Smart Power Distribution Board Optimized for Energy Management

MORINAGA Tsuyoshi, SHIBUYA Tenda, TSUDA Shunsuke
NAGASAKI Shigeru, MARUYAMA Atsushi, KATAGIRI Yoshihiko

Abstract

The usual method for implementing an energy management system featuring visualization of power is to install power distribution data sensors and collect their data via an optimally arranged management network. Nevertheless, this method has become a factor in obstructing the dissemination of EMS because it is accompanied by various issues as well as inconveniences for the user. This paper reviews the functions and requirements necessary for optimum EMS implementation and introduces the Smart Distribution Board as a new tool for dealing with them.

Keywords

environment, visualization, environmental energy, energy management, CONNEXIVE M2M platform

1. Introduction

Following the power supply distribution shortfalls in the areas under the jurisdiction of Tokyo Electric Power Company and Tohoku Electric Power Company due to the 2011 Tohoku Earthquake, the Japanese Government was forced to impose government-controlled power blackouts and an electricity usage limitation ordinance was enacted. Japanese enterprises have in consequence been forced to consider measures for effectively dealing with the new situation. In order to make this possible, each enterprise needs to identify the actual level of its in-house electricity usage and to reduce it optimally, without causing hindrance to business performance. The energy management system (EMS) featuring the visualization of electricity usage is attracting attention as a suitable solution to this issue.

This paper introduces the Smart Distribution Board that is optimized for the implementation of EMS.

2. Toward EMS Implementation

In order to perform optimum energy management, it would be ideal to identify the actual state of use correctly and with details of “WHEN,” “WHERE,” “FOR WHAT” and “HOW MUCH” electricity is used as well as other information such as the equipment operating situation and environmental information on temperature and humidity.

Specifically, if the purpose and amount of electricity usage can be identified, not on a per-electricity contract basis, but if the details per each circuit breaker of the distribution boards are known, it would be possible to define issues that had not previously been possible, such as to specifically quantify any excessive use of electricity. In addition, if the equipment operating situation and environmental situation can also be identified, it will be easy to take effective improvement measures for the reduction of power consumption (**Fig. 1**).

The EMS conceived by NEC refers to the mechanism for implementing energy management via IT as described above (**Fig. 2**).

The following paragraphs deal with the essential functions and requirements of EMS.

(1) Accurate identification of power usage situations

The electricity demand countermeasures applied by the Japanese Government as prescribed in Article 27 of the Electricity Business Act [1] have made it obligatory for the big electricity users including factories, data centers and office

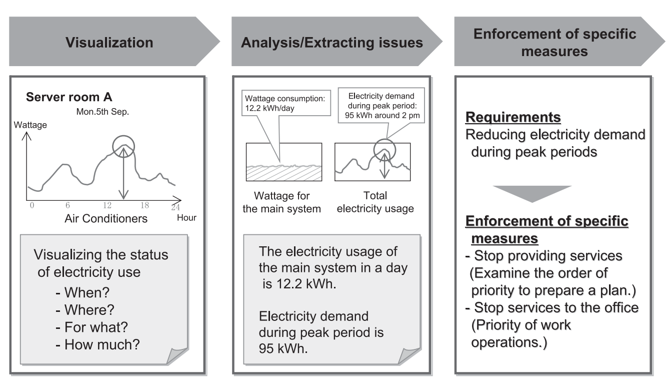


Fig. 1 Example of specifically enforced measures utilizing EMS.

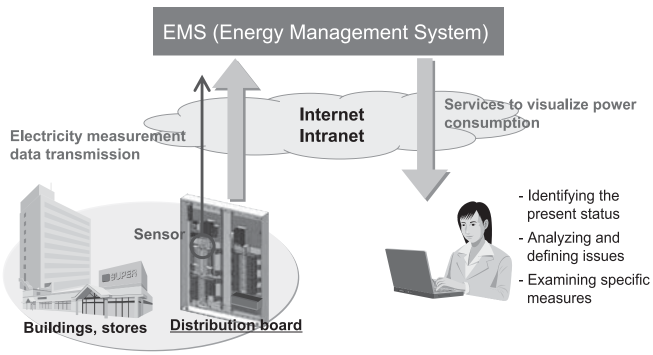


Fig. 2 EMS as conceived by NEC (image).

buildings to reduce electricity usage in the peak demand period. For smaller electricity users such as convenience stores and restaurants, non-binding targets for the reduction of electricity usage in the peak demand period. These are being applied by setting and enforcing independent action programs [1] that are based on the "Standard format of the electricity-saving action plan."

To reduce the electricity usage in the peak demand period based on the actions described above, it is necessary to identify "WHEN?" (time), "WHERE?" (location), "FOR WHAT?" (equipment and appliances) and "HOW MUCH?" (wattage) electricity is used for the peak demand period. In addition, it is also necessary to identify the variation in the electricity usage amount of each group of equipment or appliance. A function for measuring the electricity usage amount accurately per finely-determined time unit of each circuit breaker is mounted on the distribution board in order to obtain such information.

(2) Acquisition of the equipment operating situation and environmental information

Identification of the equipment operating situation and environmental information including temperature and humidity data enable awareness of the factors that increase electricity usage. Such information enables analysis of the electricity usage situations. Specifically, it is desirable to install mechanisms and functions that can readily acquire the information affecting electricity usage, such as details of the equipment and appliances including air conditioners and lighting facilities, the temperature and humidity and the flow lines of people.

(3) Implementation of the communication function

The integrated and precise management of the electricity usage amount of an enterprise is desirable for the implementation of optimum energy management. For this purpose, it is required to prepare a mechanism allowing the EMS that controls the energy management to identify the electricity usage situations of multiple distribution boards as closely as possible to real time.

The implementation of such a mechanism necessitates a communication function capable of efficient transmission/reception between the distribution boards and the EMS.

(4) Reduction of installation work

In general, when measuring the electricity usage of each circuit breaker of the distribution boards, a clamping-type CT (Current Transformer) sensor is installed on each of the circuit breaker wiring cables.

However, this procedure necessitates much work from advance surveys of the existing distribution boards to the installation of sensors and wiring of the cables inside the distribution boards. Consequently, the burden imposed by this work has become one of the factors hindering the introduction of EMS.

This has led to the need for a distribution board with a structure that can minimize the effects of this issue.

We concluded that a distribution board that can meet the functional and other requirements as described above would facilitate implementation of EMS in enterprises.

3. Outline of Smart Distribution Board

NEC has developed the Smart Distribution Board optimized for implementation of EMS.

The Smart Distribution Board incorporates CT and voltage sensors for measuring the electricity usage of each circuit breaker as well as the main unit that gathers data from all of the sensors (**Fig. 3**). The main unit is also equipped with interfaces for connections to the equipment, appliances and external sensor devices as well as a network interface for transmission/reception of the collected data in combination with the upper-level system (see **Table**).

Our Smart Distribution Board has the following features.

(1) Highly accurate power measurements

The Smart Distribution Board samples the instantaneous current and voltage values of each circuit breaker and the main unit calculates the wattage based on measurements every 10 seconds.

The main unit uses the following logic to calculate the wattage more accurately.The main unit samples the current and voltage of thesensors at short intervals and calculates the effective power P every 10 seconds (formula (a)). In the case

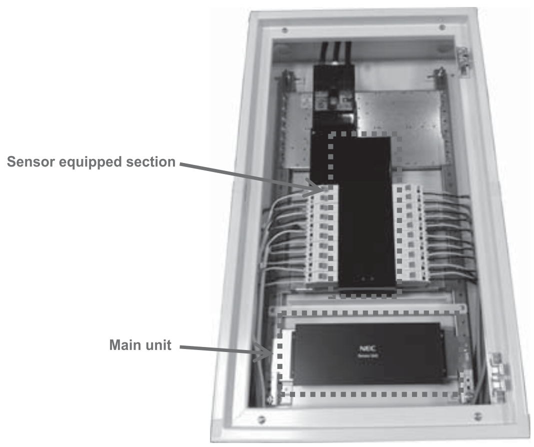


Fig. 3 Smart Distribution Board.

Table Outline of the Smart Distribution Board specifications.

Item	Description
Circuit-breakers	Electric light distribution board • Master circuit breaker (Standard); 125 A type • Branch circuit breakers: [100 V] 20 A, [200 V] 20 A/30 A, [100 V/200 V] 30 A Power distribution board • Master circuit breaker (Standard); 125 A type • Branch circuit breakers: [200 V] 20 A/30 A/50 A
Current sensors	CT sensors: Max. 24 sensors. Installed on the primary sides of the branch circuit breakers (when shipped with embedded CT sensors).
Network interfaces	100BASE-TX / 10BASE-T (LAN connection)
Output data	• Measured electrical information: Wattage, power factor, current, voltage (2-line voltage measurements, R-S-T/L1-N-L2 • External connection information: Data formats dependent on the connected equipment.
Extension interfaces	• RS485 × 2 ports • RS232C × 2 ports • Contact inputs (extension possible) • Contact outputs (extension possible)
Power supply	PoE (Power over Ethernet) supply
Power consumption	Approx. 5 W (main unit only)
Operating temperature/	Temperature: 0 to 50°C
humidity	Humidity: 20 to 80% (without condensation)
Dimensions & weight	Dependent on the circuit configuration of the board. (The distribution board is a custom-made product.)

of a single-phase three-wire system, effective power P is output as the wattage value.In the case of a single-phase three-wire system, the differences in potential between

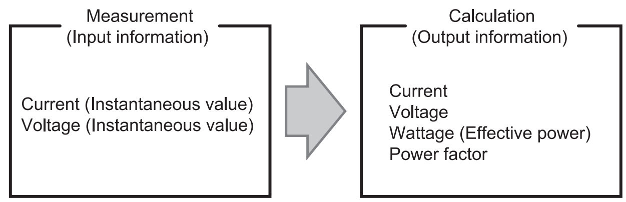


Fig. 4 Input and output information.

phases L1 and N and between phases L2 and N are measured as the voltage values. With a three-phase three-wire system, the two-wattmeter method2) is used measuring the differences in potential between phases R and S and between phases T and S as the voltage values so effective power P can be measured as a more accurate wattage value. At the same time as the calculation of the effective power P , the main unit also calculates the apparent power S (formula (b)) and the power factor p (formula (c)) (**Fig. 4**).

$$P = \frac{\sum_{n=1}^{N\times t}\{i(n)\times v(n)\}}{N\times t} \quad \cdots \text{(a)}$$

$$S = I(rms)\times V(rms) \quad \cdots \text{(b)}$$

$$I(rms) = \sqrt{\frac{\sum_{n=1}^{N\times t}\{i(n)\}^2}{N\times t}}$$

$$V(rms) = \sqrt{\frac{\sum_{n=1}^{N\times t}\{v(n)\}^2}{N\times t}}$$

$$\rho = \frac{P}{S} \quad \cdots \text{(c)}$$

* $i(n)$: Instantaneous current value. $v(n)$: Instantaneous voltage value.
$I(rms)$: Effective current value. $V(rms)$: Effective voltage value.
t: Time (10 or 60 seconds) N: Number of samples per second

(2) Versatile extension interfaces

The main unit has an RS-232C connector and contact input/output terminals as extension interfaces.

Examples of connection targets include equipment and appliances such as air conditioners and office lighting and refrigerators in stores as well as various external sensors such as indoor and outdoor thermometers and humidity meters.

(3) Built-in standard network interface

To implement integrated energy management, the distribution board is compatible with the http protocol, which is the standard network interface enabling efficient measurement data exchange via Internet and intranet.

(4) Efforts for cost reduction

Despite the electricity measurement sensors and the main unit being incorporated, the distribution board applies structural measures to avoid size increases. These specifically include the space-saving circuit breakers and the installation of sensors in the wiring on the primary side of each circuit breaker (**Fig. 5**).

This configuration enables the Smart Distribution Board to reduce manufacturing costs and installation work expenses.

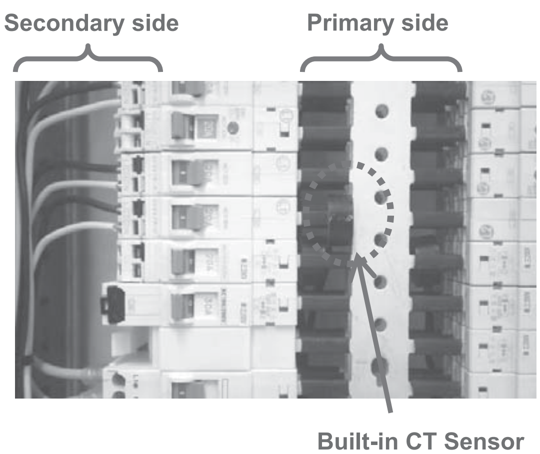


Fig. 5 Built-in CT sensor.

4. Conclusion

NEC aims to market this innovative Smart Distribution Board and the CONNEXIVE M2M platform to contribute to the implementation of energy management in enterprises and organizations.

In addition, we intend to implement more advanced EMS by linking the Smart Distribution Board with the energy related systems that are expected to become mainstream in the future; such as the solar and wind power generation systems and power storage systems. We are determined thereby to

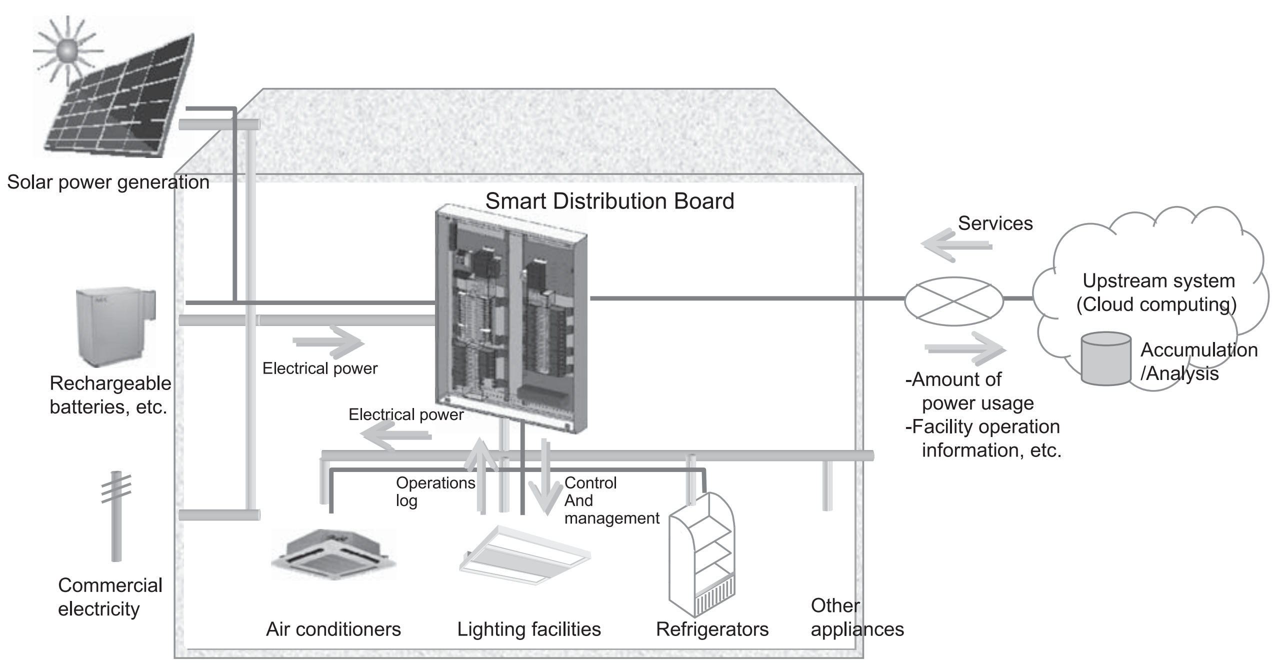


Fig. 6 Diagram illustrating the future utilization of the Smart Distribution Board.

continue to enhance our efforts toward advantageous technological developments (**Fig. 6**).

*Ethernet is a registered trademark of Fuji Xerox Co., Ltd.

Authors' Profiles

MORINAGA Tsuyoshi
Manager
Application Appliance Division
IT Hardware Operations Unit

SHIBUYA Tenda
Executive Expert
Application Appliance Division
IT Hardware Operations Unit

TSUDA Shunsuke
Application Appliance Division
IT Hardware Operations Unit

NAGASAKI Shigeru
Engineering Expert
Products Development Group
Development Division
NEC Computertechno, Ltd.

MARUYAMA Atsushi
Leader
Nagano Branch Division
NEC Soft, Ltd.

KATAGIRI Yoshihiko
Assistant Manager
Server Platform Division
Platform Operations Unit
NEC System Technologies, Ltd.

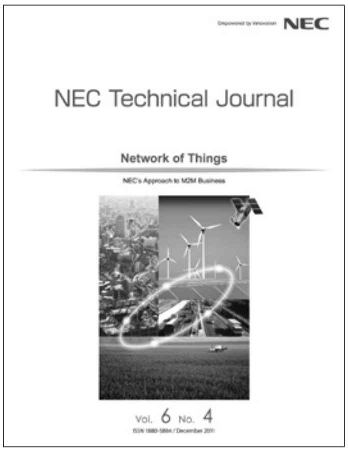
Information about the NEC Technical Journal

Thank you for reading the paper.
If you are interested in the NEC Technical Journal, you can also read other papers on our website.

Link to NEC Technical Journal website

Japanese | English

Vol.6 No.4 "Network of Things"



Vol.6 No.4

December, 2011

Special Issue TOP