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Issues and Solutions of Plug-in Electric Vehicles on Power Distribution Networks

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Abstract

Increase in the population and modern life styles causes increased pressure on the electrical, transport, manufacturing and food industries. To maintain the balance between the supply and demand the transportation industry plays very vital role. In recent years, increase in the diesel, petrol and natural gas fuelled vehicles contributing more in the air pollution. To tackle the pollution triggered by traditional vehicles, EV's can be encouraged and used to a better extent. Still, there are few difficulties in implementing EV technology. The method of charging electric vehicles is the key significant concern, as charging an ambiguous number of battery storage of EVs with vague power and energy demand. It is difficulty in managing the power requirements and supply conditions in the real time. In addition, the high charging current demand of EVs also creates challenges for the competent operation of the power system as the large amount of intermittent BES loads are frequently connected and disconnected.

KEYWORDS: Electrical vehicle, charging stations, renewable energy sources, power systems, optimal penetration.

Introduction

In addition, the implementation of the battery storage systems in electric vehicles faces various challenges, for example battery degradation with shortened lifespan, as numerous charging and discharging of battery storage systems directs to degradation of battery lifespan and capacity [1-4]. Advanced communication infrastructures between electric vehicles, charging stations and the battery storage systems are needed for the continuous monitoring of various BES parameters. The total electrical energy required by electric vehicles in a given area is referred to as the charge load curve of electric vehicles for that area. Predicting this load pattern is needed to investigate the impact of EV penetration on power distribution networks [5-7]. The EV load pattern analysis can facilitate estimation of several elementary parameters of the electric distribution network as part of the impact assessment, i.e., stress on distribution cables or conductors [8].

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Problem Statement:

Due to increase in the population, modern life styles, new technologies innovations creating new avenues in all the sectors. In recent years, the electrical infrastructure has also undergone drastic changes in terms of generation, transmission and distribution systems. The Indian electricity sector faces many problems such as load shedding, poor quality of supply, high Transmission and Distribution (T&D) loss, poor electric infrastructure, lack of investments and up-gradation of the networks etc [9]. Due to this, at present we are experiencing 22% of T&D loss and it is nearly three times higher as compared to average world power loss of 8.2% [10].

The Indian power grid is connected with 4,00,000 MW of power generation. The thermal power plants contribute 60% of the total generation causing the emission of the green house gases [11]. The interconnection of a large number of electric vehicles to the power grid leads to unreliable operation of the network.

The optimal placement and penetration of renewable energy sources is carried out in this proposed work. The impact charging stations is considered in different scenarios for the next 20 years is also considered as one of the main objectives of the work. The possible solutions for the best charging locations with their capacity, the different strategies are also considered for an efficient and reliable operation of the power grid. The proposed work also uses strategies to minimize the power loss with significant improvement of network parameters without violating network limits.

Gap identified from the literature:

- Forecasting of electrical load for next 20 years
- Estimation of growth of electric vehicles and their corresponding electric load for next 20 years
- Investigation of the impact of electric vehicles on the electric networks
- Evaluation of electrical distribution system with and without EV power demand
- Impact of RES integration and V2G on existing electrical system
- Evaluation of better solutions for connection of EVs to the grid
- Impact of new technologies on the future power demand

Charging infrastructure:

Fast charging is crucial to the success of electric vehicles. The charging infrastructure can be “alternating current (AC) charging or direct current (DC) charging”. In case of alternating current charging, AC power is given to on-board chargers, which promote charging of the electric vehicle battery energy storage by converting AC power to DC power. In case of DC charging, DC directly feeds power to the BMS of BES, which is implanted in the EV [6-7]. No supplementary on-board charging is required for DC fast charging. High-speed charging can be done with direct current. The AC and DC charging infrastructure is shown in Fig.1

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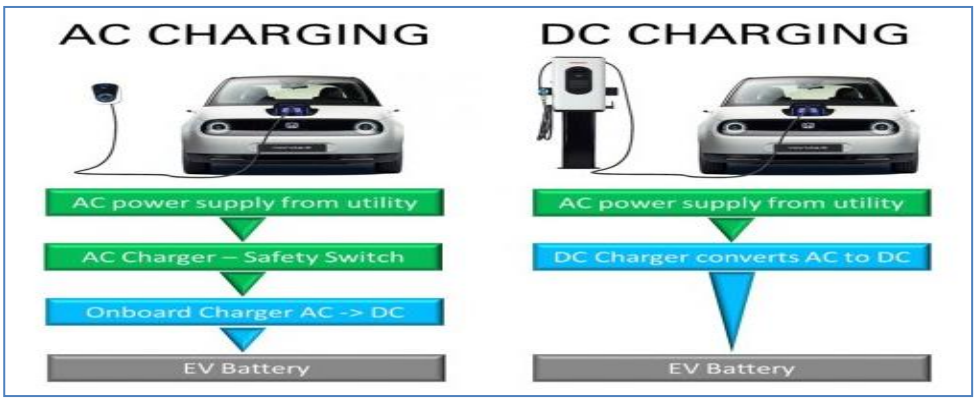

Fig.1 AC and DC Charging of EV

Proposed Work Flow:

1. Forecasting of the electrical load for the next 20 years.
2. Estimation of the EV equivalent load and its impact on the grid
3. Charger specifications
4. Charging scenarios (location and timings on the grid)
5. Charging types
6. The fast charging impact and strategies to be adopted in the grid during peak load
7. Impacts of uncertainties of the load patterns on the grid
8. The repeated "connect and disconnect of EV's to the charging stations" having high DC power charging and its impact on the power quality
9. Optimal penetration of renewable and their size to the existing grid to achieve the greater reliability of the electrical networks
10. Investigation of V2G technology during dynamic pricing conditions and its role during peak load conditions.
11. Investigations of feasibility of mobile charging stations and its impacts on the grid.

Table.1 Action plan

Sl.No	Work to be carried out
1	➢ Literature review, collection of the electrical network data in terms of load, line, generation and Single line diagrams. ➢ Load flow analysis ➢ Selection of forecasting tools for load forecasting considering the previous data ➢ Impact of the increased load on the electric infrastructure
2	➢ Forecasting of the EVs depending on the previous data ➢ Estimation of EV load by considering 2 wheeler, 4 wheeler commercial and non commercial vehicles

	➢ Impact of the EV on the grid for next 20 years
3	➢ Analysis of different charger specifications ➢ Investigation of different types of batteries and their performance during summer (when temp above 40'C) as safety measure
4	➢ Investigations on different scenarios of EV on the grid and its impacts on the power loss and voltage stability Case.1 90% of the vehicles charges at home and 10% at charging stations Case-2 75% of the vehicles charges at home and 25% at charging stations Case-3 50% of the vehicles charges at home and 50% at the charging stations All three case studies will be tested at different time frames (Day and Night time) to check grid behaviour in-terms of power loss and voltage profiles.
5	➢ Investigations of pros and cons of large AC charging and DC charging on the grid ➢ Behaviour of the grid for AC and DC charging stations.
6	➢ Impact of the fast charging on the grid during different time frames and its impact on the grid performance. ➢ Investigations of fast charging impacts on the battery performance
7	➢ Analysis of uncertainties of the load patterns on the grid and remedies.
8	➢ The repeated "connect and disconnect of EV's to the charging stations" introduces the power quality issues ➢ Impacts of the harmonics and proper designing recommendations of the filters to mitigate the harmonics in the grid to assure the power quality
9	➢ Optimal penetration and sizing of renewable in the grid to boost the network performance ➢ Impacts of RES and EV on the network performance.
10	➢ Investigation of V2G technology during dynamic pricing conditions and its role during peak load conditions.
11	➢ Investigations of feasibility of mobile charging stations and its impacts on the grid ➢ Feasibility analysis of mobile charging stations
12	➢ Optimal site selection of the charging stations in the network ➢ Optimal number of charging stations with their capacity

Conclusion:

The systematic investigations to model the strategies for integrating renewable energy sources and charging stations for electric vehicles play a key role for efficient and stable grid operation. This study helps the grid operators to follow the different strategies when expanding/improving the electricity

grid capacities and during peak loading conditions. This study will also address issues related to power quality, identify the best locations to install charging stations and new technologies to meet power demand requirements.

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