EE 3260
Renewable Energy Power Systems

Understanding the “BATTERY”
The powerhouse of an Electric Vehicle

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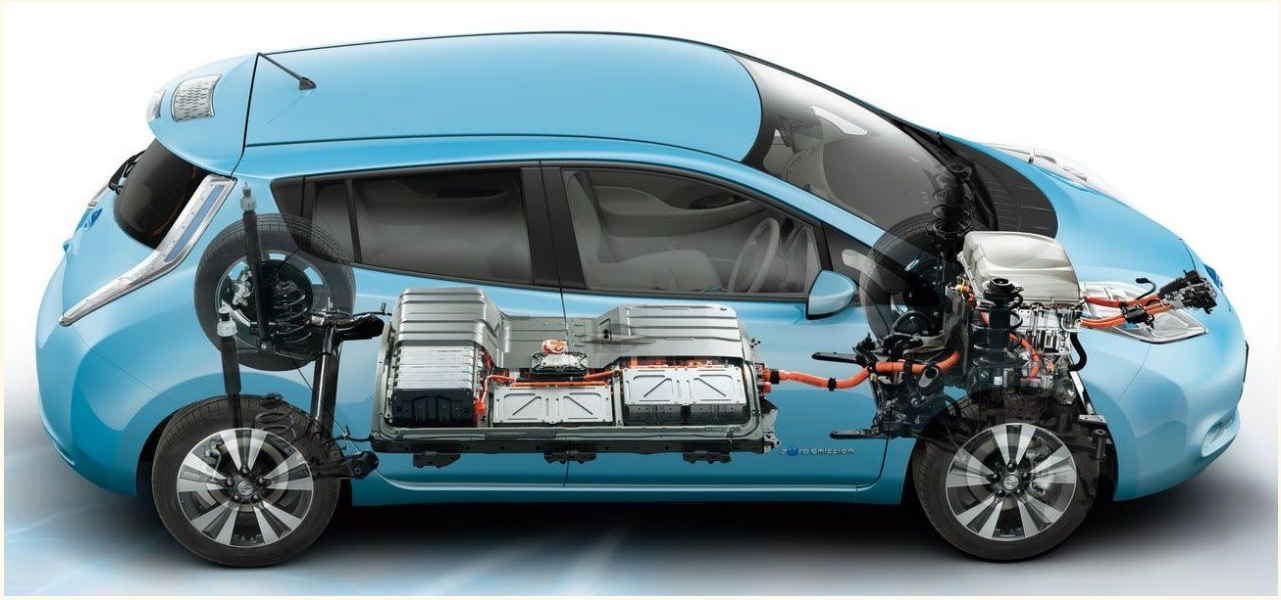

INTRODUCTION

According to a prediction by the International Energy Agency, by 2030, Electric vehicles will rise from 3 million to 125 million. With the increase in concerns over climate change and soaring gasoline prices, the Electric vehicle industry is expected to grow exponentially. So, if EVs are so green and clean , why are we still using ICE(Internal Combustion Engine) vehicles? Let's try to find it out through this article.

What is an EV and how is it different from an ICE vehicle ?

An electric vehicle uses stored energy from a battery to operate its electric motors. They are quieter, have no exhaust emissions, but the most overlooked factor is their

efficiency. An EV engine has almost 50 percent fewer moving parts than an ICE. This helps it become four times more efficient than an ICE.

An EV (without a battery) costs less than a petrol/diesel-driven vehicle. The cost significantly rises when we bring in the battery costs. Hence there is a great need to understand the characteristics and economics of the battery. This can help us bring down the cost of EVs, which encourages the public to use them.

India's requirements

India, unlike other countries, faces a different set of challenges. There is a serious affordability problem; to overcome this, we need to go for small batteries as a solution. Another challenge is that Li-ion batteries, which are becoming the backbone of energy storage for EVs, work best at 25^0 celsius temperature, while summers in India usually cross 40^0 celsius. Hence India needs to improve the existing technology so as to cater to its needs.

Why are batteries falling behind petrol / diesel ?

They are 3 important parameters of interest when we talk about improving a Li-ion battery or any battery in general.

i) Gravitational Energy density (Wh/kg)

This describes the amount of energy that can be stored per kg of the battery. The higher the value of it , the more energy can be stored for less battery mass. Thus less raw materials used.

Comparing GED for different energy sources

Energy Source	GED (in Wh/kg)
Petrol	12,888.9
Diesel	12,666.7
Li-ion batteries	100.00–243.06

We can see that the GED for petrol/diesel is way better than the state-of-the-art Li-ion batteries. This gives us room for improvement, and extensive research is being done to raise this quantity. Increasing this might help lower the vehicle's weight, which then requires less energy to drive it.

ii)Volumetric Energy density (Wh/lt)

The above argument holds true even for the Volumetric Energy density. The higher its value the smaller will be the battery size.

Comparing VED for different energy sources

Energy Source	VED (in Wh/lt)
Petrol	9,500.0
Diesel	10,722.2
Li-ion batteries	250.00–730.56

iii) Efficiency (Wh/km)

This parameter is an analogue to "mileage" in gasoline-driven vehicles. The most important aspect for a consumer will be, how much distance I will travel with this much energy. These parameters define almost everything about your EV. As we try to decrease this quantity (which translates that we would need less energy for traveling the same distance) , we can then rely on smaller batteries for travel, thereby reducing batteries' investment.

Range anxiety

As discussed earlier, India needs smaller batteries to make EVs compete with ICE vehicles. One of the down-sides of having a small battery is that you can store less energy in it, and since the vehicle is solely dependent on the battery, the user will always be in a state of doubt whether he could reach the destination. This problem does not occur with ICE vehicles since the fuel tanks can be refilled in any nearby petrol station. This fear is predominant in EV users and is coined as "**range-anxiety**".

Battery cost- reduction strategy

In countries where EVs have taken off, range-anxiety is solved by installing a sufficiently large battery, ensuring that the user will not run out of energy during travel. But this battery capacity is more than the public's actual need; besides, this also increases the cost of the vehicle drastically, which is not much of a concern in the developed countries. But in India's case, to popularise EVs, we need to use smaller battery capacity to make EVs affordable for the masses.

Some strategies are mentioned below :

i) Increase Energy efficiency :

Since Li-ion batteries are in their infancy stage of development, researchers are trying to improve the efficiency of the battery, this means that they are trying to reduce the Wh/km parameter.

ii) Reduce battery size :

Small batteries can significantly reduce the costs, but causes range-anxiety. This can be solved by establishing a battery-swapping system in the community.

Battery- Swapping System to the rescue

The core idea of this system is that EVs will be using smaller batteries, while users can buy the EV without a battery. A charged battery will be leased from an Energy Operator. Once the battery runs out of charge, the user goes to the nearby outlets of the EO and gets it replaced with a charged one.

This system is very much similar to that of the existing LPG cylinder supply chain, where customers pay for the gas in the cylinder but do not own the cylinder. Similarly, customers pay for the electricity used to charge the battery and some other costs, and they don't own the battery. This makes it similar to refueling the tank when you run out of petrol, and all the swapping stations can be replaced with the large network of existing petrol stations. This eliminates the range-anxiety phenomenon and also breeds a new energy business.

Fast charging of vehicles is not preferred due to the tropical weather of India, which leads to the damage of the battery and thus reduces its lifetime. With a battery swapping system, the EO can set up a large charging station with cooling support. This solution solves both affordability and range anxiety issues and is thus considered the best option for India for faster adaptation of EVs.

Is India capable of manufacturing batteries, or will they be exported?

Li, Ni, Co, Mn, Graphite are the main constituents of the battery and unfortunately, India does not have abundant reserves of these and hence it should rely on imported batteries, which can raise the prices similar to petrol.

Some solutions that can work for us will be understanding the battery design and rebuilding them by importing at least the raw materials.

Battery designing involves a great deal of thermal (for indian temperatures) and mechanical (for indian roads) engineering design , and thus the indian weather conditions are to be taken into consideration while doing it.

Battery manufacturing consists of **3 main components** , for which India is capable of carrying out a major part of it in the country.
The steps and India's approach to perform it are discussed below :

i) Cell to pack manufacturing

This involves importing the cells and assembling them . It is done by keeping in mind the thermal and mechanical design that will suit indian roads, while designing a good Battery management system (BMS) to make the battery efficient. Indian researchers have figured out a way to perform this step and it holds around 35% of the value of the whole battery.

ii) Cell manufacturing

This step accounts for 25% of the battery value. This involves rigorous R&D about improving the energy density of the material and manufacturing it , which requires a

high investment. This is not in the better interest of India as of now as much of it involves understanding of the chemistry of the battery materials and takes in a lot of cost for experimentation.

iii) Battery material

This accounts for 40% of the battery's value, as said earlier, we need to rely on imports for these. But some emerging solutions try to reduce the import. One such is extracting materials through urban-mining. As Li batteries are predominantly used in cell-phone and laptop batteries,one can recycle them and extract the materials from it. This can help us recycle e-waste and also cut off some raw material imports.

Conclusion :

Throughout the article, we tried to understand the problems with batteries, which are stopping us from using them . India especially is taking giant steps to popularise EVs and renewable energy by subsidising. India is committed to manufacture the components of the battery and vehicle to a maximum extent in India itself, which help us achieve "**Atma Nirbhar Bharat**"

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THE END