Development of Battery and Charger Integration System (BCIS)

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Abstract

NEC has developed a Battery & Charger Integration System (BCIS) to support the burgeoning infrastructure for electric vehicles (EVs). The system controls several quick chargers and large capacity stationary batteries and thereby enables charging time reductions and peak charging power reductions while simultaneously charging multiple EVs. By conducting field trials as part of the Yokohama Smart City Project (YSCP) while linking with the Community Energy Management System (CEMS), we are aiming to examine how much BCIS can contribute to the demand and supply adjustment for community. This paper introduces an outline of the BCIS and of its field trials.

Keywords

Electric Vehicle (EV), quick charger, simultaneous charging of multiple EVs
power peak-cut function, EV charging time reduction, power demand and supply adjustment, stationary battery, Community Energy Management System (CEMS)

1. Introduction

After the Great East Japan Earthquake, anxieties relating to power shortage have increased the need for efficient and stable management of power grid operations. Moreover, it is necessary to prepare suitable countermeasures for the problems of the new power demand and supply, such as the peak of power demands by charging the electric vehicles (EVs), and the instability of power grids by increase in power generation supplied from renewable energy sources.

NEC has previously marketed household energy storage systems incorporating Li-ion batteries [1)] and has also developed EV quick chargers and EV charging systems by optimally using cloud computing for member authentications, administration and billing settlements [2)] . By applying these technologies, NEC has developed the Battery and Charger Integration System (BCIS) and is currently attempting to resolve the problems referred to above. BCIS realize the reduction of the peak power consumption (peak cut) for EV charging demands, and the shortening of the EV charging time because BCIS which is linked to the multiple quick chargers and stationary batteries controls the power to be supplied to the EVs efficiently. The field trials of BCIS will be carried out in Yokohama City as one of the themes of the Yokohama Smart City Project (YSCP) from 2012. In addition, there are some plans in order to verify the effectivity of BCIS for the regional power demand and supply adjustment.

In the following sections, we explain the new problems of power demand and supply, the details of the BCIS proposed by NEC, and the field trials of the BCIS.

2. Issues Contained in the New Power Demand/Supply

The dissemination of EVs brings about increase in power demands. And renewable energy increases unstable power generation. This means that the power supply arrangement capability with the conventional power grid may not be able to maintain stable power supply.

(1) Increased power demand due to the dissemination of EVs

In the future, as EVs become more popular, there is fear that there will be electric power shortages due to the simultaneous charging of multiple EVs. An increase in the waiting time for charging might be another issue for drivers. When assuming that multiple EVs may charge their batteries at an EV charger service station, it is essential to provide multiple EV quick chargers at suitably located charging stations. However, a large volume of power is required for charging multiple EVs via quick chargers. Charger business operators and electric power distribution business operators may need to enhance power distribution facilities in order to cope with the projected peak power consumption, and also they have to prepare the expenses burden for such enhancement of power distribution facilities. Another concern is shortage of power supply in case quick charging peak time is concentrated to certain hours. EV drivers may also have to wait long hours in queues for charging even at the multiple charging facility stations.

(2) Unstable power generation due to renewable energy

Power generation using renewable energy such as that provided by solar or wind installations is expected to become available more readily to ordinary households in the future. However, such energy sources will be influenced by weather and the amount of sunlight, therefore such a system has inherently unstable power supply characteristics as well as limitations regarding the available supply periods.

Such characteristics are issues that are of concern with regard to the use of renewable energy power supplies so that a mechanism to store surplus power is demanded. The mechanism features to store the surplus power of the renewable energy during which a large amount of power is produced. It can also supply such accumulated surplus power when the ordinary power supply becomes low.

3. Battery and Charger Integration System (BCIS)

We propose BCIS as a suitable countermeasure to solve issues mentioned in Sec. 2. BCIS combines several quick chargers and large capacity batteries. The system configurations, operations and features of BCIS will be described in the following sections.

3.1 The System Configuration and Its Operation

BCIS incorporates six components. **Fig. 1** shows the system configuration and the function of each component is described below.

(1) Grid power receiving section

This component converts the AC power transmitted from the grid into DC power and then supplies it to the battery control and quick charger sections.

(2) Battery control section

This section receives commands from the power controller in order to control the charge and discharge operations of the battery unit.

(3) Battery unit

The battery unit consists of the Li-ion batteries and a battery management system (BMS) that is designed to secure a suitable power storage level and a safe environment for the stationary batteries.

(4) Quick charger

The quick charger provides a rapid battery charge for the EVs while receiving commands from the power controller to enable the dynamically controlled charging of power during fast charging for the EVs.

(5) Power controller

The power controller monitors the status of each component and controls the power resources to provide optimum control of the EV chargers. Moreover, by receiving commands from the BCIS manager unit it is able to control the charging amounts of the quick chargers for the EVs and the charge/discharge amounts of the stationary batteries.

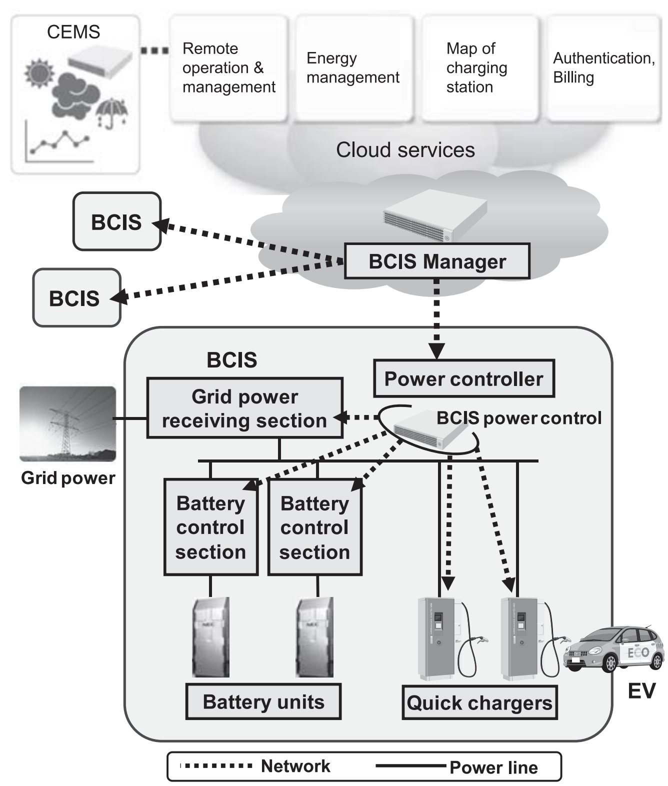


Fig. 1 System configuration of the BCIS.

(6) BCIS manager

The BCIS manager monitors and controls each BCIS as well as managing and maintaining the BCIS system.

As shown in Fig. 1, the BCIS manager can be provided as a service via cloud computing. By collaborative linkage with the Community Energy Management System (CEMS), power demand and supply adjustment within a region will be available via the demand response function.

3.2 Features

BCIS features a power output control function for the quick charger to use electric power efficiently, and also features a power demand and supply adjustment function that contributes to stable regional power supply.

(1) Power output control function for a quick charger

BCIS is capable of controlling the power output for a quick charger, which could not hitherto be performed dynamically. It thus utilizes electric power more efficiently. With the general system, a quick charger and the EV to be charged will set the maximum charging power at the start of charging and then the EV will be charged within the maximum charging power according to commands from the EV. This means that the quick charger is requested to be ready to charge the maximum power that is set at the beginning whenever this is necessary. However, the Li-ion battery installed in an EV employs a constant-current/constant-voltage charging system. With this system, battery charging during the constant voltage stage requires less power than that acquired from a quick charger at the start of charging. BCIS optimally utilizes the surplus power acquired from a quick charger while consuming less power to charge an EV during the constant voltage charging stage. BCIS can then control the power output of the quick charger and dynamically distribute the power to other EVs as well as to the stationary batteries.

With this control function, the excess power from an EV charger can be used for charging other EVs in a queue. This allows charging service business operators to manage their service stations via the conventional power distribution facilities.

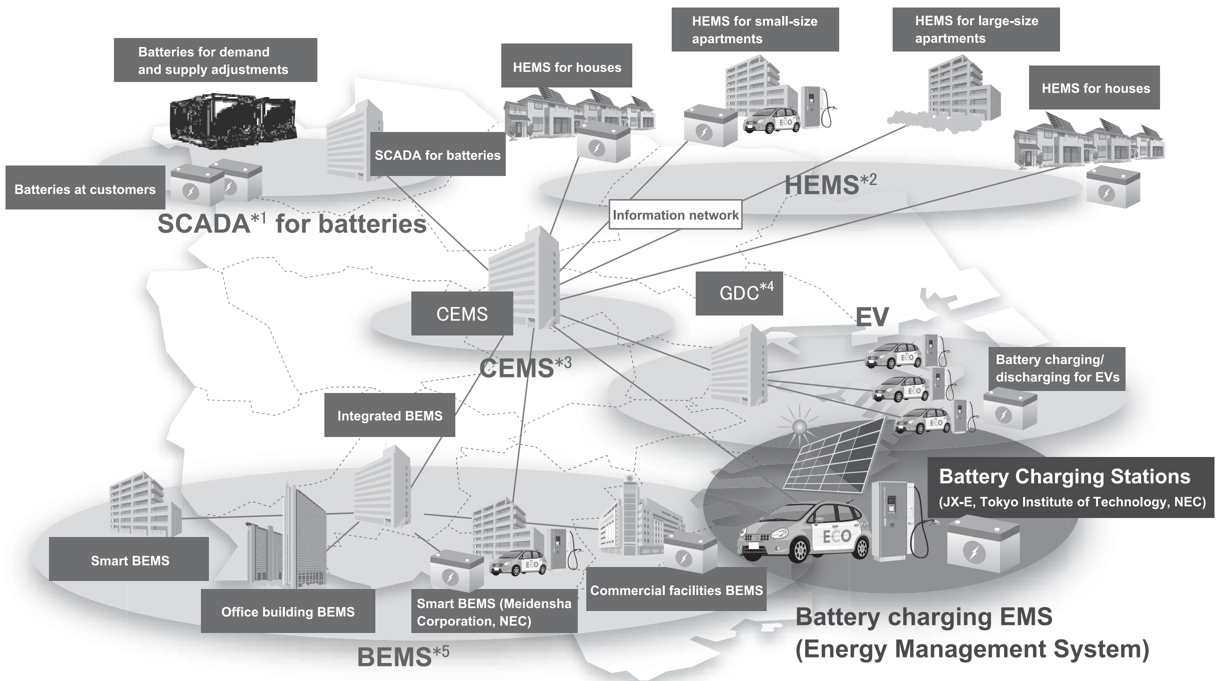
Moreover, charging the next EV can be started immediately when surplus power is generated from an EV charger. This will contribute to the simultaneous charging of multiple EVs and to a reduction in the time spent in charging EVs. Using power from stationary batteries located at the same station may also further reduce the charging time.

(2) Power demand and supply adjustment function

By controlling the supply of power for EV battery charging using BCIS, a stable regional power supply can be expected. When any surplus power is generated in the region via the renewable resource energy introduced to generate power, such surplus power will be used for charging EVs and for the stationary batteries. If a shortage of power occurs in the region, power to be used at an EV quick charger service station will be suppressed by decreasing the output of the quick charger even during active charging of an EV, or by supplying power from a stationary battery for charging the EVs. Moreover, CEMS can provide regional power shortage/surplus reports to BCIS. The reports are calculated as power costs, and BCIS controls the EV quick chargers and stationary batteries according to such costs. This procedure will help to suppress the expenses burden for an EV quick charger service station, and it will also contribute indirectly to a stable power supply for a region.

4. Field Trials at the Yokohama Smart City Project

The “Next Generation Energy and Social System Field Trial” to be evaluated by METI (Ministry of Economy, Trade and Industry, Japan) will be a project that aims to construct a Japanese original smart grid system and the promotion of this system in overseas countries. The development of BCIS was adopted as one of the themes of this project. In collaboration between Yokohama city and various commercial companies, the project is being carried out as a part of the YSCP (Yokohama Smart City Project) in order to realize a city that is environmentally friendly (**Fig. 2**) [3]. The field trial was started in 2011 by introducing BCIS to a certain facility of Yokohama city. In 2012 and subsequently, various benefits will be examined including time reduction and power peak-cut effect by charging EVs simultaneously, an issue that is mentioned above. By linking BCIS with CEMS (Community Energy Management System), it will also be verified how much BCIS can contribute to the power demand and supply adjustment of the region.



*1 SCADA: Supervisory Control And Data Acquisition
*2 HEMS : Home Energy Management System
*3 CEMS : Community Energy Management System
*4 GDC : Global Data Center
*5 BEMS : Building Energy Management System

Fig. 2 Overall image of YSCP.

5. Conclusion

We have explained the BCIS which balances the load reduction of the power distribution facility in charging multiple EVs with the user benefits of the Smart Charging Stations. We intend to promote further development of BCIS and to encourage its business deployment while studying the results from the field trials.

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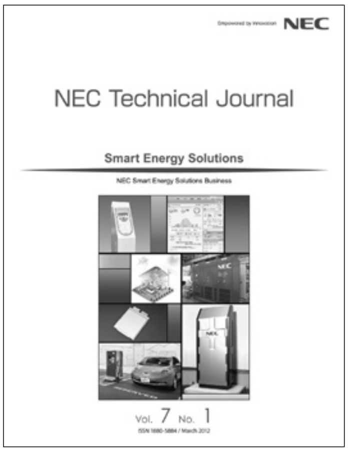

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