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An Analysis on Various Charging Methods of EV Vehicle

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Abstract: ***Electric vehicle is a growing technology, which captures a huge impact on human resources nowadays. Over a few years, Electric vehicle technology has been grown into a great business and placed enthusiasm in the EV vehicle concept. For the smooth operation EV vehicles needs to be charged. In electric vehicles, it requires their batteries to be "fueled up" for operation. For charging, the conventional method is being grid-based, usage of solar energy for charging batteries and incorporating vehicle to grid and grid to vehicle power transfer has been identified. Using the solar chargers provides clean electricity to electric-powered vehicles enabling them to be free from pollution. In this paper, we analyzed various methods for charging Electric Vehicle.***

Index Terms: EV vehicle, charging, vehicle to grid (grid to vehicle)

I. INTRODUCTION

Timeline of Electrical vehicle was marked from 1890 to 1924 with a peak production of electric vehicles in the mid-year of 1912. However, in old days the EV requires continues charging. An electric vehicle can be powered with electricity from extravehicular sources, or it can be powered autonomously by a battery (sometimes charged by solar panels, or by converting fuel to electricity using fuel cells or a generator). The utilization of electric charging is depended on the location and time of charging of electric vehicle. It can be operated by an electric motor for charging or by other means of charging battery in a vehicle rather than using an internal combustion engine. Nevertheless, the concept of electric vehicles has been familiar from mid-19's, it has drawn a considerable amount of interest in the past decade due to rising carbon footprint and other environmental impacts of fuel-based vehicles. The basic benefit for commercialising EVs will be requiring an installation of charging infrastructure that is easy to approach, easy to use, and reasonable in price. There is an uncertainty in infrastructure if one looks into. The historical growth of electric vehicles is shown in the fig.1. Electric vehicles are the most efficient form of transportation as compared to other forms. Owing to that next generation vehicles will be requiring electric drive trains to propel the vehicles. The basic advantage of using electric vehicle is that they are of low maintenance and having less pollution hazards. According to International Energy Forecast, the usage of electric vehicle will be increasing from 3.5 million to 125 million users by 2030.

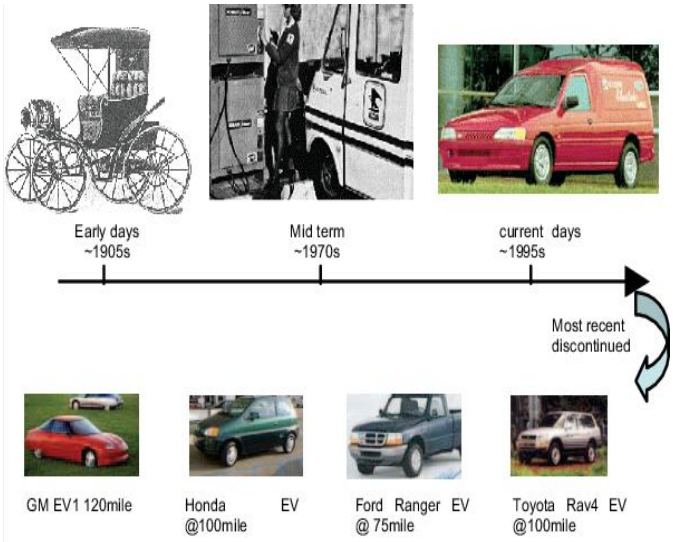


Fig.1. History of electric vehicles

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II. ELEMENTS OF ELECTRIC VEHICLE

The basic elements of electric vehicle are simple in construction and it consists of battery pack, motor, transmission unit containing converters and inverters and the most importantly a battery charger.

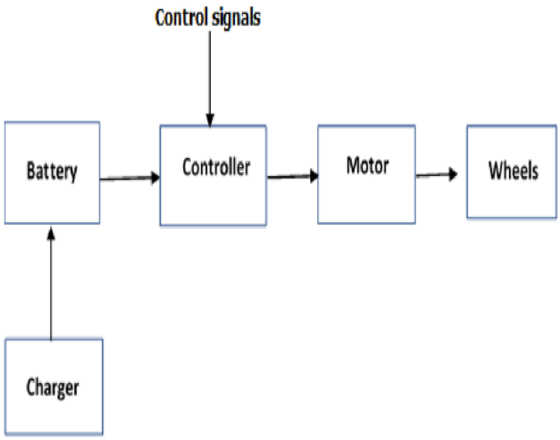


Fig. 2 Elements of EHV

Lead acid, nickel iron, nickel cadmium, nickel metal hydride, lithium polymer and lithium iron, sodium sulphur and sodium metal chloride are commonly used batteries for electric vehicles. Among these, the most commonly used battery for electric vehicle is lead acid battery. Controller is used to control the signals from battery and control signals give input to motor for running wheel.

III. DIFFERENT TYPES OF ELECTRIC VEHICLES

The Electric Vehicle (EV) is basically classified into three types based on battery charging method such as battery powered Vehicle (BEV), Hybrid Electric Vehicle (HEV) and Plug in Hybrid Electric Vehicle (PHEV). BEVs and PHEVs are also referred to more specifically as plug-in electric vehicles (PEVs). The statistical growth in EV vehicle is shown in figure 3.

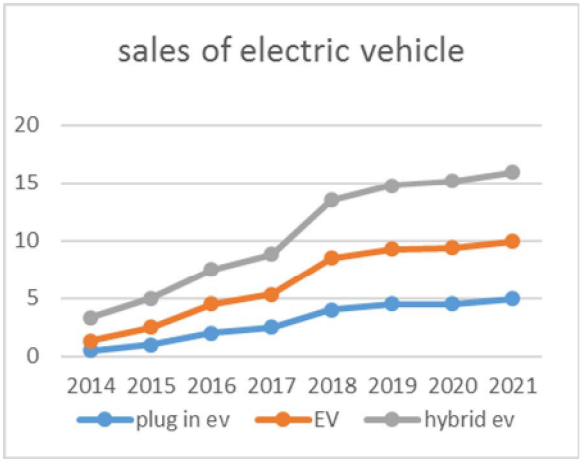


Fig. 3 Growth of EV vehicle sale

A. Battery Powered Electric Vehicle

In battery powered EVs it does not operate on petrol or gasoline but uses internal combustion engines. Rather electric vehicles can operate solely on battery power. The charging of battery is to be done at particular intervals. The charging can be done by using type 1 and type 2 EV chargers, and at commercial charging stations with type 3 chargers. Battery technology continues to improve, enabling electric cars to have greater range. BEV's is using electric motors or motor controllers in the place of internal combustion engines.

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B. Hybrid Electric Vehicle(HEV)

By definition Hybrid Electric Vehicle contains two modes of propulsion for operating. Feasible way for operating hybrid electric vehicle are by including any one of the following combinations- diesel/electric, gasoline/fly wheel, and fuel cell (FC)/battery. Compared to battery powered electric vehicle, HEVs are powered by an internal combustion engine or other source of energy propulsion. The energy stored in battery while charging can be used by an electric motor. There are wide range of advantages as well as disadvantages of HEVs such as high fuel economy and low emissions with high power range in comparison to that of traditional gasoline fuelled vehicles. Basic disadvantage in HEV is that they still produce fossil fuel emissions and also require high maintenance cost. In this type, the charging is done by using regenerative braking and the internal combustion engine. They capture energy normally lost during braking by using the electric motor as a generator, storing the captured energy in the battery. The energy from the battery provides extra power during acceleration and auxiliary power when idling.

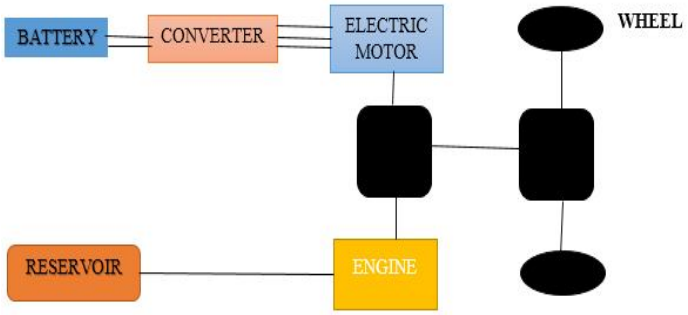


Fig.4. Hybrid Electric Vehicle Block Diagram

C. Plug In Hybrid Vehicle

Plug in hybrid vehicle is the one which the vehicle uses both the conventional internal combustion engine (ICE) and an electric motor. The plug in hybrid vehicle is also known as Series hybrid vehicle. This vehicle offers the user a wide variety of fuel options. Initially for charging purpose gasoline, biodiesel or a battery charging pack can be used. The plug in hybrid vehicle can charge in two modes either by connecting to a plug externally or by using electric charging station.

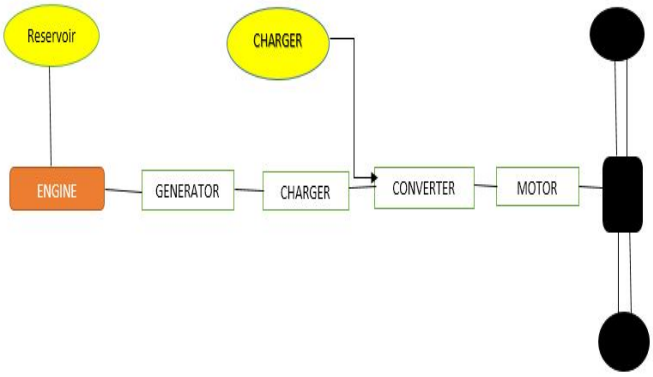


Fig.5 Plug in Hybrid vehicle

IV. TYPES OF ELECTRIC CHARGER

The main aspect of electric vehicle is charging of battery whether it is battery charged electric vehicle, hybrid electric vehicle or plug in hybrid vehicle. For long distance operation of electric vehicle, it will require an efficient charging network. Unlike conventional fueling methods which only has standardized nozzles for filling fuel to vehicle. EV vehicle has different types of chargers for different types of vehicles. Basically, there are three types of chargers such as AC charger (type 1), fast chargers (type 2) and rapid chargers (type 3).

A. AC Charger -Type 1 Charger

AC type 1 charger is the simplest charger, which can be used for entry-level electric vehicle. Charging can be done from home-charging system using plug socket or using an AC charger. It is a slow charging system. AC charger can provide power levels up to 220 volts and a maximum of 16 amps of current. Also use single phase power level upto to 3 kW. With such kind of chargers, the vehicle has to convert AC power to DC, which makes it a slow process.



Fig.6. AC charger

B. Fast Charger –Type 2 charger

The Type 2 Charger is used for faster charging. It is used for both AC and DC charging systems. Rather than AC Chargers, these chargers work with three-phase system. Since it is three phase it can maintain input power from 7.4 kW to 43 kW with a 400-volt AC supply. It is commonly used in European charging stations. These types of chargers are used in EV consumers' homes for faster charging times as it is also compatible with vehicles with CCS plugs.



Fig.7.AC-DC charger

C. Combined Charging System

A combined charging system plug or CCS type plug (often called as CCS Type 2) is a common type charger. It can provide normal ac charging using home charging plug set up as well as it can provide combined charging of dc fast charging for commercial charging purposes. As by the name indicates it is providing other two additional contacts or pins for DC fast charging. Normally DC fast charging will provide with an input of 50 kW, but this type of plug can handle charge power levels up to 350 kW as well.

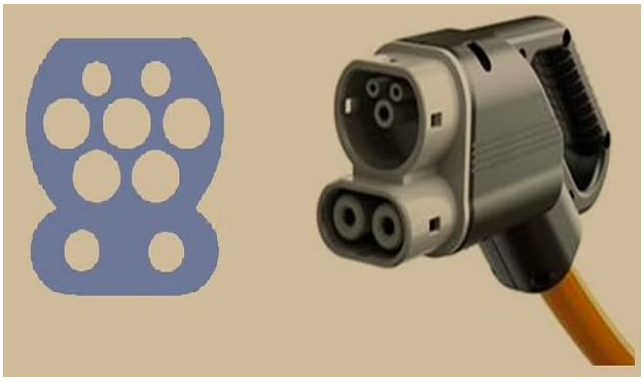


Fig. 8.CCS system charger

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D. GB/T Charger

Under Bharat DC 001, standard Indian government had recommended the GB/T type charger for EVs in India. The governing body Energy Efficiency Services Limited (EESL) is installing chargers, which are capable of DC fast charging with an output of 10-15 kW for low-power EVs. In spite of this, the connector can operate up to 230 kW. The comparison of electric chargers of electric vehicle are shown in the table 1

TABLE I

COMPARISON OF ELECTRIC CHARGERS

Type of charger	Voltage	Current type	Useful power	Maximum power	Charging time	Connector
Level 1	120	AC	1.4kw	1.9kw	12hr	J1772
Level 2	208 to 240	AC	7.2kw	19.2kw	3hr	J1772
Fast charging	200 to 450	DC	50kw	150kw	20 min	J1772,CHAdeMO

There are various factor, which affects the charging status of a battery-using charger, which includes state of charge, charging level, battery size, and onboard charger.

V. ELECTRIC VEHICLE SUPPLY EQUIPMENT

Electrical vehicle supply element is the crucial link between electric vehicle, battery and charging method to battery. While considering Electric vehicle supply equipment (EVSE) infrastructure there are various barriers that will be facing such as lack of knowledge about need of recharging network in electric vehicle. This infrastructure provides electrical energy from an electricity source to charge a EV's battery. The EVSE transmit signals with Plug in Electric Vehicle (PEV) to make sure that an appropriate and safe flow of electricity is supplied to battery. EVSE units are commonly referred to as charging stations. The basic components of EVSE includes connector, Electric vehicle inlet and Battery charger.

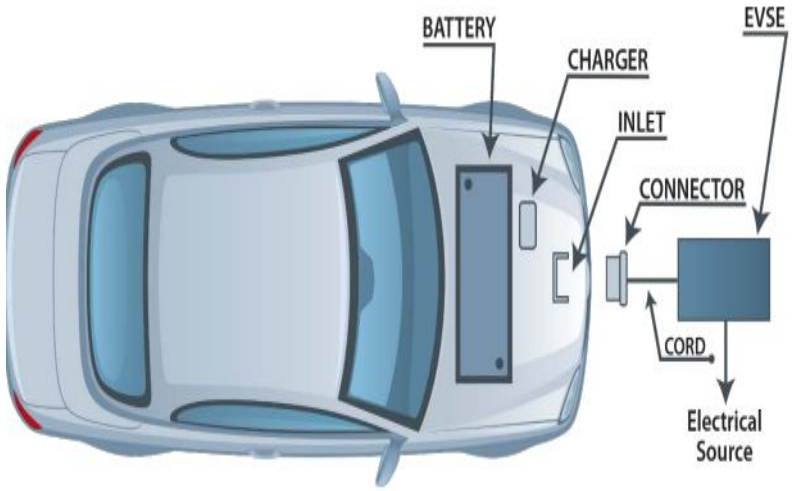


Fig.9. EVSE Architecture

VI. CHARGING TECHNIQUES

There are wide range of charging techniques for charging an electric vehicle. Author [1] presents a fast charging station (FCS) for EVs supplied by renewable energy with a novel decentralized control of the system. Whereas author [2] describes some novel methods for wireless charging methods in his paper. The wireless charging methods incorporates inductive coupling, electromagnetic coupling and resonance coupling. The comparison of wireless charging technique is shown [2] in table 2. The block diagram for wireless charging using resonant charging method is briefly included in paper [2], which contains basic blocks such as source, High frequency converter, transmitter and receiver coil, ac-dc converter, battery.

TABLE 2
WIRELESS CHARGERS

Techniques	Advantages	Disadvantages
Inductive coupling	Simple, safe and high transfer efficiency in short distance.	Short transmission distance needs accurate alignment.
Magnetic resonance coupling	Long transmission distance, no radiation.	Difficult to adjust resonant frequency for multiple devices.
Electromagnetic radiation	Very high transmission efficiency over a long distance.	Produces radiation, needs a line of sight.

As per paper [3], chargers which operates using inductive coupling principle utilizes the inductive coil to develop an electromagnetic field from charging base station. There will be a second inductive coil in the electric vehicle for charging from the base station. These two inductive coils combine to form an electric transformer. Greater distance is to be maintained which can be achieved by using resonant inductive charging method. The advanced improvement for this resonant inductive coupling includes a movable transmission coil also by using silver platted copper coil for receiver [4].

The source of power for EVSE has an impact on both the ownership expense and environmental impact [5]. Power supplied to EVSE by solar panels may be a viable alternative and augment to grid supplied electricity. The new Vehicle to Grid (V2G) concept is developed [6] in which an EVSE and EV act together to become a distributed energy resource (DER). In incorporating vehicle to grid technology inverter is installed in either EVSE technology or EV for converting DC energy from the EV battery into AC synchronized with grid. In actual practice, the charger and inverter functions would be integrated into a single bidirectional converter, but the device is commonly referred to as an inverter. Distributed energy resource can discharge energy from battery in two forms.

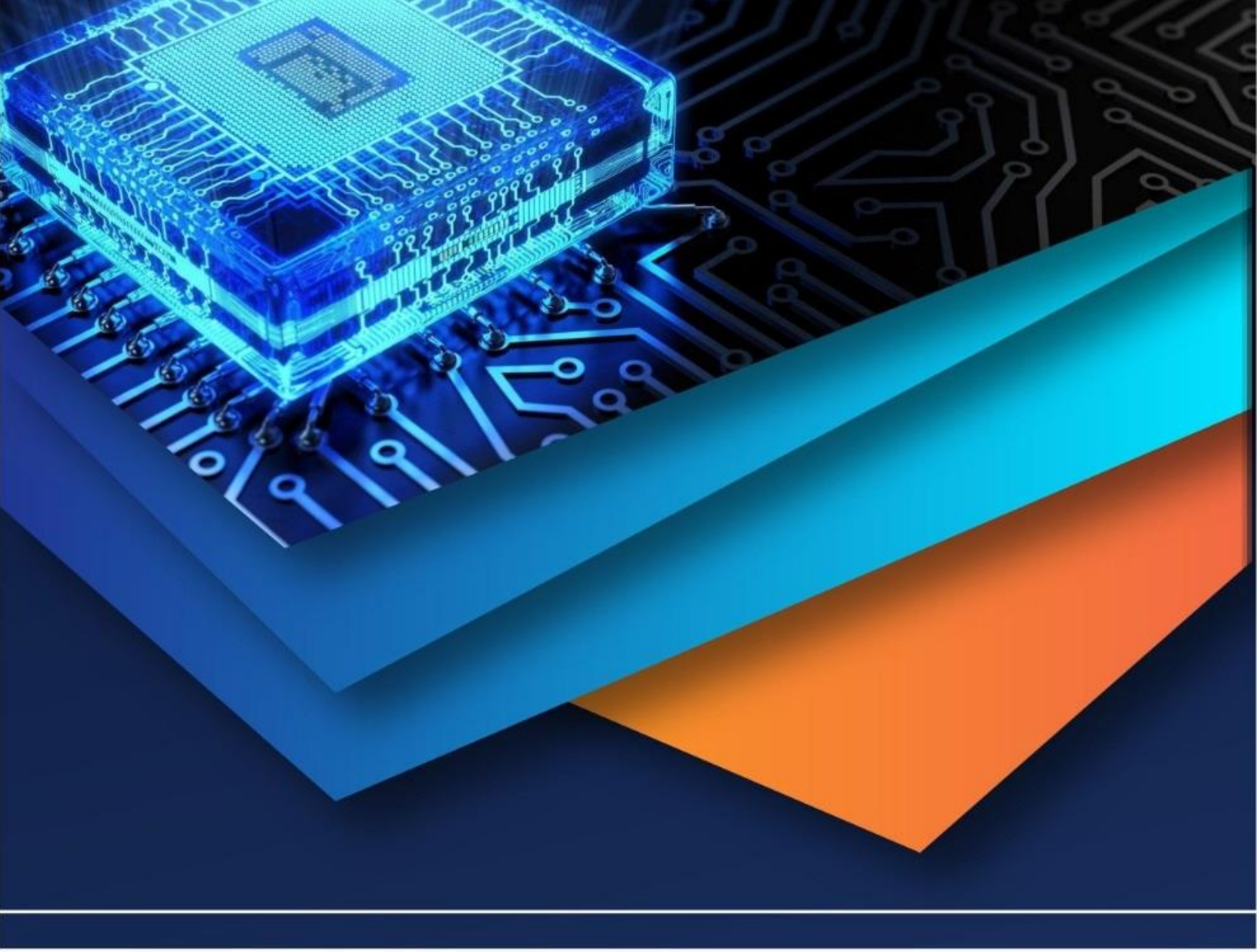
VII. CONCLUSION

In an electric vehicle, charging methodology is having much importance. This paper presented a comprehensive review on various charging methods in an electric vehicle. This paper presents an overall review of available trends of electric vehicle charging and by comparison, it is to be noted that charging using renewable sources are considered to be an efficient one. This work will also help to provide most relevant and significant information about the existing studies and it gives an opportunity to research further on battery performance optimization and intelligence systems related to integration of multi power sources, stability, reliability analysis of distribution networks, and location and sizing.

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