ISSN: 2278-4632
Vol-11 Issue-01 2021

Smart Charging for advanced Electric Vehicles: A Survey from the Algorithmic Perspective

Piyush Sharma (Department of Electrical Engineering, SS College of Engineering, Udaipur, Raj, India

Luv Sharma (Department of Electrical Engineering, SS College of Engineering, Udaipur, Raj, India

Deepak Somani (Department of Electrical Engineering, SS College of Engineering, Udaipur, Raj, India)

Abstract

Smart interactions between the smart grid, aggregators, and EVs may benefit all parties involved, such as better grid stability and safety, greater profitability for aggregators, and increased self-benefit for EV users. The goal of this study is to look at smart interactions from an algorithmic standpoint. Important dominant elements for coordinated charging are explored in terms of smart grid focused, aggregator oriented, and client oriented smart charging from three distinct viewpoints. To begin, we outline several formulations offered for load flattening, frequency regulation, and voltage regulation for smart grid oriented EV charging, then investigate their nature and major resemblance. Second, for aggregator-oriented EV charging, we classify the algorithmic ways given by research papers with this viewpoint as direct and indirect coordinated control, and we study these approaches in depth. Finally, we generalise multiple formulations given by researched research works for customer-oriented EV charging, based on a single shared goal of lowering charging costs. Moreover, many uncertainty concerns, such as EV fleet uncertainty, electricity price uncertainty, regulatory demand uncertainty, and so on, have been explored in terms of the three viewpoints. Finally, we cover some of the difficult difficulties that arise often when modelling smart interactions, as well as potential future research objectives in this intriguing field.

Introduction

Electric cars (EVs) are becoming more popular. This is due to rising worries about pollution, fossil fuel depletion, and urban noise [1], [2]. In the future decades, large-scale EV penetration is expected; for example, the number of EVs in the globe is expected to climb by 5 million per year by 2020 [3], and EVs are expected to contribute 3.47 percent of the U.S. automotive industry by 2014 [4].

As electric vehicles become more popular, they will pose new challenges to the electrical infrastructure. The loads from charging an EV with a charging power of 19.2kW at 80A and 240V, which is known as the alternating current (AC) level 2 charging standard [5], for example, may be almost twenty times that of sustaining a normal North American house [6]. When considerable EV charging demands are aggregated but not coordinated, the consequences will be significantly more severe.

This may result in concerns such as a mismatch between EV charging demand and power grid supply, increased power losses, and higher voltage variation, among other things. At the same time, EVs may be controlled effectively with well-coordinated control tactics.

Demand/ Charging Allocation Aggregated Demand/ Auxiliary Services VANETs Communication Wired Communication Demand/ Charging Allocation Aggregated Demand/ Auxiliary Services

Load Variance Power Loss Overload, etc. Communication Delay Transmission Failure Communication Collision, etc.

Aggregators for roadside units

Electric Vehicles on the Smart Grid

Figure 1 Interaction between electric vehicles and smart grids. Aggregators, who represent EV consumers in negotiations with the smart grid concerning auxiliary services and power tariffs, and transmit charging control signals to EV customers, aggregate charging loads from current EVs. The creation of control methods for both the smart grid and aggregators necessitates the collection and transmission of real-time information from EVs to the smart grid and aggregators via road side units (RSUs) through vehicle-to-vehicle and vehicle-to-RSU (V2R) communication.

aid in the development of the smart grid, which is intended to integrate electric vehicles, renewable energy sources, and distributed generation into the traditional power grid, as well as use real-time communication to perform intelligent control strategies to coordinate bidirectional power flow [7].

Fundamental infrastructures must be upgraded in order to accomplish both the smart grid and the smart integration of EVs.

For example, present power grid infrastructures and electric vehicles (EVs) are not yet mature enough to manage bidirectional power flow, and communication infrastructures for vehicular dedicated communication are still being developed. Smart interactions may be implemented based on real-time communication between EVs and the smart grid, as well as coordinated smart grid flow management and intelligent EV charging control, with better developed essential infrastructures.

Methodology

Several studies and evaluations have looked into the interplay between electric vehicles and smart grids. The effects of plug-in hybrid electric cars (PHEVs), which are a unique form of EV, on the grid have been studied in [8]. [9] provides an overview of electric vehicles and basic industrial informatics systems. Richardson et al. [10] and Mwasilu et al. [11] both looked at how EVs interact with the smart grid, focusing on the existence of integrated renewable energy. These current studies are mostly concerned with the effects of electric vehicles on future infrastructure and the integration of renewable energy.

Instead, we're focusing on aggregator-based interactions between the smart grid and EVs. Smart interaction between EVs and the smart grid is still in its early stages, and more study is required before the desired benefits, such as increased smart grid reliability and safety, revenues for aggregators, and self-benefit for EV consumers, can be demonstrated in broad industrial practise. This article will provide an outline of current developments in this field. We concentrate on analysing the smart interaction between EVs and the smart grid from an algorithmic viewpoint since many parts of this interaction have been addressed by previous research works, which mostly apply mathematical formulations to represent this interaction. Important dominant elements for coordinated charging are explored in terms of smart grid focused, aggregator oriented, and client oriented smart charging from three distinct viewpoints. We outline their arguments and examine the nature and degree of resemblance between them. Furthermore, we cover some of the difficult difficulties that arise often when modelling smart interactions, as well as potential future research objectives in this intriguing field.

The remainder of this survey is laid out as follows. The backdrop for electric vehicles, rechargeable batteries, the smart grid, and communication networks is covered in Section II. Sections III through V look at smart grid focused, aggregator oriented, and consumer oriented EV smart charging research, respectively. Section VI highlights a number of important outstanding questions as well as possible future research options.

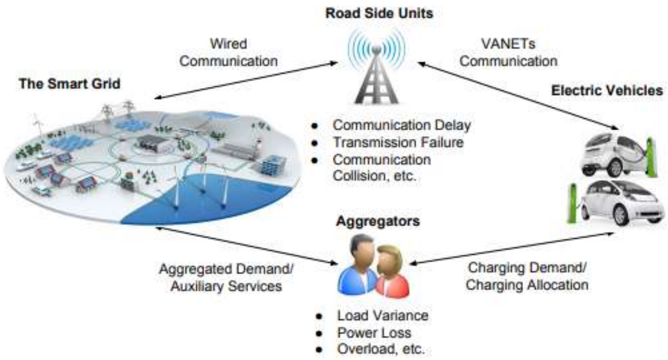
The survey comes to a close with Section VII.

II. INTRODUCTION

In this part, we not only offer background information on the main components of the architecture displayed in Fig. 1 (i.e., EVs, the smart grid, aggregators, and RSUs), but also highlight their distinctive qualities in the power and communication networks. These characteristics are critical for future prospective study into more practical difficulties involving the interplay of electric vehicles and smart grids.

Electric Vehicles (A)

Because the goal of this survey is to learn more about how EVs and the smart grid interact, this part focuses on plug-in EVs (PEVs that can be charged using grid power). PEVs are a subset of many kinds of EVs with a plug-in function, such as battery electric vehicles (BEVs) and plug-in hybrid electric cars (PHEVs).

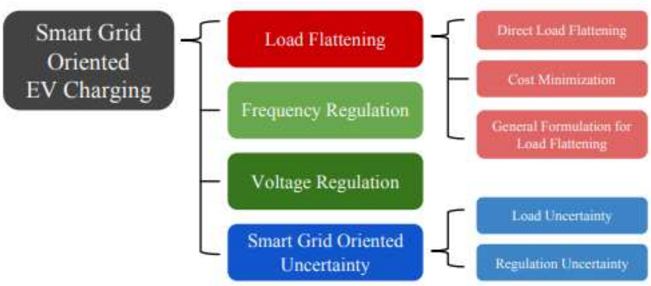


1) Electric Vehicles with Plug-in Charging Stations: BEVs and PHEVs both utilise electricity to power electric motors, which provide propulsion for EVs. On-board batteries provide the energy, which are charged either by the power grid when plugged in or by on-board generators when regenerative braking is activated [12These hybrid energy resources may be used in either charge-sustaining (CS) or charge-depleting (CD) modes [12]. In CS mode, fossil fuel is the primary source of energy.

The activities of a PHEV in CD mode are reliant on power supplied by batteries. A PHEV may significantly decrease fuel usage when used in CD mode [13].

Results

]. The primary distinction between a BEV and a PHEV is that a PHEV additionally utilises fossil fuel and an internal combustion engine (ICE) to expand its range.



We divide coordinated control solutions for achieving EV charging load flattening into (1) direct load flattening and (2) indirect load flattening in the following sections. In the first scenario, the smart grid operator handles EV charging loads directly in order to address the imbalance between EV charging demand and power network supply. In the second scenario, the smart grid operator is primarily concerned with lowering the costs (energy production and consumption costs) associated with EV charging. These concerns are also proven to be analogous to issues such as enhancing load factor and lowering power losses. Then, for load flattening issues, we provide and analyse a generic formulation. Finally, with a little adjustment to the overall concept, we briefly examine V2G issues.

Conclusion

Integration of EVs will have an influence on more than just load variation in the smart grid. If uncoordinated EV charging is common, other aspects such as load factor and power losses would be altered. The challenges of reducing load variation, decreasing power losses, and optimising load factor create a 'triangle equivalency' when all loads are coupled to a single bus, as shown in [90].

Despite the fact that the assumption is unworkable, simulations in [90] show a near approximation between these difficulties.

Furthermore, the authors demonstrated that the topology-independent equivalence between decreasing load variance and maximising load factor. Furthermore, since all of these issues are often modelled as convex optimization problems, their related techniques may be far less computationally intensive (compared with the algorithm for minimising power losses). As a result, an effective load flattening method may not only approximate address the other two issues, but also be more efficient in avoiding power losses, which is very important.

References

[1] C. Chan, “The state of the art of electric, hybrid, and fuel cell vehicles,” Proc. IEEE, vol. 95, no. 4, pp. 704–718, Apr. 2007.

[2] A. Emadi, Y. J. Lee, and K. Rajashekara, “Power electronics and motor drives in electric, hybrid electric, and plug-in hybrid electric vehicles,” IEEE Trans. Ind. Electron, vol. 55, no. 6, pp. 2237–2245, June 2008.

[3] N. Tanaka et al., “Technology roadmap: Electric and plug-in hybrid electric vehicles,” International Energy Agency, Tech. Rep, 2011.

[4] Electric Drive Transportation Association, “Electric Drive Sales Dashboard,” http://electricdrive.org/index.php?ht=d/sp/i/20952/pid/20952, 2015, [Online; accessed 11-Aug-2015].

[5] M. Yilmaz and P. Krein, “Review of battery charger topologies, charging power levels, and infrastructure for plug-in electric and hybrid vehicles,” IEEE Trans. Power Electron, vol. 28, no. 5, pp. 2151–2169, May. 2013.

[6] O. Ardakanian, C. Rosenberg, and S. Keshav, “Distributed control of electric vehicle charging,” in Proceedings of the Fourth International Conference on Future Energy Systems, New York, USA, 2013, pp. 101–112.

[7] X. Fang, S. Misra, G. Xue, and D. Yang, “Smart grid-the new and improved power grid: A survey,” IEEE Commun. Surveys & Tutorials, vol. 14, no. 4, pp. 944–980, 2012.

ISSN: 2278-4632
Vol-11 Issue-01 2021

8] R. C. Green II, L. Wang, and M. Alam, “The impact of plug-in hybrid electric vehicles on distribution networks: A review and outlook,” Renewable and Sustainable Energy Reviews, vol. 15, no. 1, pp. 544–553, Jan. 2011.

[9] W. Su, H. Eichi, W. Zeng, and M.-Y. Chow, “A survey on the electrification of transportation in a smart grid environment,” IEEE Trans. Ind. Informat, vol. 8, no. 1, pp. 1–10, Feb. 2012.

[10] D. B. Richardson, “Electric vehicles and the electric grid: A review of modeling approaches, impacts, and renewable energy integration,” Renewable and Sustainable Energy Reviews, vol. 19, pp. 247–254, Mar. 2013.