A review on Energy Management and System Operation of EV charging station

Yu WU, Daniela CHRENKO, Alexandre RAVEY, Abdellatif MIRAOUI
FEMTO-ST Institute, Energy Department, CNRS
Univ. Bourgogne Franche-Comte, UTBM
90010 Belfort, France

Mots-clés : Recharge rapide véhicule-vers-réseau, Commande coordonnée, système photovoltaïque, stockage d'énergie

Keywords: V2G fast charging; Coordinated control; PV system; Energy storage system.

Résumé.

An EV charging station is nothing else than a DC or AC micro grid system. A hierarchical control system is usually used in a DC or AC micro grid, since it offers decoupled control objectives in each layer of micro grid systems. Based on the control objectives and time scale, the hierarchical system can be divided into three layers. The objective of the first layer is to realize the closed loop control of EV, ESS, and other components. The objective of the second layer is to select different operation modes, keep DC bus or AC bus stable, including DC voltage, AC voltage amplitude and frequency stabilization. The objective of the third layer is to optimize the energy allocation through forecasting the load and generation power for the maximum profits and efficiency. Most literatures focus on one or two layers of them. The presented article is a literature review on system architectures and control methodologies.

In [Rivera, Sebastian, et al.], a novel architecture for plug-in electric vehicles (PEVs) dc charging station at the megawatt level is proposed, through the use of a grid-tied neutral point clamped (NPC) converter. The proposed bipolar dc structure reduces the step-down effort on the dc-dc fast chargers. This paper also proposes a balancing mechanism that allows handling any difference on the dc loads while keeping the midpoint voltage accurately regulated. By defining the unbalance operation limit, complementary balancing capability is provided with an additional NPC leg acting as a bidirectional dc-dc stage, keeping the control on the dc voltages under any load scenario. The solution enables fast charging for PEVs concentrating multi charging units into a central grid-tied converter.

In [Liu, Baoquan, et al.], a dc micro-grid with hybrid energy storage and renewable energy is investigated. A novel system operation strategy and the corresponding energy management method is proposed to achieve high penetration depth of renewable sources into the utility grid. In the operation strategy, the ultra-capacitor unit works as the sole voltage source of the micro-grid to support the dc link in both connected and islanding mode. The micro-grid is controlled to deliver/absorb a predefined amount of power to/from the utility grid during connected mode

and zero during islanding mode. This design simplifies the power dispatching algorithm and increase the possibility of assimilating large quantities of micro-grids into the utility grid.

In [Fan, Pingyi, Bilguun Sainbayar, and Shaolei Ren], considering the impact of requested SoC on charging time, an operation analysis of fast charging station (FCS) is investigated, where operators of FCS can set a limit on the EVs' requested SoC to obtain maximized revenue. Short charging time duration is FCS's main advantage with regard to other ac charging stations. Due to the characteristics of internal resistance of EV batteries, the charging time increases significantly if charging request is near the full state of charge (SoC). The FCS operation is modeled with an M/G/S/K queue and the dc fast charging model is incorporated into the queuing analysis, as well as the revenue model of FCS. This method can increase total charged energy and revenue, and decrease the probability of blocking arriving EVs.

In [Guo, Yi, et al.], a two-stage framework is proposed for the economic operation of a micro grid-like electric vehicle (EV) parking deck with on-site renewable energy generation (roof top photovoltaic panel). Although EV parking decks can enable greater adoption of renewable energy sources by scheduling charging loads to coincide with periods of strong sun, the inherent intermittency of renewable energy resources and variable EV parking behaviors complicates the economic operation. The first stage of this framework provides the parking deck operators with a stochastic approach for dealing with the uncertainty of solar energy so as to make an optimal price decision at the day-ahead time scale. The second stage introduces a model predictive control-based operation strategy of EV charging dealing with the uncertainty of parking behaviors within the real-time operation.

The drawbacks and advantages of each paper will be analyzed in the future edition. And more papers will also be presented and classified into different categories according to their focal point, including system modeling, decentralized control technique, energy allocation methods, etc.

An intensive literature review is the starting point of each scientific works. It provides background knowledge and reveals interesting topics to work on. The presented resume is a the starting point of a complete review on energy management and system architecture of EV charging stations and will be the baseline for the development of a novel energy management approach.

Références

[1] Rivera, Sebastian, et al. "Electric vehicle charging station using a neutral point clamped converter with bipolar DC bus." *IEEE Transactions on Industrial Electronics* 62.4 (2015): 1999-2009.

[2] Liu, Baoquan, et al. "System operation and energy management of a renewable energy-based DC micro-grid for high penetration depth application." *IEEE Transactions on Smart Grid* 6.3 (2015): 1147-1155.

[3] Fan, Pingyi, Bilguun Sainbayar, and Shaolei Ren. "Operation analysis of fast charging stations with energy demand control of electric vehicles." *IEEE Transactions on Smart Grid* 6.4 (2015): 1819-1826.

[4] Guo, Yi, et al. "Two-stage economic operation of microgrid-like electric vehicle parking deck." *IEEE Transactions on Smart Grid* 7.3 (2016): 1703-1712.