Chapter 9

Electric Vehicles in Smart Grids

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ABSTRACT

Electric vehicles were proposed as a good solution to solving energy crisis and environmental problems caused by the traditional internal combustion engine vehicles. In the last years due to the rapid development of the electric vehicles, the problem of power grid integration was addressed. In order to not put additional pressure onto the power grid several new technologies were developed. This chapter presents the smart grid technology, vehicle-to-grid concept, and electric vehicles grid integration. These technologies made possible the integration of electric vehicles without any major changes in the power grid. Moreover, electric vehicles integration brought new benefits to the power grid like better integration of renewable energy.

INTRODUCTION

Some of the greatest concerns of our era is reducing carbon dioxide emissions and greenhouse gases and resolving the issue of rapid increase of energy demand. Studies present that the most energy demanding sector of the last years is the transport sector. According to the U.S. Energy Information Administration (EIA) this is justified by the increase of population growth and economic sector. In many countries mitigating measures were undertaken in order to impose an emission target. One of those solutions is electrifying the transport sector.

Electric vehicles represent a zero tail pipe emission alternative to the internal combustion engines. Another benefit is that the electric vehicle uses the energy stored in the battery for powering the electric motor which has a lower operation cost and a higher efficiency. Moreover the electric vehicle noise is much lower compared with the classic vehicle. MacKey (2009) presented a research that concluded with the statement that electrifying the whole transport sector will result in cost reductions of 80% from the actual one obtained using internal combustion powered vehicles. Another study made by Short and Denholm (2006) stated that electrifying the transport sector would promote the use of renewable energy sources. The number of electric vehicles will increase rapidly as a result of continuous battery development and charging stations infrastructure development.

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Nowadays, the fact that the electric vehicle has a high acquisition price and that the charging infrastructure still lacks, are considered drawbacks for potential clients. Also another thing to be considered is the power grid integration. This is a problem due to the fact that usually an electric car’s battery is charged at home after work, at peak energy consumption hours according to Alhelou et al (2015). This fact will add extra load to the power grid.

As a solution to the above presented issues, using new technologies was developed. The first and foremost solution is the implementation of the smart grid, a power grid able to use bidirectional communication with all the smart equipment installed with the purpose of optimizing the energy usage.

This chapter focuses on presenting the problems that the electric vehicle power grid integration arise. First part of the chapter presents the background and framework of the electric vehicles, smart grids and charging infrastructure. The second part of this work is dedicated to presenting new technologies and energy management strategies, that were developed to meet this issues. Last part of the chapter is dedicated to presenting some conclusion and future development regarding electric vehicles and their role in smart grids.

BACKGROUND

Integrating a constantly growing number of electric vehicles into the electric power grid is a great challenge. For a successful integration into the power network, observation and than careful assessment of the economical impact is required. A lot of research activity was dedicated into finding the issues, solutions and impact of electric vehicle grid integration. Su (2013) presented a research that proved that most of the vehicles battery is charged at home and the future trend is the development of commercial or work place chargers. This charging scenario is bound to greatly overload the power grid. Another consequence may be the overheating of the power transformers or demanding new investments for the energy distribution system.

Pecas et al. (2011) proved in their work that integrating electric vehicles into the power grid will add value if this action is well planed and technically reorganized to meet the operational standards. In order to confirm the benefits of merging the grid and the vehicle fleets different studies were made. The benefits were divided among the vehicles owners and the utility providers. Bessa and Matos (2012) are the ones to propose a mitigating method using the aggregator. The aggregator is responsible for delivering information and communication between energy service provider, distribution system operator and the transmission system operator. The same idea is presented by Pillai and Bak-Jensen (2011) that propose a virtual power plant concept in which the vehicles fleets are controlled as a distributed energy unit.

All these new concepts developed recently are based on the assumption that the electric vehicles owners will accept to participate in these programs. Basically the vehicle’s battery is used as an energy storage or supply source according to the grid demand. There are still some barriers to overcome until these assumptions are feasible. One of those barriers is the economical one. The most expensive part of the vehicle is the battery, which capacity will decrease over time if it is subjected to a large number of charging and discharging cycles. If new battery technologies will be developed, than the production cost will lower and this economical barrier will be easier to overcome. Another approach is the intelligent battery usage. Peterson et al. (2010) made a study in which they compared a battery in a normal duty...