Chapter 5
Electric Vehicle Infrastructure Planning:
A Distribution Side Perspective

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ABSTRACT

Widespread adoption of electric vehicles would bring a paradigm shift in the way distribution infrastructure is planned and electricity markets operate. Electric vehicle adoption could help in meeting the worldwide targets for greenhouse gas emissions. Moreover, the health benefits for the public would be immense as the source of emissions would be far away from the massively populated areas. For electricity markets, electric vehicles can serve as a distributed plug in facility of energy storage at low cost requiring minimal capital investment from grid utilities. However, widespread electric vehicle adoption faces a number of hurdles such as limited range in comparison to Internal combustion engines, but from the grid perspective, it faces issues such as limitations of available charging infrastructure to charge large number of electric vehicles and longer charging time currently as compared to refueling fuel driven vehicles. This chapter explores such issues and their remedies in the current literature.

INTRODUCTION

Transportation of goods and services effectively is the rock bed of any thriving economy. Increased population and especially population density in urban areas has driven the demand for vehicles. Increased population density in urban areas has driven the demand for vehicles but the bulk share of this demand is taken up by conventional vehicles driven by fossil fuels and the upswing in the demand is matched by the upswing in CO2 emissions and pollution levels in the densely populated areas. Thus this population is directly exposed to the long-term risk of health deterioration. Electric vehicle adoption could help in

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meeting the worldwide targets for greenhouse gas emission reduction. Moreover, the health benefits for the public would be immense as the source of emissions would be far away from the massively populated areas. The International Energy Agency estimates that the sales of passenger light-duty EVs/plug-in hybrid EVs (PHEVs) will increase significantly from 2020 onwards and might reach more than 100 million EVs/PHEVs sold per year worldwide by 2050 (International Energy Agency, 2011). Widespread adoption of Electric vehicles would bring a paradigm shift in the way distribution infrastructure is planned and electricity markets operate. For electricity markets Electric vehicles can serve as a distributed plug in facility of energy storage at low cost requiring minimal capital investment from grid utilities.

However widespread Electric vehicle (EV) adoption faces a number of hurdles (Saxena, MacDonald & Moura, 2015), such as limited range in comparison to IC engines but from the grid perspective it faces following issues:

- Limitations of available charging infrastructure to charge large number of Electric vehicles.
- Charging time for Electric vehicles is much longer currently as compared to refueling fuel driven vehicles.

Improper management of charging loads can negatively impact grid operations and reliability, increase emissions and electricity prices (He, Wu, Yin & Guan, 2013; Parks, Denholm & Markel, 2007). Uncontrolled charging refers to charging when little or no information is available about the electricity prices and the owner decides the time to plug in, and the charger draws maximum power from point of plug-in till the battery is charged fully. Controlled charging is the practice of directing EV charging behavior by providing price signals or other incentives to the consumer, in order to limit negative grid impacts (M.J Bradley and Associates LLC, 2013).With controlled charging, EVs can levelize the overall load, make better use of baseload generating units, and require no extra installed capacity. On the other hand, large numbers of EVs charging uncontrolled can result in voltage limit violations, increased line losses and transformer overloads (Richardson, 2013). Huge penetration of the RES into the existing power infrastructure would require large scale energy storage to support the electrical power demand and to meet the operating standards in place currently. Electric vehicle fleets could help in meeting this challenge head on. Plug in Electric vehicle charging patterns have also been explored in recent studies to tackle the negative effects of such patterns on the distribution networks (Zhou, Wang & Gao, 2018). Moreover large scale data management for Electric vehicles in itself poses a challenge of protecting privacy of customers as their usage patterns could be monitored.

Electric vehicle owners would like to know how to minimize their cost of charging, so selling cost of power should be known to the electric vehicle owners for providing V2G services.

Similarly for responding to frequency regulation and Demand Side Management (DSM) issues the real time information regarding the electric vehicle parameters such as overall capacity, mobility patterns etc. is essential. Electricity cost would determine the interaction of electric vehicle owners with the grid whereas grid operators would consider the load profile. Demand response initiatives and inbuilt vehicle timers could help in easing the stress on the power grid. However such schemes are effective for residential charging points but fast charging stations can draw huge amount of power for shorter time intervals because they may not be frequented by drivers. As a result they could incur high demand charges which depends on the highest capacity used which would in turn lead to increased charging cost for drivers.

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