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Charging the Indian Future with Electric Vehicles (EVs)

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Abstract: Growing population increases the problem of growing pollution all over the globe. Population in India is about 135 crores and this number suggests the amount of pollution caused knowingly or unknowingly. Over the few decades it has been observed that the largest contributor to the pollution in India is the use of large numbers of automobiles or vehicles. Electric Vehicles prove to be one of the most efficient replacements to the fueled automobiles. These are just another automobiles or vehicles but run on electric power or electrical energy. This paper reviews the state of art of the electric vehicle concept, its advantages and benefits to the society and its power management strategies.
Keywords: Electric Vehicles, Power management strategies.

I. INTRODUCTION

Driven by powerful environmental, macroeconomic and technological factors, the global transportation sector is in a period of historic transition. New business models such as mobility as a service and the increasing economic viability of technologies such as electric vehicles will soon change the way we travel [Kesari et al, 2019]. Road EVs include a wide range of vehicles from electric two-wheelers, three-wheelers (rickshaws), cars and electric buses. In addition, plug-in electric vehicles are often classified into two types: battery electric vehicles (BEVs), and plug-in hybrid electric vehicles (PHEVs). BEVs have an electrical motor in situ of combustion engine and use electricity from the grid stored in batteries. Plug-in hybrid electrical vehicles (PHEV) use batteries to power an electric motor and liquid fuel like gasoline or diesel to power an IC engine or other propulsion source. EVs can transcend the above-mentioned technology-based classification, and may be classified on the idea of their attributes like i) charging time, ii) driving range, and iii) the maximum load it can carry. Of these attributes, the two most vital characteristics of an EV of concern to the buyer are: -

1) Range of Driving
2) Charging time of batteries (i.e. the time required to fully charge the battery) and Charging time depends on the input power characteristics (i.e. input voltage and current), battery type, and battery capacity.

A. The Indian Context

While many countries have included EVs as an element of transportation policy, their responses have varied according to their stage of economic development, energy resource endowments, technological capabilities, and political prioritization of responses to climate change. In India, a particular set of circumstances which are conducive to a sustainable mobility paradigm have created an opportunity for accelerated adoption of EVs over ICE 3 vehicles. These are: A relative abundance of exploitable renewable energy resources, high availability of skilled manpower and technology in manufacturing and IT software, an infrastructure and consumer transition that affords opportunities to use technologies to leapfrog stages of development and a universal culture that accepts and promotes sharing of assets and resources for the general commonweal. These circumstances position India to pursue an EV policy which systematically ensures that India's EV program keeps pace with the global scale since large economies seem to take significant steps towards electrification of vehicles. India's growth prospects create potential for developing leadership in EV in certain segments.

II. LITERATURE SURVEY

The Indian auto industry is the fourth largest in the world and is expected to become the third largest in 2021. The industry accounts for 7.1% of India's gross domestic product (GDP) and the automotive mission plans of India. The Indian government aims to reach 12%. The Indian auto industry (including component manufacturing) is expected to grow at 5.9% per year and reach INR 16.18-188 billion (251.4 to 282.8 billion US dollars) by 2026, which will make it the fastest growing industry in the country. According to the report of the National Mission Plan for Electric Mobility 2020, the Indian car market is governed by two-wheeled vehicles, which account for 75% of the entire number of vehicles sold in the country and the passenger car segment is dominated by the small car

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segment and it will increase significantly by 2030. Although India has seen an increase in vehicle sales year-on-year, the number of motor vehicles in the country remains low, with only 18 cars per 1,000 inhabitants, compared to nearly 69 in China and 786 in the United States. US11. This indicates that a large proportion of Indians do not own a vehicle and depend on shared or public mobility means [Kesari et al, 2019]. In the face of the growing predominance of Indians in road and rail transport, buses and public trains have been the main mode of transport in the country. The report, Key indicators of household spending on services and Durable goods, published by the Ministry of Statistics and Program Implementation in 2016, indicated that buses are the most popular means of transportation in both rural and urban areas. According to the report, buses represent the maximum expenditure of about 66% of households in rural areas and 62% of households in urban areas. Other modes of transportation include rickshaws, taxis and trains. However, supply has not been able to catch up proportionally with growing demand due to population growth. In addition, the share of public transit buses has decreased, necessitating an overhaul of the public transit system in the country [Kesari et al, 2019]. This has led to the growth of application-based booth aggregators and is synonymous with smartphone penetration. Today, India's two largest application-based taxi aggregators provide nearly 3.5 million daily trips. This has transformed the sector in terms of mobility and is a turnkey solution. However, within the long-term perspective, an efficient conveyance system within the country is required, with vehicles running on electricity or alternative fuels, making this mode of transport efficient, convenient, comfortable and safe, and encourages people to opt for public transport. In this regard, the Indian electric vehicle industry is making great strides. The National Mission Plan for Electric Mobility (NEMMP) 2020 was launched by the central government of India in 2013 to stimulate the manufacturing of hybrid and EVs in India which aimed to supply seven million EVs by the end of 2020. This initiative has supplemented by the government providing demand-side incentives through its FAME program (Rapid Adoption and Manufacturing of Hybrid and Electric Vehicles in India). Private auto players took up the challenge and invested in R&D facilities and the establishment of additional manufacturing units for electric vehicles. Rakesh Kumar and Sanjeevi Kumar Padmanaban [2019] stated that the transportation sector is one of the biggest emitters of CO2 and hence it is important to convert the sector to green sector. Joeri Van Mierlo [2018] reported that gaining interest in e-mobility and related fast developments in electric vehicles has been leading to the need for the academic and industrial world, as well as the societal stake holders. Samual E. de Lucela [2011] reviewed on the technology of modern EVs including the various types and classification of EVs, electrical motor kinds employed by EV manufacturers, power electronics driver topologies, control strategies, battery types and performances and infrastructure demands. Gujrathi et al, [2018] presented the current Indian EV market, market players in 2 and 4 wheelers with recent development along with the current status of Indian road transportation, policies, and initiatives of government with feasible options along with global scenarios. Mahmudi et al [2014] reviewed state of art on EV concept, power management strategies and charging techniques highlighting the problems and solutions. Niti Aayog [2018] perused EV policy which ensures India's EV program to keep the pace with global scale since large economies seem to take significant steps towards electrification of vehicles to reduce primary oil consumption in oil transportation and facilitate the customer adoption of electric and clean energy vehicles to reduce pollution in cities and facilitate the employment growth in a sunrise sector. In addition, the government has decided to finance up to 60% of R & D costs for the development of low-cost local electric technologies, global players in the automotive industry invest heavily in R & D on energy technologies for electric vehicles in India. India's electric vehicle industry should definitely get a makeover thanks to the government's initiative. The differentiator will be how automakers will deliver unique, tailored services to different segments while meeting prescribed standards, quality and rate of innovation. This will catapult some organizations to the next league and, at the same time, will see others fall.

III.CONCEPT OF ELECTRIC VEHICLES

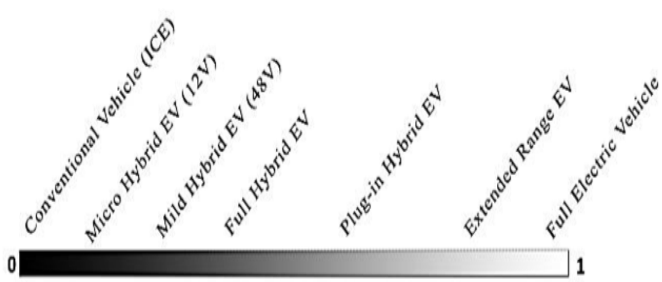

Figure: concept of EVs

There are mainly three main types of electric vehicles [Mahmoudi et al, 2014]

1) *BEV:* AEV The All Electric Vehicle (AEV) or Battery Electric Vehicle (BEV) uses high capacity batteries and electric motor for propulsion. It derives all the energy from its batteries pack and has no combustion engine, neither cell, nor fuel tank. The only way to recharge its batteries is by plugging in the vehicle to a charging point [Y. He, B. Venkatesh, L. Guan, 2012].
2) *HEV / PHEV:* The second type is the Hybrid Electric Vehicle (HEV) that uses mechanically a combination of Electric Motor (EM) in low speeds dedicated for in-city traffic and a standard IC engine to be used outside urban areas. When ICE mode is activated, the EM stops and batteries starts charging using an alternator driven by the same equipped ICE. The HEV get an upgrade to the Plug-in Hybrid Electric Vehicle (PHEV), it includes actually a replacement battery charging system which will be fed externally. The combustion engine works as a backup when the batteries are depleted and the driver cannot have a break for charging.
3) *REEV:* The main third type is the Extended Range Electric Vehicles (EREV or REEV); in this structure, vehicle propulsion is driven only by an electric motor powered by high capacity batteries. These batteries are maintained charged alittle engine generator unit. Its small consumption, less than two liters of fuel at 100km, offers an extended range of autonomy and distance to be reached [L. Rosario et al, 2006].
4) *FCEV:* Additionally to those three main types, Fuel Cell Electric Vehicle (FCEV) has been introduced to perform long distances. It uses a fuel cell system to power its on-board motor. Proton Exchange Membrane fuel cells generally called Polymer Electrolyte Membrane (PEM) fuel cells utilized in FCEVs use hydrogen fuel stored onboard and oxygen from the air to supply electricity. As long as a fuel is supplied FCs continue to generate electricity, similar to conventional ICEs [L. J.-S. and Nelson, 2007] [L. –F. Xu et al, 2008].
5) *SEV:* Solar electric vehicle (SEV) is a vehicle powered importantly or completely by direct solar power. Through solar arrays installed on top of the vehicle, often photovoltaic (PV) cells, solar energy is converted directly into electric energy. Since converted solar power is only source, it powers all or a part of SEV's propulsion, electronics, communication, navigation, security and other auxiliary features [Hongjun Chen, Fei Lu, Fujuan Guo, 2012]. Sensors provide assistance to the driver similar to conventional vehicles. Here, gathered information allows monitoring the car's energy consumption, solar energy capture and other parameters. SEVs are often equipped with A battery pack assistance to make sure continuous driving during shaded days or night use giving an extended range of autonomy to the users. Practically, SEV can reliable in some uses when vehicle operates relatively little but spends most of the time parked in the sun, such as golf carts,

The electric vehicles can also be classified according to the hybridization degree. It (degree of hybridization) indicates how much important is the role played by the electric motor in the car propulsion.

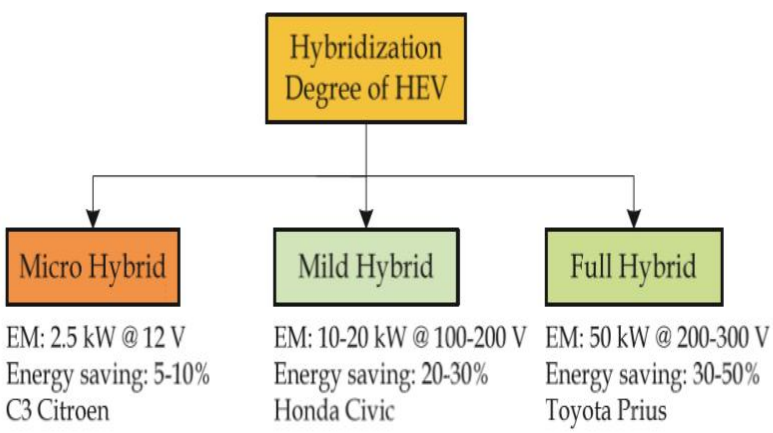

Figure – Classification of EVs according to the hybridization degree. (EM – Electric Motor)

A. Charging of EVs: Batteries in EVs

Over the past 15 years, lithium ion has grown dramatically and has become widely used for portable electrical products. The most used battery in an electric vehicle is the Li-ion battery. These batteries have been tested on the road all over the world and are the most suitable for electric vehicles applications. [www.tf.uni-kiel.de]

B. Principle of the Li-ion Battery

Lithium ions are inserted or extracted from the interstitial velocity between the atomic layers within the active material of the Li-ion battery during a typical charge/discharge cycle. In simple in other words, the Li-ion is exchanged between anode and cathode through a lithium electrolyte. The operation of a Li-ion battery depends on the "intercalation" mechanism (i.e. inclusion of a molecule in materials with a stratified structure). This process includes the inclusion of Li ions within the space lattice of the host electrode without affecting its quality crystal structure. The electrodes involved in Li-ion batteries have two essential properties: I. They need an open crystalline structure that permits the insertion/extraction of Li-ions freely. II. Electrodes have the power to simply accept compensating electrons at equivalent of your time. The efficiency of Li-ion batteries features a typical range of 95-98% in its life cycle.

C. Battery Charging

In low power applications the conditioning which includes the AC to DC conversion, the facility control unit which delivers a variable DC voltage to the battery, and various filtering functions are all carried out within the charger and can be implemented at a relatively low cost. The Battery Management System (BMS) is tightly integrated with the battery. It monitors the key battery operating parameters of voltage, current and temperature and controls the charging rate to supply the specified constant current / constant voltage (CC/CV) charging profile and it triggers the protection circuits if operating limit is overmatched, isolating the battery if needed. Battery charging scheme is shown within the figure below.

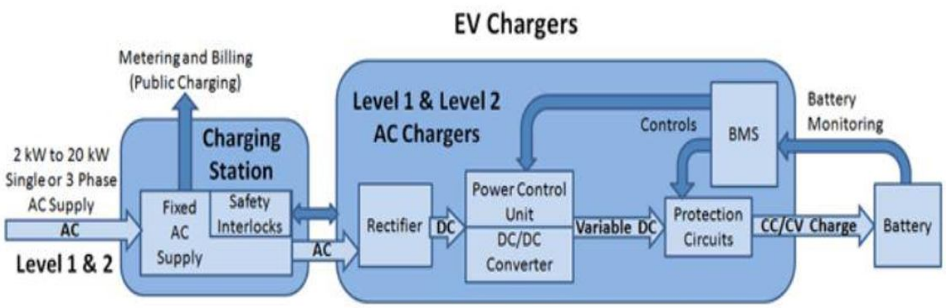

Figure: Battery charging scheme

D. Charging Techniques and Standards

There are four key standards associated with safety, installation and connection of the Electric Vehicle Supply Equipment (EVSE) to the EV; UL 2594, UL 2231, SAE J1772, and NEC Article 6252. EVs typically charge from conventional power outlets or dedicated charging stations, a process that typically takes hours, but is often done overnight and usually gives a charge that is sufficient for normal everyday usage. To date, mainly three charging techniques are available.

1) *Conductive Charging:* This is a direct electrical connection (typically through an insulated wire/cord set) between the source and the charging circuitry. The circuitry and its controls can also be housed within the vehicle or external thereto. All new EVs are compatible with this approved standard. Semi-Quick mode provides up to three phases 32A current. It takes much shorter time to charge electric vehicles compared to standard charging. And ultimately, quick mode uses a specialized fast charger that is connected to a high-powered electrical source and the high power greatly reduces charging time. Nevertheless, it requires infrastructure investment, spaces and additional costs. It is suitable for emergency charging purpose [mil B. Iversen et al, 2014]. The actual charge time will vary according to the charge level and condition of the batteries
2) *Inductive Charging:* No wiring is required; instead the energy is transferred between the charger and the "Paddle" inside the vehicle's inlet via a magnetic field generated by a high AC current. Inductive charging is still expensive and complicated to set up for end user.
3) *Batteries Swapping:* Instead of recharging EVs from electrical socket, batteries could be mechanically replaced in a couple of minutes in some special stations. Here battery size and geometry should be standardized so as to relay on Battery swapping technique.

E. Power Electronics in EVs:

Power electronics is the concept or domain that takes care of various power conversion processes from the plug to the wheel. The various power electronics convertors in the EVs are: AC-DC convertors, DC-DC convertors, DC-AC convertors, AC-AC convertors. The following image depicts the power electronics employed in typical EVs. [Yilmaz and Krein, 2013]

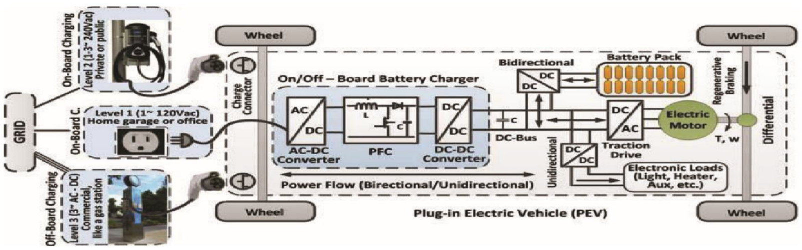

Figure: Power Electronics of the an EV

IV. CONCLUSION

In the near future, combining diverse energy sources and power trains in optimal way, as well as performing an accurate and robust power management control algorithm will be essential to build a reliable and affordable EV while preserving our environment and intelligently using our limited resources. India has a huge challenge in shifting the transportation sector from ICEs to EVs. This requires lot of planning, research, and development. Government policies need to be updated on regular basis to keep the pace with the development throughout the world. India should focus on improving the energy efficiency of EVs. The power electronics, electric motors, should be planned for Indian conditions. A battery eco-system needs to be developed which can support many companies and start-ups developing battery backup and cell manufacturing. Charging infrastructure needs to be adequately built to address range anxiety. The option of swapping also be explored. Based on the review it is very important to create demand generation by making all government busses electric and offering tax exemptions for private EV owners. The government of India should encourage EV manufacturers to design vehicles with changeable batteries so that the EV owner can just move in the charging station, replace a battery with a fully charged one and move on. The charging station can plan to change the batteries during the off- peak time at reduced electricity tariffs or direct from solar power. Investment for R&D for future battery technologies resulting in batteries with much higher specific energy, environment friendly and lower costs needs to be encouraged.

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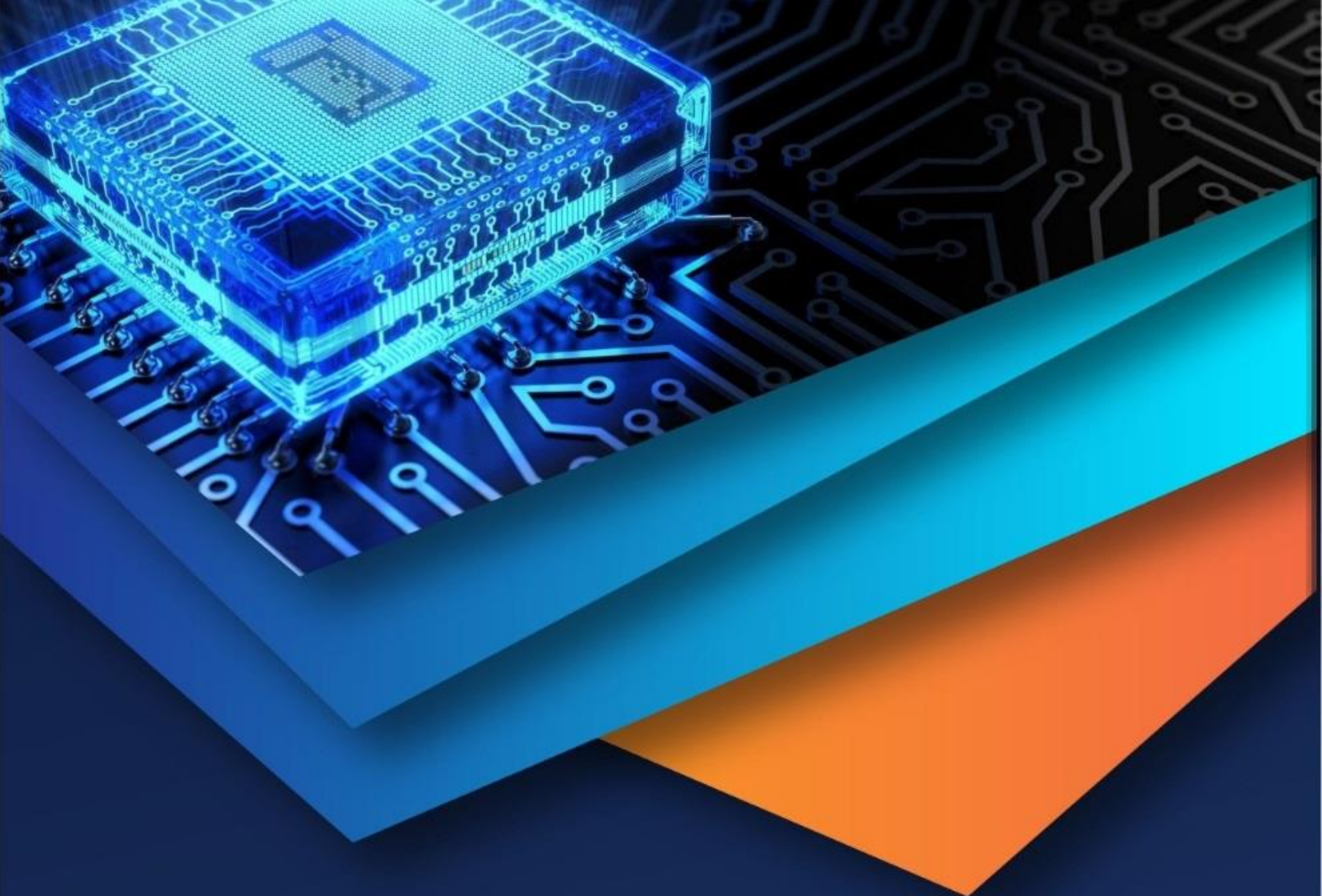

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