IMPACT OF CONNECTING ELECTRIC VEHICLES TO GRID AND ITS CHALLENGES

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Abstract:The demand for electric vehicles is abruptly increasing due to over consumption of conventional fuel by automobiles, which in turn leads to harness the renewable sources of energy to compensate the depletion of conventional fuels. With the increase in usage of electric vehicles, charging station and its supporting facilities to recharge Electric Vehicle should be taken care off. Thereby affecting the voltage stability, peak load demand, power quality and equipment overloading. This paper deals with the challenges faced by EV charging station and certain alternative methods to overcome these challenges.

Keywords: **Electric vehicle, Charging station, Battery management system, Power grid, Hybrid system.**

I. INTRODUCTION

In present scenario, due to serious crisis in energy sector, alternative energy and energy for sustainable development is imminent. Hence, clean and efficient usage of energy sources becomes the prime importance across the global [1]. Recently, innovation in Electric Vehicles (EVs) has attracted prominent attention since they use clean electricity. The increased demand in usage of electric vehicle started because of lower noise pollution, reduced emission, less maintenance requirement, and decreased power consumption along with eco-friendly technology. Integration of renewable energy sources such as solar and wind power would be an efficient method to overcome this problem [2, 12].

Batteries, as a source of stored energy, helps to drive Electric Vehicles (EVs).However, it is challenging that the growing number of EVs cause hike in charging demand and hence create burden on the power grid since it is needed to recharge the battery [3]. The massive production of electric vehicle and acceptable energy charges will be an added factor for increasing number of EV's [4]. The choice of batteries used in electric vehicles depends on the energy density, weight, availability and price, as they require large number of batteries [5, 8]. The most commonly used batteries are lead acid batteries which are economically beneficial. Recently, batteries using lithium ion are gaining global acceptance due to its improved efficiency, reduced weight, minimal charging time, better power output, increased lifetime, and reduced environmental impacts from battery disposal.

The studies have stated that the charging of electric vehicle is non-linear and may cause harmonic distortion, phase imbalance, extra load on transformer [6, 13]. DC offset and voltage variation in the distribution system. This could be analyzed by using various simulation platforms like Matlab, Simulink which are used to predict the effect of charging of batteries on various feeder systems. The charging of electric vehicle batteries majorly includes AC to DC conversion, delivery of variable DC voltage to battery by the power control unit and also various filtering functions. The Battery Management System (BMS) [7], which is associated with the battery, monitors the operating parameters of battery, such as current, voltage and influence the rate of charging to provide the needed current / voltage charging profile.

The increased EV charging stations results hike in the demand for power during peak time along with decreased reserve capacity [10]. An electric vehicle charging station which uses communication technology to enable it to intelligently integrate two-way power flow enabling electric vehicle batteries to become a useful utility asset Charging Stations(CS) are considered as the hub of fuelling EVs.

There are three main types of electric vehicles (EVs), classed by the degree that electricity is used as their energy source [14].

- **Hybrid Electric Vehicles** (HEVs) -powered by both petrol and electricity.
- **Plug-in Hybrid Electric Vehicles** (PHEVs) known as Extended-Range Electric Vehicles (EREVs), which is powered by both petrol and electricity.
- **Battery Electric Vehicles** (BEVs) are fully electric vehicles, where they are only powered by electricity and do not have petrol engine, fuel tank or exhaust pipe.

II. ELECTRIC VEHICLE CHARGING

Electric vehicles use one or more electric motors or traction motors for propulsion. An electric vehicle may be powered through a collector system by DC electricity from self-contained batteries, EVs are not only limited to road and rail vehicles, but also electric aircraft and spacecraft.

The emerging of EVs in urban areas depends on the quality and accessibility of charging infrastructure, and facilitation of a supply chain for charged batteries. Charging infrastructure consists of low speed charging stations in residential areas as well as fast charging points located in public areas including shopping malls, petrol pumps, public parking and mass transit stations.

An electric vehicle charging station is an equipment that interconnects an electric vehicle (EV) to a source of electric energy to recharge electric vehicles and plug-in hybrids. Some charging stations have advanced features such as smart metering, cellular capability and network connectivity.

The battery performance of EV is highly depends on the way in which the battery is charged and discharged [11]. The battery charger top up the energy to electric vehicle is as same as refilling a fuel tank with gasoline. The battery charger converts the alternating current distributed by the power grid to the direct current required to recharge the battery. Effective charging is completed when the battery recharges to its full capacity without beyond overcharge and excessive temperature. Hence, over voltage or overheating may cause breakdown of the battery's performance and its life, and even cause safety issues.

The battery chargers operate in two modes. The recharge mode, which depends on the battery's chemistry, referred as grid-to-vehicle (G2V). And the inverter mode, where battery energy can be inverted and supplied back to the grid which is referred as vehicle-to-grid (V2G). The block diagram of power flow from grid to vehicle and vehicle to grid operation modes is shown in figure 1.

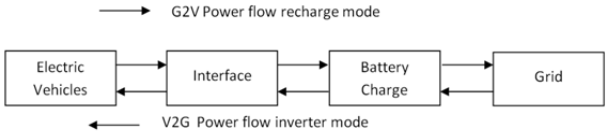

Figure 1: Power flow for G2V and V2G Operation Modes

III. CHARGING STATION AND ITS INFRASTRUCTURE

A. Slow charging: This kind of charging is used at home and work. EV plugs in to home plug with dedicated metering circuit. It requires about 6-8 hours [9] of charging and drives for 15 to 20 kms for one hour charging. The power output requirement is upto 3.7kW.

B. Fast and Slow Public Charging: It is used in places such as restaurants, shopping malls, business centers, rail stations, bus terminals, with fee for charging in a parking lot. It requires about two or more hours of charging and drives for 40 to 50 km for every hour of charging. This type of charging is also slow type and encourages users to charge while in parking. The power output ranging from 3.7kW to 22kW

C. DC Fast Charging: This is used in places such as highways and transport hubs. It requires about 30 minutes of charging time. The vehicle runs for about 280 to 300 kms for every hour of charge. The hierarchical diagram of different types of charging is shown in in Figure 2.

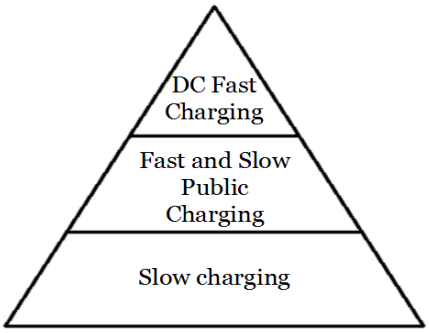

Figure 2:Hierarchical diagram for different types of charging

Capacity of battery and capability of handling rapid charging are increasing and methods of charging are required to change and improve for greater efficiency. The power output exceeds 22kW.

IV. ELECTRIC VEHICLE CHARGING STATION AND ITS CHALLENGES

The advantages of electric vehicles with low pollution, reduced global warming, green energy utilization, its impact on power grid needs to be considered. The major parameters of power grid which is directly affected by EV charging stations are voltage stability, peak load demand, harmonic injection, power quality, grid equipments overloading and demand response. In order to ensure stable power supply to the distribution network, challenges comprised with the EV charging station needs to be looked into. The parameters which affect the power grid illustrated in the Figure3.

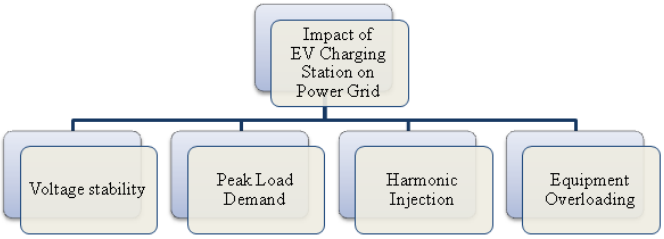

Figure 3:Impacts of EV charging station on power grid.

A. Voltage Stability: It is one of the major trouble in grid. The stability issue would be obvious under higher loading conditions. It results in reduced voltage depends on the capacity of grid generators and distribution network. Increase in EV plug-in stations may lead to rapid change in voltage stability, which affects generator voltage, line losses, transformer tappings, load losses. They can be solved by making required changes in system voltage, system reactance

and voltage ratio. Therefore, with the increase in number of EV charging station, it will definitely affect the grid voltage stability.

B. Peak Load Demand: The increased EV charging stations results hike in the demand for power during peak time along with decreased reserve capacity [10]. To overcome this, peak load shifting needs to carried out in coordination with the EV charging Stations on daily load curve basis. This will improve the load profile of the distribution network. The fast charging and advanced charging infrastructure the sudden load on the grid increases due to charging is upto 80% capacity is within the shorter period of less than minutes. This stabilizes the power grid and there by impact of connecting EV's to grid is substantially high.

C. Harmonic Injection: The distribution network is able to deliver power to load with standard system frequency and voltages. Higher the number of Electric vehicles plugged into the grid, it behaves variably than its actual working. It is the major effect of grid and needs to be focused on which involve variation in voltages, distortion of harmonic voltage and current. The load of EV Charging Station are particularly nonlinear in nature which may give rise to change in system current, resulting in temperature rise, reduced transformer winding insulation and mal- functioning of circuit breaker. The total harmonic distortion (THD) is the measure of difference between actual and reference frequencies.

D. Transformer Overloading: Large number of EV Charging Station adversely affects the transformers in distribution network. They reduce the lifespan of transformers and coordinated charging may reduce the temperature of transformer hot spots. The tariff based charging decreases the remaining life and aging of equipments. EV Charging Station connection to distribution network alters the shape of transformer load profile.

The connection of EV's at different intervals may affect the load profile and increase the life cycle of transformer. Based on EV charging profile considered in the simulation, baseline of 50% loaded commercial feeder can safely absorb about 20% of additional EV load from fast charging, similarly the residential feeder can be safely handles a ratio of 3:2 from Residential load and EV load (fast charging) respectively. The impact from slow charging stations on both the feeders will be negligible.

V. PROPOSED METHODOLOGY:

EV Charging Stations which are located on highways, parking lots, malls have high charging current rate for fast charging around 30-70A compared to home charging it is 12-16A . The short period of charging satisfies the consumer and provides flexibility in the charging. An optimum location for EV charging stations reduces the peak demand on distribution network.

The rapid growth of EV's will certainly increase the demand on grid which in turn affects the generation system. In order to achieve this demand, there is a need to increase the number of power generating stations which would be expensive. Hence one such alternative is to integrate the existing system with renewable sources of energy such as solar roof top, wind power, battery energy storage units and usage of tidal energy near coastal areas. The demerits of renewable sources is, it is intermittent and storage of energy in batteries when it is available. The hybrid energy sources enables EV charging stations doesn't much depend on conventional grids for power, they can easily achieve the power demand of EV's with the help of renewable energy resources (RER) and makes the system independent. The construction of Hybrid EV charging stations improves the reliability of charging stations, reduces burden on power grid, and also reduces the greenhouse gas emissions[8]. The block diagram for the suggested EV hybrid charging stations is shown in Figure 4.

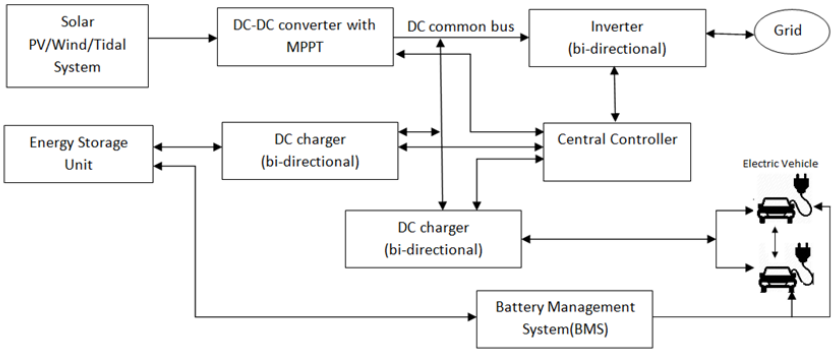

Figure 4:Block diagram of EV Hybrid charging system.

VI. CONCLUSION:

This paper deals with impact of electric vehicles charging station on power grid and its consequences. The establishment of EV charging station depends on the driving range and number of electric vehicles. In fast developing technological world, the need for alternative sources of energy is increasing. The electric vehicles plays an important role in transportation sector for reduction of greenhouse gas emissions, global warming. The penetration of electric vehicles charging stations in large quantities into the existing grid network severely affects the grid parameters and it cannot be neglected. The use of hybrid technology involving solar, wind and other renewable energy resources along with battery storage system in the EV charging stations may eventually improve the reliability and availability of the power supply and also reduces its impact on to power grid. The influence of charging stations on the connected power grid is the major factors that should be accounted in planning and establishment of future EV charging stations.

VII. ACKNOWLEDGEMENT

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