ELECTRIC VEHICLE CHARGING STATION

Case study on infrastructure of EV charging station

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Abstract: This report discusses about the potential need for electric vehicles (EV), charging station (CS) infrastructure and its challenges for the Indian scenario. With increase in liberalization, privatization and expansion of distributed and renewable power generation of Indian electricity market, transmission and distribution, as well as market processes related to the allocation of energy and energy mix are undergoing an evolutionary development with improved efficiency and reliability. A structured analysis of respective parameters is performed for the commercial scopes of electric vehicles in existing energy market. Market-based and regulatory concerns are considered to outline a scenario where an aggregator controls the charging of electric vehicles and provides ancillary grid services. Searching charging stations for electric vehicles is an important issue for the drivers which need the implementation of smart charging infrastructure network. Selecting the location for installing electric vehicles charging stations is important to ensure EV adoption and also to address some of the inherent risks such as battery cost and degradation, economic risks, lack of charging infrastructure, risky maintenance of EVs, problems of its integration in smart grid, range anxiety, auxiliary loads and motorist attitude.

Keywords- **Electric vehicle, Charge scheduling, smart charging, charging stations, electric vehicle battery, charging stations location conditions, infrastructure.**

I. INTRODUCTION

A. Electric Vehicles:

An electric vehicle, also called an EV, uses one or more electric motors or traction motors for propulsion. An electric vehicle may be powered through a collector system by electricity from off vehicle sources, or may be self-contained with a battery, solar panels or an electric generator to convert fuel to electricity. EVs include, but are not limited to, road and rail vehicles, surface and underwater vessels, electric aircraft and electric spacecraft. EVs first came into existence in the mid-19th century, when electricity was among the preferred methods for motor vehicle propulsion, providing a level of comfort and ease of operation that could not be achieved by the gasoline cars of the time. Modern internal combustion engines have been the dominant propulsion method for motor vehicles for almost 100 years, but electric power has remained commonplace in other vehicle types, such as trains and smaller vehicles of all types. Commonly, the term EV is used to refer to an electric car. In the 21st century, EVs saw a resurgence due to technological developments, and an increased focus on renewable energy. A great deal of demand for electric vehicles developed and a small core of do-it-yourself (DIY) engineers began sharing technical details for doing electric vehicle conversions. Government incentives to increase adoptions were introduced, including in the United States and the European Union. Electric vehicles are expected to increase from 2% of global share in 2016 to 22% in 2030. [1] During the last few decades, environmental impact of the petroleum-based transportation infrastructure, along with the fear of peak oil, has led to renewed interest in an electric transportation infrastructure. EVs differ from fossil fuel-powered vehicles in that the electricity they consume can be generated from a wide range of sources, including fossil fuels, nuclear power, and renewable sources such as tidal power, solar power, hydropower, and wind power or any combination of those. The carbon footprint and other emissions of electric vehicles varies depending on the fuel and technology used for electricity generation. The electricity may then be stored on board the vehicle using a battery, flywheel, or super capacitors. Vehicles making use of engines working on the principle of combustion can usually only derive their energy from a single or a few sources, usually non-renewable fossil fuels. A key advantage of hybrid or plug-in electric vehicles is regenerative braking, which recovers kinetic energy, typically lost during friction braking as heat, as electricity restored to the on-board battery.[2]

B. About conventional fuels

Petroleum is a naturally occurring, yellowish-black liquid found in geological formations beneath the Earth's surface. It is commonly refined into various types of fuels. Components of petroleum are separated using a technique called fractional distillation, i.e. separation of a liquid mixture into fractions differing in boiling point by means of distillation, typically using a fractionating column. It consists of naturally occurring hydrocarbons of various molecular weights and may contain miscellaneous organic compounds. The name petroleum covers both naturally occurring unprocessed crude oil and petroleum products that are made up of refined crude oil. A fossil fuel, petroleum is formed when large quantities of dead organisms, mostly zooplankton and algae, are buried underneath sedimentary rock and subjected to both intense heat and pressure. Petroleum has mostly been recovered by oil drilling. Drilling is carried out after studies of structural geology (at the reservoir scale), sedimentary basin analysis, and reservoir characterization have been completed. Petroleum is used in manufacturing a wide variety of materials, and it is estimated that the world consumes about 95 million barrels each day. The use of petroleum as fuel causes global warming and ocean acidification. According to the UN's Intergovernmental Panel on Climate Change, without fossil fuel phase-out, including petroleum, there will be "severe, pervasive, and irreversible impacts for people and ecosystems".

Fig. 1- conventional fuel

C. Overview of Batteries

A **battery** is a device consisting of one or more electrochemical cells with external connections for powering electrical devices such as flashlights, mobile phones, and electric cars. When a battery is supplying electric power, its positive terminal is the cathode and its negative terminal is the anode. The terminal marked negative is the source of electrons that will flow through an external electric circuit to the positive terminal. When a battery is connected to an external electric load, a redox reaction converts high-energy reactants to lower-energy products, and the free-energy difference is delivered to the external circuit as electrical energy. Historically the term "battery" specifically referred to a device composed of multiple cells, however the usage has evolved to include devices composed of a single cell. Primary (single-use or "disposable") batteries are used once and discarded, as the electrode materials are irreversibly changed during discharge; a common example is the alkaline battery used for flashlights and a multitude of portable electronic devices. Secondary (rechargeable) batteries can be discharged and recharged multiple times using an applied electric current; the original composition of the electrodes can be restored by reverse current. Examples include the lead-acid batteries used in vehicles and lithium-ion batteries used for portable electronics such as laptops and mobile phones. Batteries come in many shapes and sizes, from miniature cells used to power hearing aids and wristwatches to small, thin cells used in smartphones, to large lead acid batteries or lithium-ion batteries in vehicles, and at the largest extreme, huge battery banks the size of rooms that provide standby or emergency power for telephone exchanges and computer data centers. Batteries have much lower specific energy than common fuels such as gasoline. In automobiles, this is somewhat offset by the higher efficiency of electric motors in converting chemical energy to mechanical work, compared to combustion engines. [3]

Lithium-ion Battery: A lithium-ion battery is a type of rechargeable battery. Lithium-ion batteries are commonly used for portable electronics and electric vehicles and are growing in popularity for military and aerospace applications. The technology was largely developed by John Good enough, Stanley Whittingham, Rachid Yazami and Akira Yoshino during the 1970s–1980s, and then commercialized by a Sony and Asahi Kasei team led by Yoshio Nishi in 1991. In the batteries, lithium ions move from the negative electrode through an electrolyte to the positive electrode during discharge, and back when charging. Li-ion batteries use an intercalated lithium compound as the material at the positive electrode and typically graphite at the negative electrode. The batteries have a high energy density, no memory effect and low self-discharge. They can however be a safety hazard since they contain a flammable electrolyte, and if damaged or incorrectly charged can lead to explosions and fires. [4]

Lead-acid battery: The lead–acid battery was invented in 1859 by French physicist Gaston Planté and is the earliest type of rechargeable battery. Despite having a very low energy-to-weight ratio and a low energy to-volume ratio, its ability to supply high surge currents means that the cells have a relatively large power-to-weight ratio. These features, along with their low cost, make them attractive for use in motor vehicles to provide the high current required by starter motors. As they are inexpensive compared to newer technologies, lead–acid batteries are widely used even when surge current is not important and other designs could provide higher energy densities. In 1999 lead– acid battery sales accounted for 40–45% of the value from batteries sold worldwide (excluding China and Russia), equivalent to a manufacturing market value of about $15 billion. Large-format lead–acid designs are widely used for storage in backup power supplies in cell phone towers, high availability settings like hospitals, and stand-alone power systems. For these roles, modified versions of the standard cell may be used to improve storage times and reduce maintenance requirements. Gel-cells and absorbed glass-mat batteries are common in these roles, collectively known as (valve-regulated lead–acid) batteries. [5]

D. Needs of battery vehicle

Cheaper to run- Owners of an EV have the advantage of much lower running costs. The electricity to charge an EV works out around a third as much per kilometer as buying petrol for the same vehicle. There are a number of handy calculators you can use to see the savings. Check out the Fuel Cost Savings Calculator on the My Electric Car website.

Cheaper to maintain- A battery electric vehicle (BEV) has a lot less moving parts than a conventional petrol/diesel car. There is relatively little servicing and no expensive exhaust systems, starter motors, fuel injection systems, radiators and many other parts that aren't needed in an EV. With just one moving part – the rotor – BEVs are particularly simple and very strong. Just maintain the brakes, tires and suspension and that's about it2.Batteries do wear out so replacement batteries will eventually be needed. Plug-in Hybrid Electric Vehicles (PHEVs) have a petrol engine that needs regular servicing so cost more to maintain. However, because the electrical motor requires little maintenance due to far fewer moving parts, this leads to less wear and tear of the petrol engine components.

Better for the environment-

Less pollution- By choosing to drive an EV you are helping to reduce harmful air pollution from exhaust emissions. An EV has zero exhaust emissions.

Renewable energy- If you use renewable energy to recharge your EV, you can reduce your greenhouse gas emissions even further. You could recharge your EV from your solar PV system during the day instead of from the grid. Another idea is to purchase Green Power from your electricity retailer. Then, even if you recharge your EV from the grid, your greenhouse gas emissions are reduced.

Eco-friendly materials- There is also a trend towards more eco-friendly production and materials for EVs. The Ford Focus Electric is made up of recycled materials and the padding is made out of bio based materials. The Nissan Leaf's interior and bodywork are partly made out of green materials such as recycled water bottles, plastic bags, old car parts and even second hand home appliances.

Health benefits- Reduced harmful exhaust emissions is good news for our health. Better air quality will lead to less health problems and costs caused by air pollution. EVs are also quieter than petrol/diesel vehicles, which means less noise pollution.

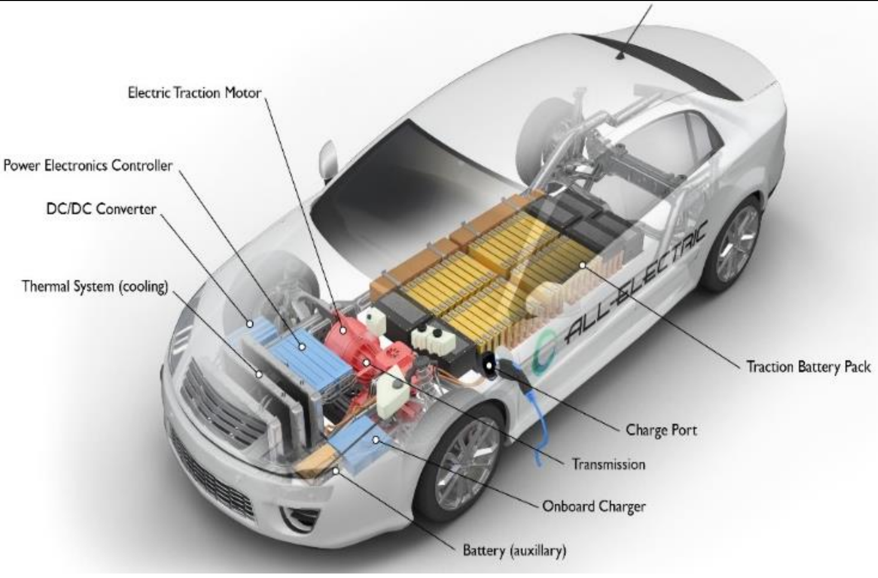

Fig. 2- overview of electric vehicle

E. Charging time-

The charging time depends on the battery capacity and the charging power. In simple terms, the time rate of charge depends on the charging level used, and the charging level depends on the voltage handling of the batteries and charger electronics in the car. The U.S.-based SAE International defines Level 1 (household 120V AC) as the slowest, Level 2 (upgraded household 240 VAC) in the middle and Level 3 (super charging, 480V DC or higher) as the fastest. Level 3 charge time can be as fast as 30 minutes for an 80% charge, although there has been serious industry competition about whose standard should be widely adopted. Charge time can be calculated using the formula: Charging Time [h] = Battery Capacity [kWh] / Charging Power [kW] The usable battery capacity of a first-generation electric vehicle, such as the original Nissan Leaf, is about 20 kWh, giving it a range of about 160 km. Tesla was the first company to introduce longer range mass production electric vehicles, initially releasing their Model S with battery capacities of 40 kWh, 60 kWh and 85 kWh, with the latter having an estimated range of about 480 km. Plug-in hybrid vehicles have capacity of roughly 3 to 5 kWh, for an electrical range of 20 to 40 kilometers, but the gasoline engine ensures the full range of a conventional vehicle. For normal charging (up to 7.4 kW), car manufacturers have built a battery charger into the car. A charging cable is used to connect it to the electrical network to supply 230 volt AC current. For quicker charging (22 kW, even 43 kW and more), manufacturers have chosen two solutions:

- Use the vehicle's built-in charger, designed to charge from 3 to 43 kW at 230 V single-phase or 400 V three-phase.
- Use an external charger, which converts AC current into DC current and charges the vehicle at 50 kW (e.g. 120-135 kW Tesla Model S). [6]

Fig.-3- charging time

Table- 1 charging time and level of charging

Charging time for 100 km of BEV range	Power supply	Power	Voltage	Max. current
6–8 hours	Single phase	3.3 kW	230 V AC	16 A
3–4 hours	Single phase	7.4 kW	230 V AC	32 A
2–3 hours	Three phase	11 kW	400 V AC	16 A
1–2 hours	Three phase	22 kW	400 V AC	32 A
20–30 minutes	Three phase	43 kW	400 V AC	63 A
20–30 minutes	Direct current	50 kW	400–500 V DC	100–125 A
10 minutes	Direct current	120 kW	300–500 V DC	300–350 A

F. Safety needs for charging station

Although the rechargeable electric vehicles and equipment can be recharged from a domestic wall socket, a charging station is usually accessible to multiple electric vehicles and has additional current or connection sensing mechanisms to disconnect the power when the EV is not charging.

There are two main types of safety sensor:

- Current sensors which monitor the power consumed, and maintain the connection only if the demand is within a predetermined range. Sensor wires react more quickly, have fewer parts to fail and are possibly less expensive to design and implement. Current sensors however can use standard connectors and can readily provide an option for suppliers to monitor or charge for the electricity actually consumed.
- Additional physical "sensor wires" which provide a feedback signal such as specified by the undermentioned SAE J1772 and IEC 62196 schemes that require special (multi-pin) power plug fittings.

Until 2013, there was an issue where Blink chargers were overheating and causing damage to both charger and car. The solution employed by the company was to reduce the maximum current.

II. LITERATURE REVIEW

Afida ayob et all (2014). This study presents a comprehensive review and evaluation of various types of electric vehicles and its associate with equipment in particular battery charger and charging station. A comparison is made on the commercial and prototype electric vehicles in terms of electric range, battery size, charger power and charging time. The various types of charging stations and standards used for charging electric vehicles have been outlined and the impact of electric vehicle charging on utility distribution system is also discussed. Authors define standards for charging stations such as IEC 61851(IEC, 20100), IEC 61851-1, IEC 61851-23, IEC 61851-24, IEC 62196-Plugs, socket-outlets, vehicle connectors and vehicle inlets (IEC, 2011, IEC 62196-1, IEC 62196-2, IEC 62196-3, IEC 60309-Plugs, socket-outlets and couplers for industrial purposes (IEC, 2012) etc. He studies the various types of EV, battery chargers and charging stations. A comprehensive review has also been made on the standards currently adopted for charging EV worldwide. For better understanding on the state of the art EV technology, a comparison is made on the commercial and prototype electric vehicles in terms of electric range, battery size, charger power and charging time.[1]

Adam Junid et all (2016) This paper assesses the effectiveness of Electric Vehicle (EV) charging station installation progress in Malaysia. Aspects of studied include: (i) planned vs actual progress of EV charging stations, (ii) main barriers to building an EV charging network in Malaysia, (iii) how should those barriers be addressed and overcome? As per research approach he surveys to collect primary data from three companies in Malaysia selling EVs: Nissan, Mitsubishi, and Renault. After research he get ways to overcome the barriers In terms of barriers, factors such as cost, regulatory approvals and vandalism/theft are affecting EV station progress . Recommendations to overcome such barriers are to increase the desirability of EV ownership by enabling sufficient EV charging stations to allow EV driving anywhere in the country, and to provide EV charging stations at all petrol stations and malls. Given that sufficient numbers of EV users are required to enable EV station operation to become a viable business, initial EV station funding to enable sufficient users of EVs to "drive anywhere in Malaysia" will likely have to come from government grants and/or subsidies.[2]

Praveen Kumar et all (2013) This paper discusses about the potential need for electric vehicles (EV), charging station (CS) infrastructure and its challenges for the Indian scenario. Up to now the BEV's bottleneck is in the range of 100km per charge due to limited on board energy which can be optimized by introduction of plug-in hybrid vehicles along with real time road traffic management. With increase in liberalization, privatization and expansion of distributed and renewable power generation of Indian electricity market, transmission and distribution, as well as market processes related to the allocation of energy and energy mix are undergoing an evolutionary development with improved efficiency and reliability. Searching charging stations for electric vehicles is an important issue for the drivers which need the implementation of smart charging infrastructure network. Charging Station selection algorithms involve the overall information obtained through interactions between the EVs and EVs- Charging Station selection (CSS) server through the mobile network, delivering information regarding availability of charging slot at nearest CS, thus minimizing individual waiting time and provide improved efficiency. India should invest in small scale reinforcements to manage the load issues locally instead of going for a massive change. Home charging should be encouraged for long battery life and grid balancing. Proper planning of place, population, traffic density and safety should be taken in to consideration before implementing the large scale charging infrastructure for the second largest populated country of the world. Consortiums of companies in the transport, energy and power electronic sectors which are working on projects connected with the initiation of commercial charging terminals for electric vehicles, as well as fast-charging stations.[3]

Kara M. kockelman et all (2018) this paper uses U.S. long-distance travel data to place charging stations in order to maximize long-distance trip completions. Each scenario assumes a certain number of charging stations (from 50 to 250, across the U.S.) and vehicle range (from 60 mi to 250 mi). This work formulates a new flow-refueling location model (FRLM) to identify optimal sites for 11 charging stations, to maximize the share of U.S. long-distance highway travel that can be achieved 12 by BEV owners. To handle the very-large-scale input data that exist for this unusually massive 13 problem, origin and destination locations were clustered into 196 points (starting from over 4,000 14 NUMA centroids), and only heavily used paths were tracked between these over 38,000 OD pairs 15 (reflecting over 90 percent of the nation's long-distance automobile travel).[4]

Marcy Lowe et all (2010) in this paper, researcher states that the automotive industry is moving away from internal combustion engines toward electric drivetrains, and advanced batteries are the key to this shift. The United States will need to be capable of making lithium-ion batteries in order to remain competitive. By 2020, roughly half of new vehicle sales will likely consist of hybrid electric, plug-in hybrid, and all-electric models. This means that what's at stake is not just the U.S. role in lithium-ion batteries, but also its future position in the auto industry.[5]

Somudeep Bhattacharjee et all (2017) in this paper, selecting the location for installing electric vehicles charging stations is important to ensure EV adoption and also to address some of the inherent risks such as battery cost and degradation, economic risks, lack of charging infrastructure, risky maintenance of EVs, and problems of its integration in smart grid, range anxiety, auxiliary loads and motorist attitude. In this article, we investigate these problems by studying three aspects – 1) three types of electrical vehicle charging stations (Level 1, Level 2 and DC), 2) different types of batteries and 3) different types of electric vehicles. We compared and contrasted the features of these charging stations, batteries. They suggest some places where charging station can be install like Schools with parking place, Restaurant with parking places, Hotel with parking places, Hospital with parking place, Temple with parking place, Shopping center with parking place, airport parking place and Other public places for EV public charging stations installation. He said Level 2 charging station is more suitable for charging station because the most important condition for selecting an electric vehicle charging station location is that how much time is spend by the consumer for charging his vehicle in the charging station. The same amount of distance travelled in km, electric vehicle required different charging time in each type of charging station. Level 2 charging station provides facility to consumer to charge his vehicle in a very short time as compared to other types of charging station. He compared some batteries on the basis of battery capacity and battery cost such as Lead acid(Pbacid), Nickel-cadium (Ni-Cd), Nickel-metal hydride(Ni-MH), Lithium-ion (Li-ion), Lithium-ion polymer (LiPo), Lithium-iron phosphate (LiFePO4), Lithium-sulfur (Li-S). after comparison he get lead acid battery is suitable for electric vehicles.[6]

Shaohua Cui et all (2018) In this paper, the location distribution of different size and types of charging stations is considered. By considering the different types of charging stations, different charging demands of different users can be satisfied. The difference in the size of the charging stations reduces the overall government budget for the construction of the stations, while meeting the minimum travel time for travelers. This paper also considers the user's anxious mileage and other factors comprehensively, making our problem more practical. In addition, he verifies the validity of the model through two networks. In the Nguyen-Dupius network, he observe the final charging station location and the size and type of charging station by changing the total budget of the establishment of charging station, the initial electric quantity, and the anxious range of agents. The final result is practical, indicating that the model is reasonable and feasible. To make the result more convincing, he applied the model to the Sioux Falls network which has more nodes, more sections, and is more complex. In conclusion, the results show that our study is meaningful and practical. [7]

Doug Kettles et all (2015) this report accesses the technologies and standards associated with Electric Vehicles (EVs), Electric Vehicle Service Equipment (EVSE) and the related infrastructure. A review of infrastructure, highway and vehicle safety standards are included in the paper. The report also evaluates the barriers and challenges of deploying an expanded network of EV charging stations and makes recommendations to help standardize and expedite EVSE infrastructure deployment to support the accelerating growth of EVs. The development of standards to support the expansion of EVSE infrastructure has been slow and frequently interrupted. There are several different power levels for recharging batteries, different equipment connectors for different recharging levels (in one case, different connectors for the same charging level), and a variety of onboard chargers for PEVs. Some charging networks are also plagued by equipment that fails to operate reliably and have unacceptably long periods of downtime. These are not "bells and whistles" options for the purchaser of a PEV, they have very real, permanent consequences that affect the day-to-day use and lifestyle of the PEV owner. Combining the lack of physical layer standardization and reliability with the proprietary nature of existing PEV recharging networks can make it a real challenge for the average motorist to consider switching to an electric vehicle. Restricting the ability to locate recharging stations to those able to acquire and master the fundamentals of Internet access, and requiring the ownership of electronic devices to do so, significantly reduces the potential market for PEVs. [8]

Yu Miao et all (2019) This paper has provided an overview of Li-ion batteries as a method for energy storage for EVs. Different materials for positive and negative electrodes, various types of electrolytes and the physical implementation of Li-ion batteries are presented and compared, and components of battery management systems are described. The performance of existing lithium batteries is heavily dependent on material and thermal characteristics. As discussed, most of the heat from the battery is generated at the electrodes and additional research in various cooling methods and electrode design criteria is needed to reduce or compensate for the heat, therefore, improving the battery life and capacity. As EV batteries reach the end of their useful life, research is showing the different approaches to repurpose them as a supplement to the existing power grid or recycle the battery materials when they are no longer viable.[9]

Henry Lee et all (2018) in this article, the challenges facing EV development have become more tractable in recent years, but they are still considerable. The life cycle cost of ownership of BEVs has fallen substantially; further declines in installed battery prices below $300 per kWh may lead to genuine parity with ICEs in the next 5-7 years. Of far more consequence for sustainably scaling EV ownership is the cost-effective, efficient deployment of charging infrastructure. Standalone economic analysis of different charging options suggests that residential Level 2 charging, where available, can be the best option for most of an EV owner's charging needs, and that ToU rates (mostly for overnight charging) can bring down the average cost of electricity to below the equivalent fuel cost for an ICE. Unprecedented levels of investment and product development planned by almost all major OEMs clearly indicates that a much larger EV market is forthcoming. [10]

III. SCOPE OF THE PROJECT

Indian current scenario- Large scale introduction of Plug-in electric vehicles (PEVs), including plug-in hybrid electric vehicles (PHEVs) and Battery Electric Vehicles (BEVs) have the potential to improve Indian energy and environmental landscape of personal transportation. Central government should start enforcing necessary measures to install EV charging infrastructure. Initial step could be to encourage international market players to make case studies on potential locations and adequate quantity of Electric Vehicle Supply Equipment (EVSE). With a projection of EVs, the effects on current, energy production, transmission and distribution scheme, road traffic density, emission level and parking space requirement need to be analyzed. Operation and maintenance of installed infrastructure should be maintained properly. Instead of direct involvement of Govt. body, private players should be tendered in order to maintain the smooth work flow. Central management through Charging Station Selection server (CSS) will play a vital role in information transfer between EVs-Server-Control centers. India is a coal driven country and so most electricity required for EVs is supplied from thermal plant. Two wheelers are seen more on road due to its fuel efficiency. India is 2nd longest 2W market after china and will remain the preferable choice fill 2035. People in India are more concerned about the Mileage, maintenance free, durable, immediately accessible and service oriented vehicles. Market of EV in India is about 1% over the decade. Indian government has released its "National Electric Mobility Mission Plan" (NEMMP 2020) in 2013, which aims to deploy 4 lakh passenger BEV's on road by 2020.

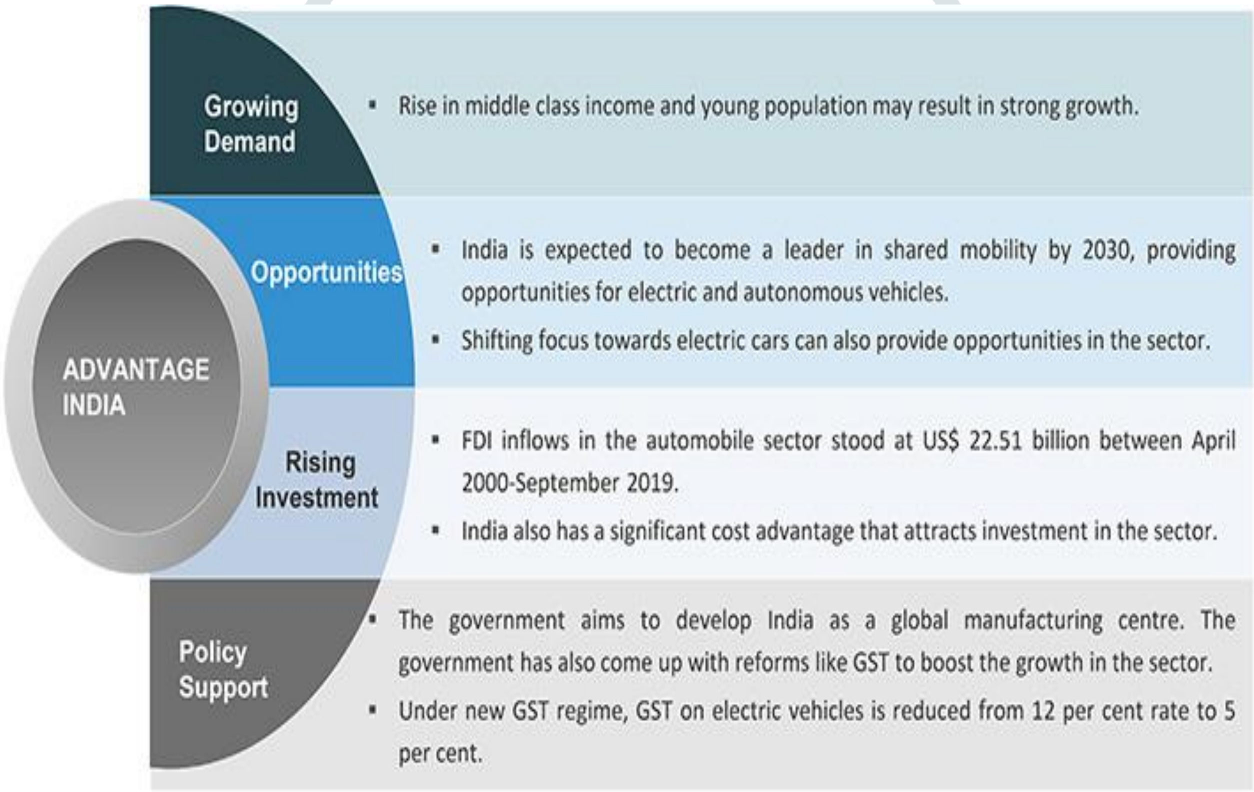

Fig. 4 - scenario of India in automobile industry

Objectives of the electric vehicle charging station –

- To enable faster adoption of electric vehicles in India by ensuring safe, reliable, accessible and affordable charging infrastructure and eco-system.
- To promote affordable tariff chargeable from EV owners and charging station operators/owners.
- To generate employment/income opportunities for small entrepreneurs.
- To proactively support creation of EV charging infrastructure in the initial phase and eventually create a market for EV charging business.
- To encourage preparedness of electrical distribution system to adopt EV charging infrastructure.

Site location for electric vehicle charging station-

In case of public charging stations, the following minimum requirements are laid down with regard to density/distance between two charging points:

- At least one Charging Station should be available in a grid of 3 Km X 3 Km. Further, one Charging Station be set up at every 25 Km on both sides of highways/roads.
- For long range EVs (like long range SUVs) and heavy duty EVs like buses/trucks etc. there should be at least one Fast Charging Station with Charging infrastructure Specifications as per para 4.I at every 100 Km's, one on each side of the highways/road located preferably within/alongside the stations laid in para3 above. Within cities, such charging facilities for heavy duty EVs shall be located within Transportnagars, bus depots. Moreover, swapping facilities are also not mandatory within cities for Buses/trucks.

Additional public charging stations shall be set up in any area only after meeting the above requirements.

- The above density/distance requirements shall be used by the concerned state/UT Governments /their Agencies for the twin purposes of arrangement of land m any manner for public charging stations as well as for priority 1n installation of distribution network including transformers/traders etc. This shall be done in all cases including where no central/state subsidy is provided. The appropriate Governments (Central/State) may also give priority to existing retail outlets (ROs) of Oil Marketing Companies (OMC s) Tor installation of Public EV Charging Stations (in compliance with safety norms including 'firewalls etc.) to meet the requirements as laid above. Further, within such ROs. Company Owned and Company Operated (COCO) ROS may be given higher preference. Any deviation from above norms shall be admissible only after specific approval of State Nodal Agency in consultation with the central nodal agency.

Requirements for the Electric vehicle charging station

- An exclusive transformer with all related substations equipment including safety appliance.
- 33/11 KV cables with associated equipment including as needed for the line metering.
- Appropriate civil works.
- Adequate space for charging and entry/exit of vehicles.
- Current international standards that are prevalent and used by most vehicles manufacturers internationally are CCS (Combined Charging System) and CHadeMO. Hence, public charging station shall have, one or more electric kiosk boards with installation of all the charger models.

Infrastructure for the electric vehicle charging station-

Public charging stations for long distance EVs and/or heavy duty EVs shall have the following minimum requirements

- At least two chargers of minimum 100 kW (with 200-1000 V each of different specification (CCS & Chademo) and with single connector gun each in addition to the minimum charging infrastructure requirements as mandated for Public Charging Stations in para3.
- Appropriate Liquid Cooled Cables for high speed charging facility for onboard charging of Fluid Cooled Batteries (currently available in some long range EVS).
- In addition to the Fast Charging Stations (FCS) for Long Distance EVs and/ or Heavy Duty EVs may also have the option of swapping facilities for batteries for meeting the charging requirements as per para 3 and para 4.1 & (i) above is notable that Fluid cooled Batteries (FBS) are generally necessary for Fast Charging/Long distance use of EVs and/or for Heavy duty vehicles like buses/trucks etc.

IV. Methodology

Electric Vehicle Charging- There are three levels commonly used to describe the charging power of EVSE: Level 1, Level 2 and DC Fast Charging. The amount of range provided for each of these is shown in Figure 1. Below with additional details in the following sections.

Level 1- 120 Volt Charging- This simplest form of charging uses a 120V AC connection to a standard residential/commercial electrical outlet capable of supplying 15-20 amps of current, for a power draw usually around 1.4 kW when charging. EVs come equipped from the manufacturers with portable Level 1 chargers. AEVs with 60-80 miles of range will require 10-14 hours for a full charge using Level 1 EVSE.

Level 2- 208/240 Volt Charging- Level 2 charging requires a 208/240V AC power connection and significantly reduces charging time. Home users commonly use 240 V power for electric clothes dryer appliances and many commercial customers have 3 phase electric service with 208 V power. Either voltage works well for "Level 2" charging. The J1772 standard connector used by most EVs can theoretically provide up to 80 amps of current (19.2 kW), although most vehicles presently available only use up to 30 amps for 3.3 to 6.6 kW6 charging. AEVs with 60-80 miles of range will usually require 3-7 hours for a full charge using Level 2 equipment, depending on the capacity of the EVSE and the vehicle charging system. EVs with smaller batteries, such as a PHEV with 10 miles of range (e.g. Toyota Prius Plug-in) may require less than an hour to reach a full charge.

DC Fast Charging- Sometimes referred to as Level 3, DC fast charging equipment delivers high power directly into an EV's battery system, enabling rapid charging. Typically, an 80% charge can be provided in 30 minutes or less for many all electric vehicles. DC fast charging does not same J1772 plug connectors as Level 2. There are three distinct connectors for fast charging equipment by various manufacturers: 1. CHAdeMO used by Nissan, Mitsubishi and Kia; 2. SAE Combo used by American and European makes, such as Chevrolet, BMW and Mercedes Benz; and 3. Tesla's Supercharger used exclusively on Tesla Model S and later vehicles. Tesla has also announced an adapter allowing their owners to use CHAdeMO equipment.

Table. 2 – direct current specification

Power supply	Power	Voltage	Max current	Charging time
Direct current	50kw	400-500V	100-125A	19-24 Min.
	120kw	300-500V	300-350A	8-10 Min.

Table- 3 charging range added per hour of charging.

		Level 1	Level 2	DC Fast Charging
Miles of Range per Hour of Charging	90			
	80			
	70			
	60			
	50			
	40			
	30			
	20			
	10			
	0			

Table- 4 EV charging level features

Charging Level	Features
Level 1	• 120 VAC, 15 or 20 Amp circuit based on the standard American home outlet. • Will take the longest time – eight to 10 hour full charge. • Simplest; easily accessible for vehicle owners. • Uses amount of power similar to a hair dryer or microwave. • Suited for low-speed NEVs and some PEVs with short electric-only range; may also be well suited for locations where a PEV will be parked for extended periods (days/weeks)

Level 2	• 208/240 VAC, 80 A maximum current (100 A circuit). • Will use only the SAE J1772 specified plug. • Uses amount of power similar to large appliances, such as air conditioners or clothes dryers. • Requires two to three hour full charge*.
DC Fast Charge	• 480 VDC / 100 A (and up) fast charge. • 80% charge in around 30 minutes*.

Residential Charging Station Installations-

Charging at home is by far the most popular option for EV owners. Convenience is high for homeowners who charge overnight when their vehicles are not in use and their electricity costs are much lower than comparable gasoline vehicle fuel expenses. Many homes have ready access to power connections which reduces EVSE installation expenses. There are generally no concerns about availability or blocking other EV owners from charging, although multifamily residents living in condominiums or apartments may encounter unique issues in getting charging equipment installed, particularly if they do not have access to dedicated parking in proximity to power connections. Existing 120V outlets can be used for Level 1 charging with the equipment supplied by the vehicle manufacturers which generally recommend the use of a dedicated 15-amp circuit with GFCI protection. A summary of the rationale and process for residential charging stations is included in Table below.

Commercial Locations- After home, workplaces are the second most common location for electric vehicle charging. An increasing number of businesses in Vermont are providing EVSE for employees, visitors and/or customers. Several additional siting factors should be considered for these areas.

- Parking capacity – Vehicles need to dwell for up to several hours while charging. Placing charging equipment in areas with excess parking capacity and restricting EV charging spaces will reduce potential conflicts with internal combustion engine vehicles.
- Proximity to employment / destinations – Since EV charging can require significant time, it is advantageous to co-locate charging at areas with services, such as shopping, restrooms, food and other workplace facilities which provides EV owners with a range of activities to pursue while their vehicle is plugged in.
- Modal Connections – Locating charging in areas with linkages to other modes of transportation, such as sidewalks, bus stops, and park & rides provides owners with access to additional destinations and opportunities.

Case Study

Proposed Locations for Charging Stations in Pune:- We have identified some places for placing an electrical vehicle charging station that is further divided into some categories:

- **Schools with parking place:-** Schools with parking places especially solar parking lots where EVs can recharge is one of the best scenarios. An EVSPL (electric vehicle solar parking lot) is suitable for schools since parents of the students can recharge their EVs while they come to school for any engagement. In the same way since schools have large parking lots especially so it can be an alternative place for recharging EVs when other solar parking lots are fully packed. In addition, number of schools are greater than rare EVSPLs so school locations with EVSPLs can be an effective of reducing "range anxiety" and can result in successful EV adoption. Keeping in view the earlier mentioned criteria for EVPLs we have identified some schools. These schools' parking lots can be transformed in to EVSPLs. These schools are Holy cross school, Don Bosco School, the Pune international school.
- **Restaurant with parking places-** Similarly the following places are suitable for EVSPLs. Momos n More, Raaste Cafe, Coffee Tea and Me, Hotel Sonari Tori, Hotel invitation, Royal Veg, Curry Club Restaurant.
- **College with parking place-** Colleges that are suitable for constructing EVSPL are: Tripura Sundari College of nursing, Women's College, Maharaja Bikram College, BBM College, Tripura Government College.
- **Government offices with parking places-** Government offices with EV charging stations can be an effective solution as well for strengthening EV market. CBI Office , Office of the AG, Pune municipal council office, Directorate of higher education office, Tripura Public Service commission office, Krishi Bhawan office.

- **Hotel with parking places**-These hotels with EV charging stations is ideal since they are public and potential customers spend more hours there. Hotel Welcome Palace, Hotel City Centre, Executive INN, Hotel Jaipur Palace, Rajdhani Hotel, Royal Guest House (Hotel), Ginger Hotel.
- **Hospital with parking place**- Hospitals with EV charging stations can be count on in times of emergency as well. ILS Hospital, GB Hospital, GB Pant Hospital, Devlok Hospital, Apollo Gleneagles Hospital Information Centre, GB Hospital Medical College, Tripura Medical College, Pune Government Medical College.
- **Resort with parking place-** Resorts are also a better place to install public charging stations. Since, not only visitors visit this place but hotel staff and general public can also come to resorts for festive seasons. Hence, it becomes a densely populated area with requirement for a electric vehicle public charging stations. Some are of the suitable places for this purpose in Pune India are Green Touch Resort, Shyamali Tourist Resort, Hotel Woodland Park, and Rose Valley Amusement Park.
- **Temple with parking place-** Temples are best locations for installing public electric vehicles charging stations since this is one of the public places with good space. Some of the appropriate places for setting up EV charging stations in temples of Pune are: Laxminarayan Bari Mandir, Jagannath Mandir, Iskcon Bari, Durga Bari , Ummaneshwar temple, Fourteen Gods Temple, Tripura Sundari temple.
- **Shopping centre with parking place-** In addition, shopping centers are one of the most suitable place for public charging stations due to its parking requirements and the frequency of potential EV customers' visit. Some public charging stations can be installed in these shopping centres in Pune i.e. ML Plaza, Metro Baazar, Bag Bazar, Pune City Center, Femme Zone/FEM Salon and spa, Saradamani Shopping mall.
- **Pune airport parking place-** Pune airport parking place is another example of suitable place of installation of EV parking place due to the availability of parking space and public reach. Pune airport can provide convenience for airport visitors, cab owners and staff of the airport. A public charging station installed at airport can also attract new EV customers due to its convenience.

V. Details of Design, Working and Processes

Electric Vehicle Charging Equipment Overview- EV charging stations are classified by their approximate charge rates and the form of power delivered (alternating current [AC] or direct current [DC]). Charging times for each specific vehicle vary depending on power electronics, state of existing charge, battery capacity, and level of charging station used. These stations are technically referred to as electric vehicle supply equipment (EVSE). AC Level 1 EVSE (at 120 volts of alternating current [VAC] up to 2 kilowatts [kW]) and AC Level 2 EVSE (at 240 or 208 VAC up to 19.2 kW) provides power in the same capacity as it is supplied and the EV uses an on-board inverter to switch it to DC power that charges the batteries. DC EVSE uses an off-board inverter so it can supply DC power to the vehicle directly at higher amps for a faster charge. Connectors, or plugs, for Level 1 and Level 2 charging stations have been standardized to allow owners of EV models to utilize the same charging infrastructure. This standard Society of Automotive Engineers (SAE) J1772 connector provides significant safety and shock-proof design laments. There are two different connectors used for DC fast charging, CHAdeMO and SAE J1772 Combo, which is why DC fast charge stations like the one at Diane's Downtown Automotive in Ithaca offers both. Tesla uses a different proprietary connector, but includes a SAE J1772 compliant adapter cable with each vehicle sold and offers adapters for CHAdeMO and SAE J1772 Combo connections for an additional price. Recharging EVs is accomplished through connections to electric vehicle charging equipment, also referred to as Electric Vehicle Supply Equipment (EVSE). This is a protective system which communicates with the vehicle and monitors electrical activity to ensure safe charging. While the actual "charger" is contained in the vehicle, the appliance commonly referred to as a charging station or EVSE is the conduit, control, and monitoring device which connect the vehicle to the electric grid.

Side Consideration- The process for installing EV charging at a particular location will depend on the property ownership and type of land use. Several primary factors relevant to siting EV charging installations within a property are listed below, followed by more detailed information on the process for installing a charging station.

General Siting Issues-

- Availability of power – Proximity to electric power service is often the key factor in determining installation cost. Placing charging equipment near existing power service will reduce cost and installation time, particularly if there is reserve capacity available to reduce any upgrade costs. Property owners may want to consider investing in efficiency improvements for other power consumption on the property to reduce ongoing power expenses and free up service capacity in constrained situations. In some situations, it may be more cost effective to install a new service drop and meter from a utility distribution transformer if that would result in a shorter power run to the preferred site for the charging station installation.

- Constructability – As stated above, placing equipment near power sources will reduce the extent of trenching needed for conduit runs. Many installations will still require some amount of trenching and in these situations it is best to go through softer features, such as grass medians, rather than sidewalks, asphalt or areas with extensive landscape features.
- Mounting – Wall mount units generally have lower capital and installation costs, so this option is often preferred if the site has a suitable wall area. Dual mount options for charging equipment may also help reduce overall installation costs as the incremental cost of adding another port is frequently much lower than installation an additional single port unit.
- Environmental protection – Charging equipment exposure to the elements should be minimized as much as possible. Areas prone to flooding or standing water should be avoided as much as possible.

Choosing the location – Public charging stations Some locations are particularly suitable for the installation of public charging stations: for example, parking lots that serve train stations, shopping centres, restaurants, hotels and resorts. Use the following criteria when selecting a location-

• Traffic, with the size of the installation to be based on the expected number of users.

• How much time EVs will spend at the station.

• Surrounding vehicle movement – vehicles stopped for charging must not hinder traffic flow.

• Winter use – the location must be cleared and accessible during winter and not be used as a snow dump or hinder snow clearing operations.

• Protection against collisions.

• Impact on pedestrian traffic – must not hinder pedestrian traffic or be subject to high pedestrian traffic and the associated increased risk of vandalism.

• Access to a cellular network, if required by the charging station • Feasibility of required excavation work.

• Proximity of distribution panel.

• Visibility of the charging station to encourage its use by drivers. In addition, consider the mounting requirements (pole-mounted, anchored to a concrete base, etc.) and the length of the charging cable in relation to the typical location of EV charging sockets.

Public and private charging stations- This section describes the different types of charging station installations to aid in selecting the most appropriate for your needs. Since this Guide frequently mentions private and public stations, it is important to define these concepts. A private station is a station purchased by an individual for personal use. A public station is a shared station; it may be installed on public or private property by a public organization or a company.

Charging station selection criteria- A variety of models designed for different uses are available on the market. When selecting a charging station, consider these factors:

- The power required (charging time, vehicle capacity, pricing).
- The communication requirements (access control, payment system, help system).
- The number of cables and plugs (for shared-access stations).

Public or private charging stations in commercial zones- When installing Level 2 charging stations for the employees or customers of a business in a building that is subject to Rate G, avoid optimization charges by ensuring that the stations do not cause the maximum power demand to exceed 50 k W (switch to Rate G-9 or M if necessary). If the maximum power demand already exceeds 65 k W and is therefore billed under. Rate M or Rate G 9, the power consumption of charging stations could result in an additional cost for each additional kilowatt. In this case, consider individual connections or a smaller number of charging stations.

Charging station for heavy industry- Heavy industry companies subject to Rate L have billing demand of 5,000 k W or more. Installing Level 2 charging stations should not have a marked impact on their maximum power demand if vehicle charging is temporarily halted or limited during plant equipment startup. The low rate per k W h and the large amount of available power suggest the use of fast-charge stations outside the plant's peak hours.

Apartment building parking areas- Before installing a charging station in the parking lot or garage of a condo or apartment building, you must consider several factors related to location and to ownership of the parking area and grid connection facilities.

In general, J1772 charging stations rated 208 or 240 V, 30 A are used. In the case of a condo where the parking spot is on the owner's premises (e.g., a townhouse), the power supply to the charging station is often connected to the owner's electricity meter, in which case the installation is the same as for a detached house. In a condo where each owner has a parking spot in the garage, the owner must agree with the condo association as to a suitable location for the charging station. Power may be supplied to the station from the condo owner's meter or from the shared meter serving the common areas. In either case, the connection is made in the same way as for a block heater or lighting outlet in an underground garage or storage area. **Workplaces**- Charging times are generally less of a constraint in the case of workplace installations, since employees have predictable work schedules. Assuming that an employee drives less than 50 km to their workplace in an E V that consumes an average of 200 W h/k m, they consume approximately 10 k W h to get to work, which is the energy delivered by a 3-k W charging station in under 4 hours. Level 1 chargers may not be fast enough to provide a full charge, since they take about 7 hours to deliver 10 k W h. However, A C Level 2 chargers rated 3.6 k W (240 V, 15 A) may be appropriate for this scenario, assuming that the E V remains connected for the entire work shift. Charging stations rated 7.2 k W or even 19.2 k W may be required for high-mileage users, such as sales representatives and delivery people, as well as for short-stay users such as visitors and customers.

Site Plans- There are many possible arrangements and designs for EV charging station installations, depending on the parking area layout, availability of power, and other site considerations. Many EV charging station sites use wheel stops to prevent vehicle contact with the charging equipment, but these can be problematic with snow removal. Bollards can also provide protection for EV charging station, and are recommended over wheel stops to increase accessibility. General EV charging station site plan considerations include:

- Power availability (240V for Level 2, 3 phase for DC fast charging).
- Level parking surface, preferably paved so EVSE spaces can be marked.
- Lit, visible area to address security concerns.
- Accessibility for disabled users. Barriers or mounting options to protect EVSE equipment from vehicles.
- Signs and pavement markings to designate sites and restrict their use.

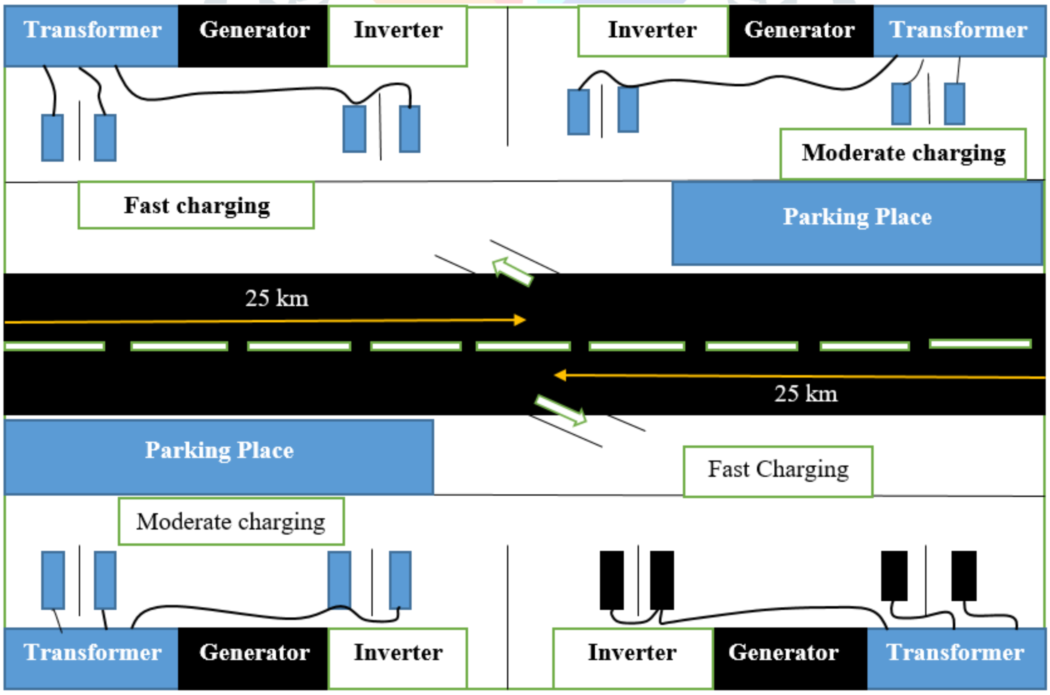

Fig. 5- actual infrastructure for electric vehicle charging station.

VI. Results and Applications

Lower Costs: Enabling EV drivers to participate in utility demand response programs and exposing customers to demand side management will significantly lower costs for drivers and station owners. In addition, avoiding long term utility investments through load management will lower costs over time for all ratepayers via greater utilization of utility generation, distribution and transmission assets.

More Charging Stations in More Places: Allowing utilities to incorporate into their general rate cases the costs of the infrastructure needed to install a charging station, alongside the other investments that utilities make every year, will cut the price per station by more than half. This can increase opportunities for workplaces, retailers, hospitals, schools, hotels, homes and apartments to add more stations in more places.

Fuel Independence & Cleaner Air: Switching from gasoline-fueled vehicles to cleaner EVs can reduce dependency on foreign oil and reduce greenhouse emissions by more than 38% per vehicle annually according to the U.S. Department of Energy.

Builds on Positive Utility Customer Relations: Utilities have a strong and historic relationship with ratepayers across their territories. By assisting in the deployment of electric vehicle charging infrastructure, utilities can provide customers the additional benefit of access to clean, affordable electricity for fueling their vehicles.

Improved Electricity Planning: By allowing utilities access to data from electric vehicle charging infrastructure, utilities can now better predict deployment of new stations and changes in local energy needs.

Grid reliability : Electric vehicle charging infrastructure can complement the increased growth of intermittent renewables, which means that utilities can balance solar energy being produced and added to the grid with the electricity flowing off the grid and into cars at the same time.

Expansion of the Smart Grid: Deploying the latest advanced technology for EV charging, including smart charging applications and "vehicle grid integration" (V2I) capable stations, ensures that current and future EV drivers are fully integrated into a smart grid of the future.

VII. Conclusion & Future scope

- Smart charging, vehicle-to-grid, solar charging of EV, contactless charging and on-road charging will be five key technologies that will enable the transition to electric mobility. These technologies will not only disrupt the transportation industry but will affect the entire energy landscape with their potential to support the grid and to increase the penetration of renewables. The right business models and standardization will play a vital role in the fast acceleration and large-scale implementation of the technologies.
- India has the largest market of EV in the world. With the development of infrastructure. Technology and power source there is chances for a shift towards EV's. To increase the public awareness in our country, the initial approach of central encourage market players at international level to carry out studies for finding potential locations for the development of EV charging infrastructure and EV Supply equipment. There is a wide scope for EV's in two wheeler market, auto rickshaw, goods vehicle, bus as well as four wheelers.
- One approach to reduce the greenhouse gas emissions in the transport sector is to change transportation modes to become more electric. The scope of this research is on the Plug-in Hybrid Electric Vehicle (PHEV), the Electric Vehicle with a Range Extender (EREV) and the Battery Electric Vehicle (BEV). BEVs are the most desirable form of passenger cars, because of their zero tailpipe emissions and their potential of 100% reduction of Co2 emissions.
- It is clear that E-mobility is a distant dream for the Indian government. It is very tough but not impossible to realize the ultimatum which has been set. If India really wants the mission to be accomplished, it's going to be a collective effort of every individual/ organization significant to the country. That includes the government, of course, the automotive consortiums/industries associated and the people. The government can offer solutions and incentivize the taxes, but it is useless if the consumer is not willing to move out of the comfort zone and grab it. The auto giants also have to take a step forward and take risks for the change to happen.
- In the near future, e-mobility would not be something of luxury but it would be something necessary for the survival because the pollution level is alarming and the only solution is the green sources and transmission of energy. Hence, EVs are inevitable when it comes down to it, so it is better to plan and organize about how the developments are going to occur rather than dodging the change. The earlier this realization occurs, the better. It is required to lay strict guidelines and a time managed framework as to how changes are going to occur and how to make the most of it. There are strengths and weaknesses in every domain which need to be pondered upon and eradicated respectively.
- There has been no evidence found in this limited research that can support the target of 25,000 stations by 2020 however there is evidence that indicates 300 stations bye and 2016 is a responsible likelihood. In Over research we find some places where we establish the charging station and as well as EV charging stations to allow EV driving anywhere in the country to provide EV charging station at all petrol stations and malls etc.

- The challenges facing EV deployment have become more tractable in recent years, but they are still considerable. The life cycle cost of ownership of BEVs has fallen substantially; further declines in installed battery prices below $300 per kWh may lead to genuine parity with ICEs in the next 5-7 years. Of far more consequence for sustainably scaling EV ownership is the cost-effective, efficient deployment of charging infrastructure. Standalone economic analysis of different charging options suggests that residential Level 2 charging, where available, can be the best option for most of an EV owner's charging needs, and that ToU rates (mostly for overnight charging) can bring down the average cost of electricity to below the equivalent fuel cost for an ICE. Unprecedented levels of investment and product development planned by almost all major OEMs clearly indicates that a much larger EV market is forthcoming. The picture is less rosy for the commercial charging infrastructure required to serve this expanding market. DCFC charging (Levels 3-5) is exposed to much higher monthly demand charges and greater need for consistently high utilization to break even. The analysis has demonstrated that for levels of utilization above 20%, DCFC breakeven electricity prices can be competitive with gasoline prices. This is an important finding—but is made in the context of many unresolved regulatory and public policy issues, and very significant downside risks for underutilized infrastructure. The debate over utility ownership of EV infrastructure is ongoing. The criteria for deciding whether public ownership and rate-basing the cost of charging infrastructure is the appropriate tool for developing this market, or whether charging infrastructure should be left entirely to the private sector, are unresolved. A further question is how utilities, third parties, and OEMs can most effectively coordinate/pool their respective expertise in a manner which preserves competitive dynamics, but optimizes EVSE charging decisions in the most socially efficient manner possible. While there are uncertainties around the commercial penetration of electric vehicles, a future scenario in which governments agree to substantially decarbonize their economies will involve partial electrification of the Belfer Center for Science and International Affairs Harvard Kennedy School 53 transportation sector. There are differences of opinion on the rate at which this transition will occur, but there is clear technological and economic traction towards much greater reliance on electric vehicles. New rate designs, better smart metering and charging equipment technologies, and a charging infrastructure that is convenient and price competitive will need to be developed and implemented. These are difficult but achievable tasks.

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IX. REFERENCES

1. Afida ayob et all., "Review on Electric Vehicle, Battery Charger, Charging Station and Standards." Research Journal of Applied Sciences, Engineering and Technology., January 2014.

2. Adam Junid et all,. "A Study of Electric Vehicle Charging Station Installation Progress in Malaysia." Research Journal of Applied Sciences, Engineering and Technology., January 2016.

3. Praveen Kumar et all,. "Potential Need for Electric Vehicles, Charging Station Infrastructure and its Challenges for the Indian Market." Research India Publications. Number 4 (2013).

4. Kara M. kockelman et all., "optimal locations of U.S. fast charging stations for long distance trips by battery electric vehicles." Journal of Cleaner Production. 2018.

5. Somudeep Bhattacharjee et all,. "Investigating Electric Vehicle (EV) Charging Station Locations for Agartala, India." 2nd International Conference of Multidisciplinary Approaches on UN Sustainable Development Goals. December 2017.

6. Shaohua Cui et all., "Locating Multiple Size and Multiple Type of Charging Station for Battery Electricity Vehicles." Licensee MDPI, Basel, Switzerland, 13 September 2018.

7. Doug Kettles et all., "Electric Vehicle Charging Technology Analysis And Standards." U.S. Department of Transportation's University Transportation Centers Program, February 2015.

8. Yu Miao et all., "Current Li-Ion Battery Technologies in Electric Vehicles and Opportunities for Advancements." Licensee MDPI, Basel, Switzerland, 20 March 2019.

9. Henry Lee et all., "Charging the Future: Challenges and Opportunities for Electric Vehicle Adoption." Faculty Research Working Paper Series, September 2018.

10. Gautham Ram Chandra Mouli et all., "Future of electric vehicle charging" International Symposium on Power Electronics, 2017.

11. Mingsheng Zhang et all., "Location Planning of Electric Vehicle Charging Station." IOP Conference Series: Materials Science and Engineering, 2018.

12. Li Zhang, Tim Brown, "Evaluation of charging infrastructure requirements and operating costs for plug-in electric vehicles." Journal of Power sources 240, 2013.

13.http://solutions.3m.com/wps/portal/3M/en_US/electronics/home/productsandservices/pro ducts/chemicals/BatteryElectrolytes/.

14.http://www.cleanfleetreport.com/clean-fleet-articles/google-energy-v2g/.

15. www.navigantresearch.com/newsroom/more-than-1-8-million-plug-in-electric-vehicles-will be-sold-in-the-largest-102-u-s-cities-from-2012-to-2020.

16.www.fueleconomy.gov/feg/evsbs.shtml.

17.http://www.afdc.energy.gov/uploads/publication/pev_workplace_charging_hosts.pdf

18.http://standards.sae.org/wip/j2847/2/

19.http://en.wikipedia.org/wiki/Inductive_charging.

20.http://www.epri.com/PressReleases/Pages/EPRI,-Utilities,-Auto-Manufacturers-toCreate-anOpen-Grid-Integration-Platform.aspx

21.http://www.afdc.energy.gov/codes_standards_basics.html

22.http://www.afdc.energy.gov/fuels/electricity_charging_station_signage.html