Development and Demonstration of Next-Generation Energy System on Demand Side (Yokohama Smart City Project)

Takashi Uyama

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Abstract

In the energy field, various demonstration programs have recently been conducted relating to smart grids development. The Yokohama Smart City Project is one such project for the purpose of establishing a smart energy model for a wide-area metropolis. As one of the project members, Meidensha Corporation has been conducting the development and demonstration of a next-generation energy system based on the new technological concept.

Under this verification project, we developed a smart Building Energy Management System (BEMS) and lithium ion battery system in combination with an existing energy system. We aim to streamline the system and realize making our system smart grids ready. In addition, we aim to make a more advanced system by implementing energy control among multiple facilities in liaison with smart BEMSs.

1 Preface

Recently, a new concept called “smart city” or “smart community” is getting increased attention. This concept refers to the building of a new social system with significantly increased overall efficiency of cities by using measures optimizing the energy efficiency level of districts. In Japan, various demonstration projects have begun to realize such new concept. Against this background, the Yokohama Smart City Project (YSCP) is a demonstration project and a joint project promoted by Yokohama City and private enterprises. For this project, a large-scale verification is carried out based on the smart grids. As one of the project members, we conduct the development and demonstration for a next-generation energy system based on the aforementioned new concept.

This paper introduces our system developed thus far and the profile of the demonstration project which we joined since Fiscal 2012.

2 Outline of the Demonstration Project

The profile demonstration project is shown below.

(1) Development of the smart Building Energy Management System (BEMS) applicable to the smart grids
(2) Development of a large-scale stationary battery system using lithium ion batteries
(3) Establishment of a next-generation energy system by applying BEMS to the existing energy systems

3 The Developed System

3.1 Smart BEMS

The purpose of the smart grid is to shape the balanced energy efficiency at the districts level by sharing the information of energy supply and demand. In exchange for receiving additional incentive at the electricity user side, it is also necessary to adjust the power demand, a system of Demand Response (DR) for the overall local energy efficiencies. On top of the conventional BEMS, we built a smart grids-ready smart BEMS by incorporating the elements listed below. Fig. 1 shows an operation model of our smart BEMS.

(1) Communication function with the host system

By managing information of power consumption at a target facility, our system transmits such

information periodically to the host system like the Community Energy Management System (CEMS), etc. Such data are aggregated at the host system and are used for the energy demanded and supply planning in the districts. On the other hand, the host system occasionally distributes the DR signal to each electricity user as a target power consumption level. This information contains the incentive data; therefore, when an electricity user conducts a DR, the system records an incentive based on the past power consumption records.

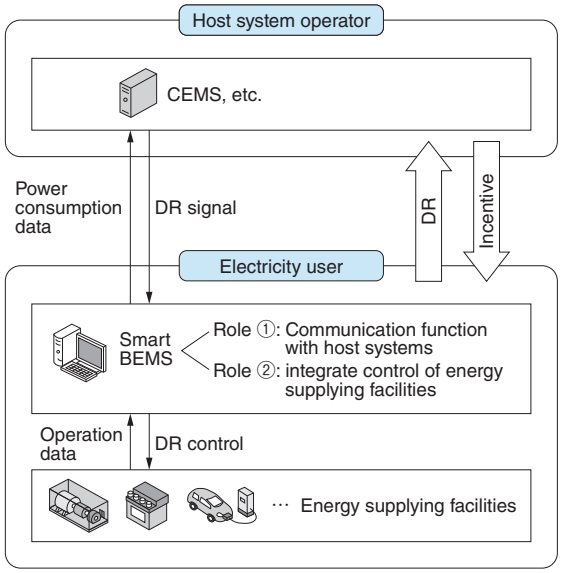

Fig. 1 Operation Model of our Smart Grid

When an electricity user receives DR-related information and responds to it, it is possible to obtain an incentive based on the past energy usage records.

(2) Integrate control for energy supplying facilities

Fig. 2 shows the outline of integrated control by the smart BEMS. In commercial facilities, energy is supplied to the local load by the combination of various energy supplying facilities such as the Combined Heat & Power (CHP) and energy storage system, solar power system, battery system, heat-source equipment, and thermal storage system. The smart BEMS computes an entire energy operation plan by factoring load patterns projection, mechanical characteristics, and energy information such as the DR signal. Based on such an energy operation plan, we conduct integrated control for the energy supplying facilities to realize the efficient operation.

As a result, DR control to adjust the amount of the grid power to be purchased becomes possible

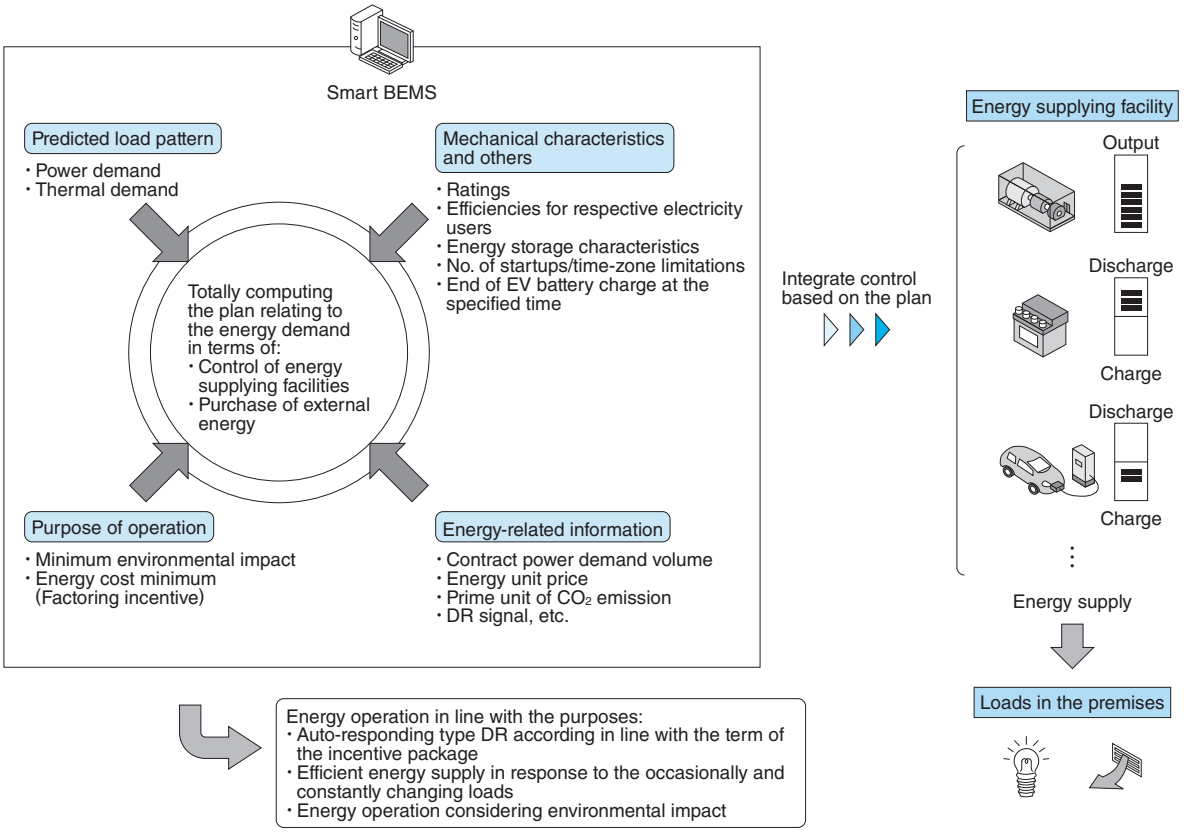

Fig. 2 Integrate Control by the Smart BEMS

Auto-response type DR control and efficient energy management in facilities can be performed by the integrate control for the next-generation energy system.

to base on the reserve power such as the number of energy supplying units in operation and operational outputs.

To accomplish DR control in line with the DR signals, it is necessary to determine the energy operation plan in advance because it is the basis for control. In addition, this plan calls for the elective energy operation in the target optimal energy management for facilities. Based on afore-mentioned energy operation plan and by comparing the condition before and after the DR, we can assess if the response to each DR signal is correct or not.

For this purpose, under normal conditions we conduct the control based on the energy operation plan to improve the energy usage efficiency in the overall facilities. In the case of DR control, we benchmark the said operation plan. By responding to the load changes and by selecting most efficiently working conditions of the energy supplying facilities within the power reserve, we realize effective energy control.

When the aforementioned series DR-related operations (such as demand control, data transmission/acquisition, judgment and control to receive or refuse responses) are automated, we can realize an auto-response type DR approach.

3.2 Large-Scale Stationary Lithium Ion Battery System

In order to add some latitude in energy control by the smart BEMS, it is necessary to set up a means to shift energy in our time and space. Therefore, we have applied a technology of lithium ion batteries for Electric Vehicles (EV). In so doing, it is possible to establish a large-scale stationary battery system featuring low cost, high safety, and long operational life.

In the building and making this system, NEC Corporation was in charge of the production of lithium ion batteries and we were in charge of the Power Conversion System (PCS).

3.3 Application of the Developed System

When existing energy supplying facilities are combined with lithium ion battery systems, it is possible to secure an energy reserve for power demand and supply balancing. In addition, by performing the central control to existing energy supplying facilities by using the smart BEMS, we can streamline the energy use and by going BEMS, such improved energy system could be connected to smart grids.

Fig. 3 Yokohama World Porters

Located in an area with various types of facilities, it offers the shopping mall, tourist spots, and walking courses — very popular places.

4 Outline of the Demonstration Project

4.1 Demonstration Project Site

The demonstration work is conducted at the Yokohama World Porters, a big shopping mall in Yokohama City. Fig. 3 shows an external appearance of the facilities.

In these facilities, a CHP is introduced for double purposes efficiency improvements by the combination of power peak-shaving and waste heat recovery. This demonstration project aims to apply the developed system to existing energy systems in order to build a next-generation energy system.

Since the Yokohama World Porters are the commercial facilities in operation, there are many restrictions relating to system introduction and energy operations. By solving each problem, we aim to build a model of turning the existing facilities into smart facilities.

4.2 Demonstration System

Fig. 4 shows an outline of the demonstration system. The smart BEMS and a lithium ion battery system were newly introduced and combined with the existing dispersion type power source. Fig. 5 shows an operator console for the smart BEMS.

4.3 Operation

Since commercial facilities are required to offer comfort to visitors, it is difficult to perform energy operation by giving restrictions to the load side. For this reason, objects of energy control are limited only to the energy supplying facilities. As a result, we realize energy usage efficiencies for the auto-

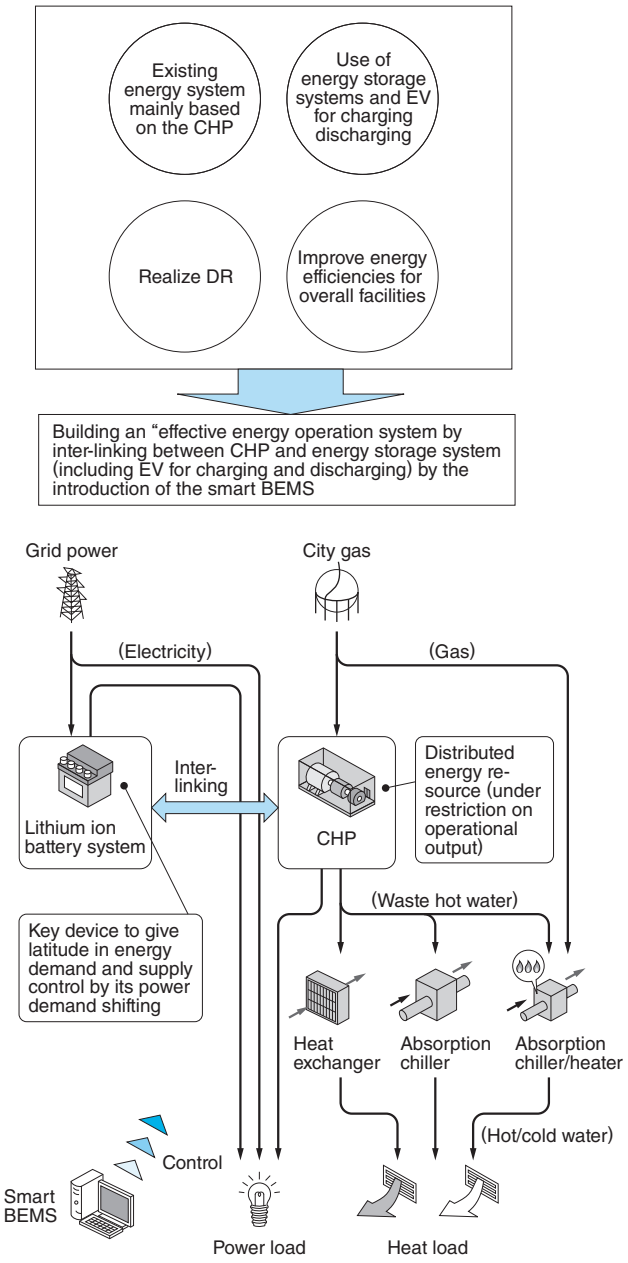

Fig. 4 Outline of the Demonstration System

By interlinking between the distributed energy resources and energy storage device, we build a complex energy system which can meet the various applications.

Fig. 5 Operator Console for the Smart BEMS

By comprehensive control of energy supplying facilities from this BEMS system, advanced energy operation is possible.

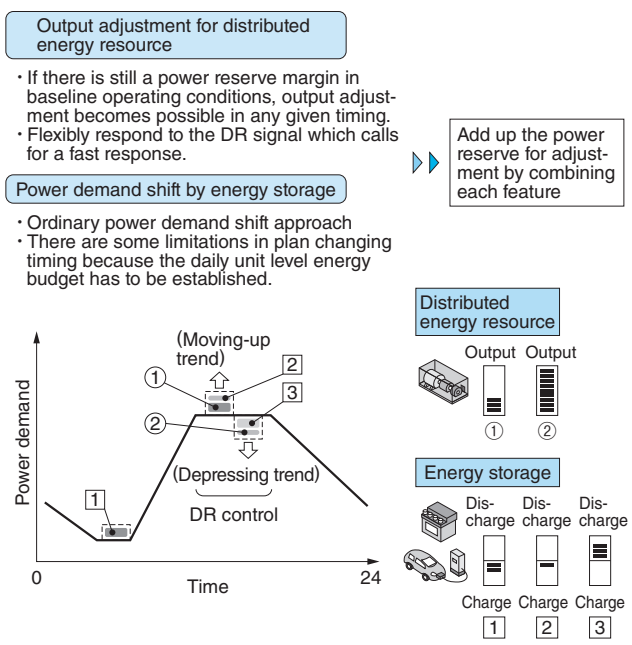

Fig. 6 Outline of DR Method

With appropriate control within the reserved power for adjustment, effective DR control became possible.

response type DR and for the overall facilities without giving restrictions to the operation of load machines.

In actual operation, however, it is necessary to secure an energy reserve for adjustments and also perform adequate control within the energy reserve range. In this demonstration project, the energy reserve is secured based on a combination of "output regulation of distributed energy resources" and "power demand shift by using energy storage device." In so doing, we realized the project goal of the efficient energy operation.

Fig. 6 shows an outline of the DR method. By combining the features of the distributed energy resources and the energy storage devices, more effective DR control becomes possible. By using DR, the peak shaving becomes possible and can absorb surplus power from the local solar power.

During regular energy operation without DR control, it is conducted by the optimized control considering both factors: environmental impact and economy.

5 Postscript

Based on the on-going project introduced in this paper, we will continue to put our energy control technologies further to the control of multiple facilities by interlinking with other smart BEMS blocks under the control of other project members. During the term of this demonstration project, which is scheduled to be finished by the end of Fiscal 2014, we would like to focus our attention on the demonstration project for the purpose of making the existing facilities go smart in realizing a smart community.