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Electric Vehicles to be Fueled by Semiconductor Innovation - A Review

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Abstract — **To minimize usage of petroleum products (like petrol, diesel) and control environmental pollution, the development of E-Vehicle has been speeding up in many countries. The implementation of EVs is considered a solution to the environmental issues. This paper gives an extensive review of implementation and development of EVs, the charging infrastructure and the technologies. This gives review of the advancement and technologies related to batteries and motors. It depicts the new technologies growing in EV developments and the challenges faced in development of EVs. Various programs and organizations of different countries is described which are involved in growth of EVs.**

Keywords — Electric motor and control, batteries, Hybrid Electric vehicles, Charging Infrastructure.

I. Introduction

Fossil fuel consumption has increased remarkable over the past half-century, which is non-renewable conventional fuel, leads to environmental pollution and energy crisis [2-3]. Also, vehicles mostly run-on internal combustion engine (ICE), It leads to greenhouse gases emission.

Therefore, many countries have started New Energy Vehicles (NEVs) as alternative to internal combustion engine (ICE) [4-6]. EVs mainly consists of PEVs also called as BEVs, HEVs and also fuel cell electric vehicles (FCEVs). Battery electric vehicles entirely made up of traction battery. BEV is shown in Figure 1.

An HEV consist of dual power source and it integrates IC engine with an electric propulsion system. The purpose behind electric power system to get better fuel economy and performance than conventional vehicles. BEVs are good step to lessen environmental problems and energy catastrophe as they have no fuel consumption and zero hazardous gas emission [7].

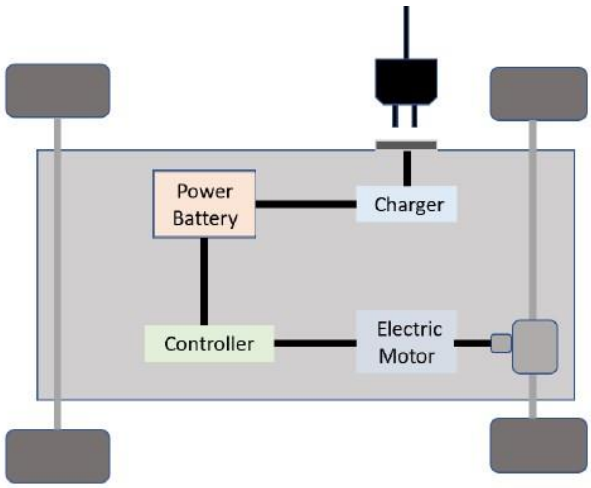

Figure 1. Design in BEV [1]

II. Battery Technology in Electric Vehicles

Development of traction batteries have huge knock-on EV industry, since these batteries are used for powering up drive system of EV [8]. EV batteries need continuous power hence large energy capacity is required [9].

A. *Lead-Acid batteries*

It includes negative plate powdered from lead and positive plate made from brown lead oxide, which are both

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immersed in electrolyte made from dilute sulphur acid. Lead-Acid battery has following reversible reaction [10].

Positive electrode reaction:

$$PbSO4 + 2H2O \leftrightarrow PbO2 + 3H+ + HSO4 - + 2e \quad (1)$$

Negative electrode reaction:

$$H+ + PbSO4 + 2e- \leftrightarrow Pb + HSO4 \quad (2)$$

Net reaction:

$$2PbSO4 + 2H2O \leftrightarrow PbO2 + Pb + 2H+ + 2HSO4 \quad (3)$$

These batteries are called as maintenance free batteries because it doesn't require constant checking of electrolyte level.

On comparison with lithium-ion batteries, the lead-acid batteries store less energy having equivalent mass or volume, as shown in Figure 2.

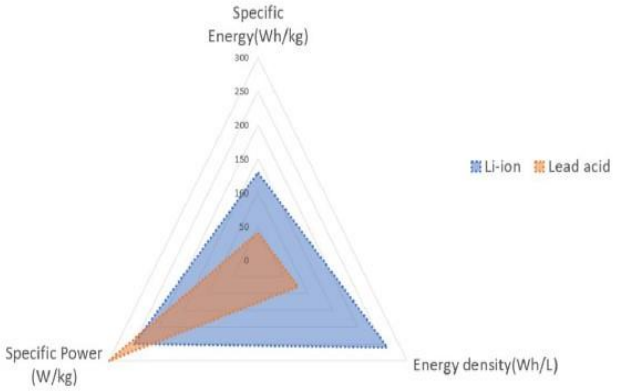

Figure 2. Comparison between the Lithium-ion and Lead-Acid batteries [1]

B. Nickel-Metal hydride batteries

In general, these batteries consist of a positive electrode nickel hydroxide and various materials are a negative electrode. Batteries comprise Nickel-iron battery (Ni-Fe) nickel-cadmium battery(Ni-Cd), Nickel-zinc battery(Ni-Zn), Ni-MH battery battery and Ni-H2 battery. Nickel-Cd battery [11].

$$X + 2NiO\,(OH) + 2H2O \leftrightarrow 2Ni\,(OH)2 + X\,(OH)2$$
$$M(H) + 2NiO\,(OH) \leftrightarrow M + Ni\,(OH)2 \quad (4)$$

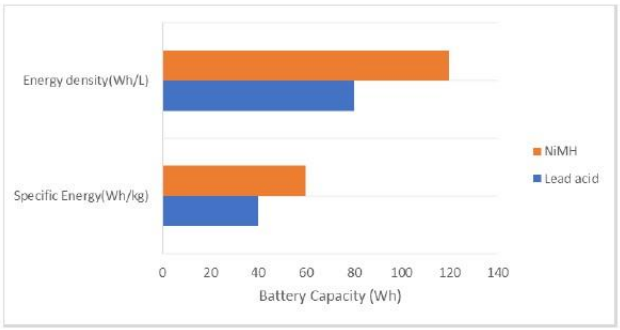

Figure 3. Comparison between the Ni-MH and Lead-Acid batteries [1]

III. Charging Infrastructure

Charging system is the most required structure in EV. It is required to have a strong and reliable charging system for the creation of the electromobility. Charging system is nothing but the infrastructure of charging system. It is the network which involves the understanding and maintaining the present charging system and easy charging source [12].

A. Charging Infrastructure Organizations

Define Various countries like USA, Netherlands, Japan, China and Germany had some organizations and the funding through government for the growth of EV and its stations. Japan had stated its work from 2013 in the charging infrastructure by the funding from government and automobile manufacturers. The charging network of japan is funded by the Japanese banks and various power companies [13]. Norway faced so many problems in the charging infrastructure but they overcame the problems through the funding by organizations and also help in the lowering the emission of Green House Gas [14]. UK power stations were funded by their government's "The Office of Low Emission Vehicles". UK government build the road strategy by planning the power stations at every 30km on major road networks. China is the leading country in having the greatest number of charging points and also the EVs globally. The Government of India has released two-pronged strategy for buyers and manufacturers. The strategy offers subsidies to the buyers and imposed hike on tariffs to increase manufacturing in India by local companies [15]. The government of India released a document on 14 December 2018 which depicts the standard and guidelines of EV charging infrastructure. The

guidelines states that it is required a charging station to be present at every 25 km along a road [16].

Many big companies such as Tata power and Fortum are involved in the activities of electric vehicles charging. They have installed and tested all types of chargers like rapid or fast DC chargers and also the level 2 AC chargers for all types of applications such as public use, workplace charging, feet charging, residential communities etc and have larger plant to scale up.

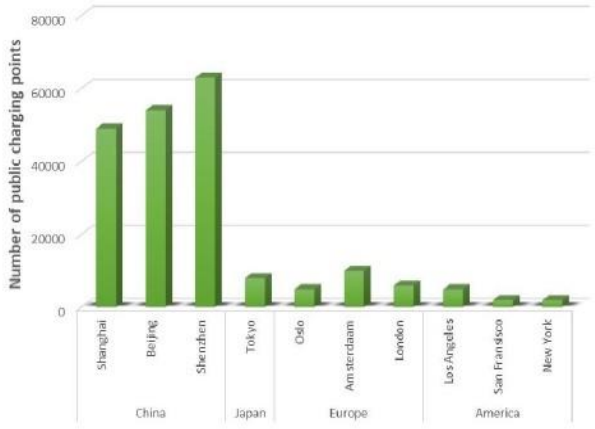

Figure 4. Total number of public charging points in metropolitan areas [1]

IV. FUTURE TECHNOLOGIES IN DEVELOPMENT OF EVS

- New technologies are being put in to transportation and real time communication such as vehicle-to-infrastructure (V2I), vehicle-to-vehicle (V2V), vehicle-to-pedestrian (V2P) resulting to autonomous vehicle [17-18].
- Vehicle-to-Grid (V2G) is a charging energy management; it provides two-way energy exchanges between the vehicle and the grid.
- Mobile charging involves charging vans, portable chargers and temporary chargers, where the chargers themselves are “on the go”.
- New technologies are being tested, like graphene-based technologies, which charge in 15 seconds.
- Toyota is working on sulphide-based, solid state batteries that are forecasted to lasts up to almost 30 years.

V. ELECTRIC VEHICLE TO BE FUELED BY SEMICONDUCTOR INNOVATION

Most electronic devices need electrical power to get transformed from one form to another. Every modern power converter or power transformer is the semiconductor power switch which directs the performance of whole system. Silicon has been the ruling power switching semiconductor material for long time; silicon fails to meet performance demands of current higher power applications as electric vehicles. Silicon carbide (SiC) has walked in to providing some gradual improvements over Si, and is used in EVs currently.

Research has proven that gallium nitride (GaN) is a way superior to its Si and SiC equivalents thanks to properties that leaves devices that are notably smaller in size and weight, with zero downgrade in performance. And these are cheaper to produce.

VI. CONCLUSION

This paper offers a short overview of progress of EV technology in key areas, such as battery charging, charging systems and future technologies. Hydride nickel-metal batteries, batteries of lithium-ion function as a source of power for electric vehicles since they are environmentally benign.

In the applications of EV, charging infrastructure is highly essential. The charging network covers the technical difficulties of infrastructure, charging organisations and equitable payment opportunities inside the charging infrastructure network.

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