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Simultaneous quick-charging system for electric vehicle

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Abstract

Electric vehicle (EV) has received an intensive attention and been deployed globally due to its beneficial characteristics including higher energy efficiency and lower environmental impacts. However, massive charging of EV leads to several problems to electrical grid because of huge amount of electricity demand and its fluctuation. Therefore, charging management for EVs is urgently demanded. In this study, a novel battery-supported quick-charging system is developed and its performance in single and simultaneous multiple EVs charging is evaluated. The objective of battery installment includes maintaining the charging rate and reducing the burden of electrical grid due to EV charging. In addition, charging behavior of EV under different seasons (winter and summer) is clarified initially. As the results of the study, environmental ambient temperature influences strongly the behavior of EV charging. Charging during summer leads to higher charging rate, hence, shorter charging time. Furthermore, the developed charging system is able to facilitate simultaneous quick-charging for EVs in both winter and summer compared to conventional quick charging system.

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Keywords: Electric vehicle, quick charging, simultaneous, battery, temperature

1. Introduction

Electric vehicles (EVs) are considered as one of the key technologies in the future transportation system due to their potential in high energy efficiency, low environmental impacts, and high conveniency [1]. In addition, different to conventional vehicles, EVs can offer additional services because of their installed battery which can be charged or discharged following the control [2]. These additional services include energy storage, energy carrier and frequency

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regulation [3]. Several countries have issued some policies [4] and incentives [5] to realize a massive adoption of EVs in consideration of environmental issues and potential of grid support. However, massive adoption of EVs lead to several technical grid problems, especially low electricity quality, due to massive and uncoordinated EVs charging [6].

As current condition, the adoption of EVs is still limited, therefore their charging load is considered as an insignificant load to the grid. Several studies have evaluated the impact of the massive increase of EVs to the local grid. In case of Tokyo area, it was assumed that about 7.3 GW of additional electricity supply will be required in case of 50% of vehicles in the area are transformed to EVs and about half of them perform quick charging at the same time [7]. In addition, the afraid of power loss and overloads in transformers and feeders also has been experienced by several countries due to high demand of EVs charging [8].

Several studies to solve the above problems have been conducted including demand response, and intelligent scheduled and managed charging. Intelligent charging control facilitates both owners and electricity operators to achieve mutual objectives including minimum electricity cost, lower environmental impacts, and lower influence to the grid quality. The scheduled charging and discharging are considered as effective methods for load leveling and peak shaving [9], especially in case of larger adoption of renewable energy [10]. Unfortunately, demand response and scheduled charging require a massive system development and huge capital cost. Furthermore, an accurate forecast for electricity demand and supply, and the availability of EVs is also very important. Regarding the DC quick charging, Capasso and Veneri [11] have developed its architecture and experimentally evaluated the system. However, no sufficient effort has been made to solve the problem related to simultaneous charging with limited capacity of electricity.

In this study, a battery-supported quick charging system for EVs is developed and evaluated for simultaneous charging of EVs. The objective of the novel charging system is to reduce the burden of electrical grid due to massive charging of EVs and also to provide high quality of quick charging to the EVs although during peak hours. The performance of the developed battery-supported quick charging system is evaluated for simultaneous charging of multiple EVs. This evaluation is also performed in different seasons of winter and summer.

2. Battery-supported quick charging system

Fig. 1 shows the conceptual diagram of the developed battery-supported quick charging system for EV. A community energy management system (CEMS) controls all the electricity demand and supply in a certain community. It is responsible for maintaining the quality of electricity in the community, as well as minimize the electricity cost. The developed battery-supported system mainly consists of AC/DC converter, battery and charger.

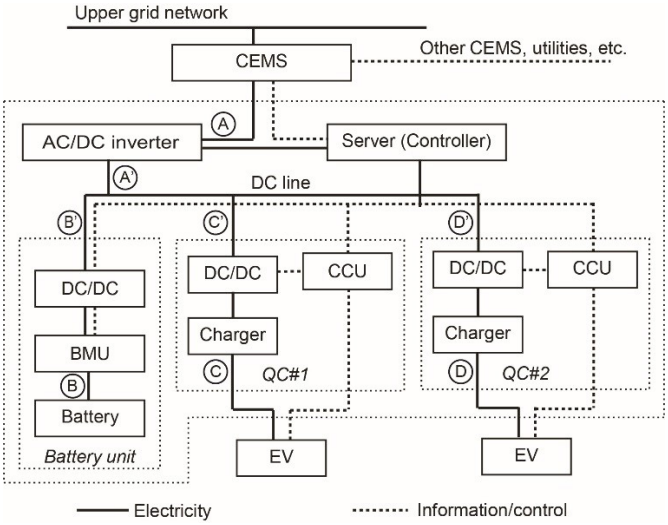

Fig. 1. Conceptual diagram of the developed battery-supported quick charging system for EV.