Wide-Area Internal Energy Sharing between Yokohama City University Medical Center and Government Office Building in Yokohama Minami-Ward

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Keywords Wide-area internal energy sharing, EMS, Integrated control, Electricity market deregulation, Energy delivery over own transmission line, Energy retail wheeling

Abstract

Wide-area internal energy sharing is maintained among internal facilities of the Yokohama City University (YCU) Medical Center, the Government Office Building in Yokohama Minami-Ward, and the Minami Civil Engineering Office Workshop. The intent of the program is to improve disaster readiness, environmental conditions, and economic gain by a wide-area efficient use of energy. As one of the key facilities to support such an energy sharing operation, we supplied a smart Building Energy Management System (smart BEMS). This facility manages the operation of energy sharing and also makes the integrated control of Combined Heat and Power (CHP) and receiving power to fit the overall energy demand and system operation status.

In order to manage energy operation, the BEMS is generally used. In the event that proper management of energy supply is required, it is necessary to control both the energy consumption side and the power supply side. In such a case, the smart BEMS plays a key role by managing both the energy consumption and supply side and by making effective control.

1 Preface

At the Yokohama City University (YCU) Medical Center, the in-house electric power grid system adopted a redundant system in order to provide safe and reliable medical services. In addition, a Combined Heat and Power (CHP) was introduced as a distributed energy resource. This enhances the reliable supply of energy. At the Government Office Building in Yokohama Minami-Ward ("Minami Office Building" hereafter) which recently moved to the vicinity of the YCU Medical Center, the continuity of energy supply was needed because a regional administrative function has to be maintained in the event of an emergency as the building is an evacuation shelter in the event of a disaster.

Against such a background, wide-area internal energy sharing is conducted among facilities of the YCU Medical Center, the Minami Office Building, and the Minami Civil Engineering Office Workshop that belongs to the Minami-Ward Government Office. This arrangement makes an effective internal use of energy in a wide area. In so doing, it aims to improve disaster readiness, environmental conditions, and economic gain.

This paper introduces the outline of the smart Building Energy Management System (smart BEMS) that we delivered as one of the major facilities designed to support optimal management of wide-area internal energy sharing.

2 Background

In order to assure the continuity of energy supply at the Minami Office Building and other affiliated buildings, the installation of a CHP in these buildings like that at the YCU Medical Center can be an effective method. When the heat load was small in buildings other than the Medical Center, however, the rate of waste heat utilization was lowered and it became difficult to maintain high-efficiency operation. When the CHP was installed at the YCU Medical Center, waste heat could be used at the hospital and generated electric power that can be simultaneously fed to other affiliated buildings. This is the best method to maintain high-efficiency CHP operation. In addition to using the power supply from the CHP, the YCU Medical Center has backup power received at a super high voltage from an Electric Power Company (EPCO) or Non-EPCO company ("Collective retail electric provider" or "REP" hereafter). As such, the continuity plan of energy supply can be improved at the Minami Office Building.

When a CHP was newly introduced to the YCU Medical Center, a structure for the internal wide-area energy use was established and it improved the features of disaster readiness, environmental conditions, and economic gain by setting up the private power transmission line toward the Minami Office Building and the Minami Civil Engineering Office Workshop so that power can be distributed to these buildings in a specific power supply mode.

In order to manage the energy operation well, a BEMS is generally used. In the event that proper energy supply management is required, it is necessary to control not only energy consumption, but also the power receiving side. In such a case, a smart BEMS plays an important role as it can properly control the energy.

3 System Outline

Fig. 1 shows an outline of the wide-area internal energy sharing system. At the YCU Medical Center, a CHP was newly installed in order to meet the estimated power demand for the power receiving related parties like the Minami Office Building. In this situation, power is fed to these affiliated buildings by combining the power of the REP. The recovered waste heat of the CHP is used as a heat source for the YCU Medical Center.

Operation for overall wide-area internal energy sharing is managed by the smart BEMS. Data linkage with the central monitor system at the Minami Office Building is also managed by this smart BEMS. In addition, the smart BEMS takes complete control between the CHP and power receiving from the REP. This control reflects on-going energy demand and operating conditions at the YCU Medical Center, the Minami Office Building.

Fig. 2 shows a system configuration of the smart BEMS. The smart BEMS is composed of the supervisory control console installed at the central monitor room and the remote stations installed at each site. This equipment acquires meteorological information via the Internet and makes time calibration by receiving the time data from land-based digital TV broadcasting. Data exchanges with external facilities are outlined below.

(1) Existing CHP

Based on communication between the smart BEMS and the existing CHP, it makes the required data retrieval and builds a control line from the smart BEMS to the CHP. It adopted standard communication protocol commonly used for control data

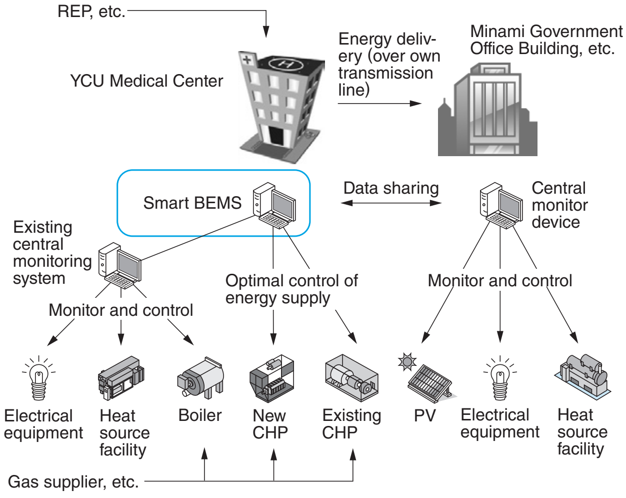

Fig. 1 Outline of Energy Wide-Area Internal Sharing System

The smart BEMS manages and controls the wide-area internal energy sharing.

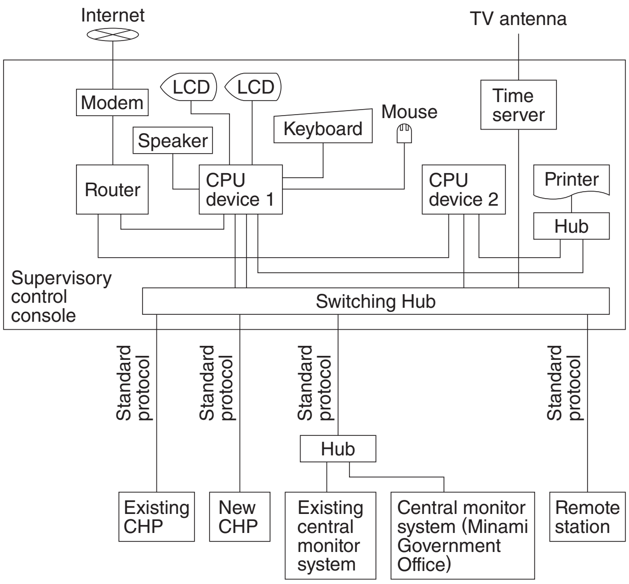

Fig. 2 System Configuration of the Smart BEMS

Data are gathered at the CPU unit in the supervisory control console and the smart BEMS manages and controls.

exchange among FA controllers.

(2) A newly-installed CHP

In the same manner as for an existing CHP, necessary data exchange between the smart BEMS and a newly-installed CHP is carried out in accordance with the standard protocol.

(3) Existing central monitoring system

Communication is maintained between the smart BEMS and the existing central monitoring system in order to retrieve necessary data. For this purpose, a standard protocol applicable to building automation was adopted.

(4) Central monitoring system (for Minami Government Office)

Similar to the existing central monitoring system, necessary data are exchanged between the smart BEMS and the central monitoring system installed at the Minami Office Building using the standard protocol.

Different energy administration screens can show the detailed CHP status display, status display of power receiving and distribution facilities at the YCU Medical Center and the Minami Government Office, and overall energy flow status display. Based on these status display screens, the operator can obtain a general overview at-a-glance.

4 Smart BEMS

4.1 From Experimental Stage to Practical Use

The total control of the CHP and receiving power by the smart BEMS is realized by the optimal control of energy supply supported by the function of this system. The effectiveness of this function was already verified through the demonstrative operations for the facilities of Yokohama World Porters, which is part of the Yokohama Smart City Project (YSCP). The delivery of this smart BEMS is, therefore, the first such achievement of practical application. Activities of wide-area internal sharing among the YCU Medical Center, the Minami Office Building, and the Minami Civil Engineering Workshop can be deemed as a follow-up development based on YSCP demonstrative test results.

Fig. 3 shows a flowchart to realize optimal control of energy supply. Based on the operational concept, design data, and actual data, we determined the technical set-up conditions in advance. In addition to these conditions, we combined with meteorological forecasts, calendar information, and various operational data to realize optimal control.

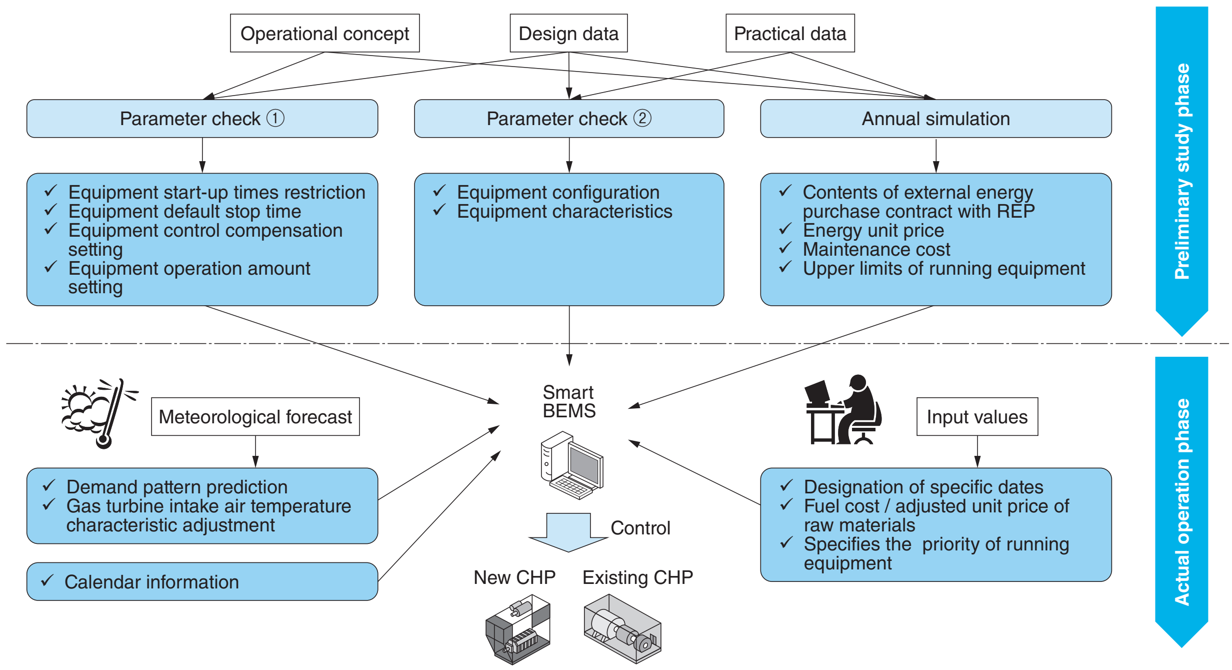

Fig. 3 Flowchart to Realize Optimal Control of Energy Supply

Condition setting is made at the preliminary study stage and final control will be realized by combining the various data in the actual operation phase.

4.2 Optimal Control of Energy Supply

Fig. 4 shows an outline of the optimal control of energy supply. First, a demand pattern is predicted based on the statistically processed data obtained from actual energy consumption results. Then, based on the combined patterns of CHP operation and the amount of purchased energy from the REP to meet the predicted energy demand, the system calculates the operation pattern to produce the minimum environmental cost or energy cost as an operation plan. Based on the obtained operation plan, integrated control between the receiving power and the CHP is made to satisfy restrictions such as an operation prohibited time zone and restrictions on start-up operation frequency.

In order to realize the integrated control at a more practical level, simply generating control signal output per the operational plan is not enough. It is required to make a program that can properly cope with any actual phenomena that may occur in practical energy management. To be specific, possible scenarios could include: energy consumption that does not result as the demand predicted or that the energy equipment which is referred to as an energy resource, energy storage, and heat source (collectively "energy equipment") become out of order, or that the start/stop operation of energy equipment may be arbitrarily designated due to maintenance service. To address such irregular phenomena, the delivered system is devised to maintain the present control status properly with the use of two methods, compensation of controlled variables and operation plan updating.

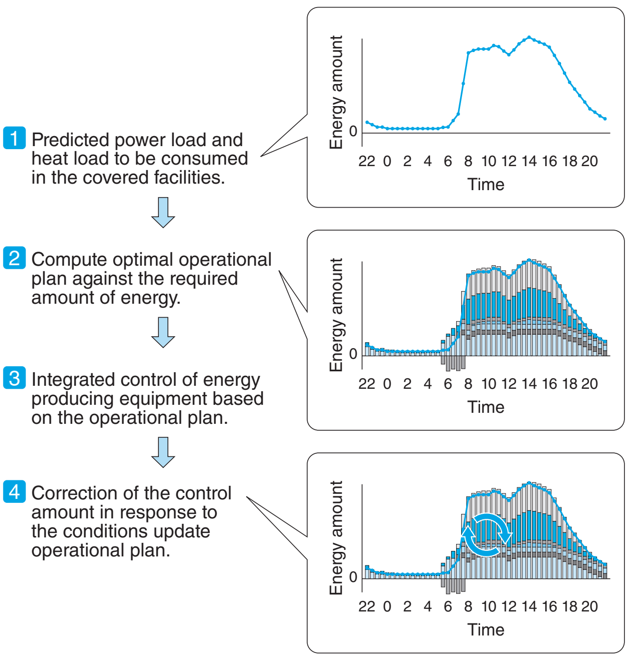

Fig. 4 Outline Optimal Control of Energy Supply

Practical level control is made following the sequence: demand pattern prediction, computation of operational plan, integrated control, control volume correction, and operational plan updating.

The above correction on controlled variables is needed in following up the situation where a dynamic fluctuation has occurred in the power load in a short amount of time. This is to meet the upper and lower limits of receiving power. These limits are already defined according to the power purchase contract and configuration of facilities. Energy management has to be made, therefore, to be within a pre-set range of a proper controlled amount of energy. In the event that there is a large difference between demand prediction and an actual situation, the operational plan will be updated after correcting the demand prediction or conducting another prediction. If the phenomenon is attributed to changes in the status of energy equipment, the present energy flow and the conditions of the equipment configuration will also be modified.

Since the mechanism of above-mentioned control volume adjustment and operation plan updating are in a mutually complementary relationship, the design consideration is made to produce an adequate interlinking operation that will not cause any contradiction in the sequential control. In addition, the steps from the assessment of conditions to the generation of control signal outputs, are all fully automated.

Further, it is possible to consider the influence of maintenance service in advance by adopting operational conditions that can compute and produce an arbitrary operation plan against the selected time frame and any related energy equipment.

4.3 Expected Effects

After the start of BEMS system operation, wide-area internal energy sharing can be maintained among the YCU Medical Center the Minami Office Building and it becomes possible to minimize environmental and energy costs. The control is made to meet the daily changing energy demands and current contract electric bill rates. Further, by updating the setup conditions, energy management can be made with due consideration to such factors as of the effect of changes in the energy unit price or energy efficiencies of the equipment.

5 Postscript

This paper introduced an example of wide-area internal energy sharing maintained among the customer's multiple facilities by using their in-house generated energy. Our smart BEMS is adopted in order to manage and control both energy consumption and supply. Meanwhile, with the deregulations of electricity market in Japan, it is anticipated that choices of power sources will increase remarkably on both the REP side and energy consumer side. For this reason, there will be cases when the approaches of sharing the in-house generated energy over one's own transmission system or (energy) retail wheeling (process of the delivery of energy generated by in-house power generation unit over its transmission system owned by an electric power company) may be taken into consideration. As such, the importance of Information and Communication Technology (ICT) will increase. The smart BEMS is a typical product that represents the "best use of energy and ICT technology." We will continue to meet such modern-day requirements in the future.

Lastly, we would like to express our thanks to many project-related individuals for your kind suggestions and supports for this BEMS system.