motors made up of permanent magnets. The rotor consists of brushes, which provides supply to stator. At low speed, they have the ability to provide maximum torque, which is very much desirable. However, the disadvantage with these motors are that they are very bulky and operate under very low efficiency. Hence, they are usually not preferred in EVs.

**b) Permanent Magnet Brushless DC Motor (BLDC):**
These motors are smaller and light in weight. They have improved heat dissipation and carry higher specific power. There are no rotor copper loss associated with them. However, the cost of permanent magnet is high.

**c) Permanent Magnet Synchronous Motor (PMSM):**

These motors do not employ any gear system and have a wide operating speed ranges. They are efficient and very compact; the disadvantage is that they carry huge iron loss at high speeds.

**d) Switched Reluctance Motor (SRM):**

These motors are relatively simple and robust in construction. They are small and operate at high speeds. The disadvantages are that they are very noisy and operate at low power factor. The PM machines are also heavier and costlier.

**e) Induction Motor (IM):**

They have matured commutatorless motor drive system technologies and operated like a separately excited DC motor. India should encourage the indigenous manufacturing of motors. The kind of design needed for designing of motors for Indian road conditions is quite different from those of other countries. The average speed of vehicles in India is 25 Km/hr as opposed to 45 Km/hr in the western countries. Hence, it is important that the motors developed should have their peak efficiency at 25 Km/hr. This will help in power savings. Importing of motors for Indian EVs will increase the price of EVs and they are not assure of working efficiently for Indian road conditions.

## 5. Conclusion

India has a huge challenge in shifting the transportation sector from ICE engines to EVs. This requires a lot of planning, research and development. Government policies like FAME and few other policies needs to be updated on regular basis to

keep in pace with the development throughout the world. India should focus on improving the energy-efficiency of EVs. The power electronics, electric motors should planned for Indian conditions. A battery eco-system needs to be develop which can support many companies and start-ups developing battery pack up and cell manufacturing. Charging infrastructure needs to be adequately build to address range anxiety. The options of swapping also be explored. It is also very important to create demand generation by making all government buses electric and offering tax exemptions for private EV owners.

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**Electric Vehicle Basics**

Just as there are a variety of technologies available in conventional vehicles, plug-in electric vehicles (also known as electric cars or EVs) have different capabilities that can accommodate different drivers' needs. A major feature of EVs is that drivers can plug them in to charge from an off-board electric power source. This distinguishes them from hybrid electric vehicles, which supplement an internal combustion engine with battery power but cannot be plugged in. https://www.energy.gov/eere/electricvehicles/electric-vehicle-basics

**Electric vehicle industry in India**

Electric vehicle industry in India. India unveiled 'National Electric Mobility Mission Plan (NEMMP) 2020' in 2013 to address the issues of National energy security, vehicular pollution and growth of domestic manufacturing capabilities. Reiterating its commitment to the Paris Agreement, the Government of India has plans to make a major shift to electric vehicles by 2030. E-commerce companies, Indian car manufacturers like Reva Electric Car Company (RECC), and Indian app-based transportation network companies like Ola are working on making electric cars more common over the next two decades. https://en.wikipedia.org/wiki/Electric_vehicle_industry_in_India