Current Status and Future Outlook

Energy Management System (EMS): Current Status and Future Outlook

SHIRAKAWA Masahiro * KOBAYASHI Naoto * KUWAYAMA Jimpei *

1. Introduction

Energy self-sufficiency in Japan is as low as 4%, and most of its energy comes from fossil fuels such as petroleum and liquefied natural gas (LNG). Improving energy self-sufficiency and securing energy security have been longstanding challenges after the first oil crisis. In addition, recently, energy consumption has been rapidly increasing against the background of economic growth of newly developing countries including China and global environmental issues are becoming more serious in addition to the issue of stable acquisition of energy.

As one of the countermeasures to these issues, proactive utilization of clean renewable energy is promoted as a policy, and the "Feed-in Tariff Scheme for renewable energy" has been in place since 2012.

Meanwhile, an urgent challenge is economic reform, and strategic efforts are necessary to realize an economic system that allows sustainable development. If we can achieve a clean, economical and stable next-generation energy system ahead of the world, it will serve as a big pillar, and help us to ensure the above-mentioned energy safety, strengthen international competitiveness and promote regional regeneration by utilizing regional resources(1).

The "Next Generation Energy and Social Systems Demonstration Project" initiated in 2010 by the Ministry of Economy, Trade and Industry promotes the advanced demonstrations of a smart grid*1 in four regions (Yokohama city, Toyota city, Keihanna Science City, and Kitakyushu city) with a view to achieving the next-generation energy system. In this project, regional renewable energy is used in highly efficient and stable. Moreover, technological and social demonstrations and evaluations are performed for demand side management, in which customers also participate in regional energy demand and supply operation by having an energy saving system on the customers' side such as BEMS*2, HEMS*3, and smart meters*4. In addition, an examination is underway on how to deploy the results of the demonstrations and evaluations to overseas energy infrastructure and infrastructure for restoration from the Great East Japan Earthquake.

The next-generation energy system provides customers with various energy menu options. In order for customers to use these options wisely, diffusion of energy management systems (EMS*5) becomes an important condition.

* Power & Social Infrastructure Business Group, Fuji Electric Co., Ltd.

***1: Smart grid**
This is an electric power distribution system to share information between energy providers and utility customers by using technology such as a smart meter, and operate a large-scale electric power system and regional power grid in cooperation. With this system, it is possible to introduce renewable energy in large quantities and utilize the energy efficiently.

***2: BEMS**
Abbreviation of building and energy management system. This is a system to perform energy management of air conditioning, lighting and power for industrial buildings. It is possible to remotely control energy equipment and load by sharing information with building facility management systems in a large-scale building.

***3: HEMS**
Abbreviation of home energy management system. This system is used to visualize energy supply and demand at home, along with diffusion of technology such as hot-water supply systems and air conditioning systems by using solar power generation for households and nighttime electric power and fuel cells for households. There are various forms of HEMS, including those that monitor and control energy by installing a home terminal at each house, provide an energy management service by using a personal computer and a smartphone, and convert home electrical appliances into intelligent devices.

***4: Smart meter**
This is a watt-hour meter with a bi-directional communication function. With this meter, it is possible to remotely read the meter of electric energy, measure voltage and current, remotely change the contract electric energy, and remotely stop and release stop of power supply.

***5: EMS**
Abbreviation of energy management system. This is a system to visualize energy such as electricity, heat and gas and optimally operate facilities. According to the management target, the system includes BEMS, CEMS, FEMS, HEMS and REMS.

This paper describes CEMS[*6] for performing regional energy management, utility customer EMS for each field, as well as each type of technology that comprises EMS.

2. Energy Management System (EMS) Technology

2.1 Global image of EMS

Figure 1 shows a global image of EMS that Fuji Electric considers.

In 2011, Fuji Electric commercialized and released the "EnergyGATE Series" as package products of CEMS to perform regional energy management in smart community[*7] and EMS to visualize customers' energy in each type of field such as in factories and stores, and promote energy saving.

In addition, Fuji Electric provides retail EMS (REMS[*8]) and factory EMS (FEMS[*9]) to achieve more advanced energy management in the field of distribution stores and industrial fields based on the know-how of energy-saving, manufacturing and facility operation that Fuji Electric has been accumulating with customers.

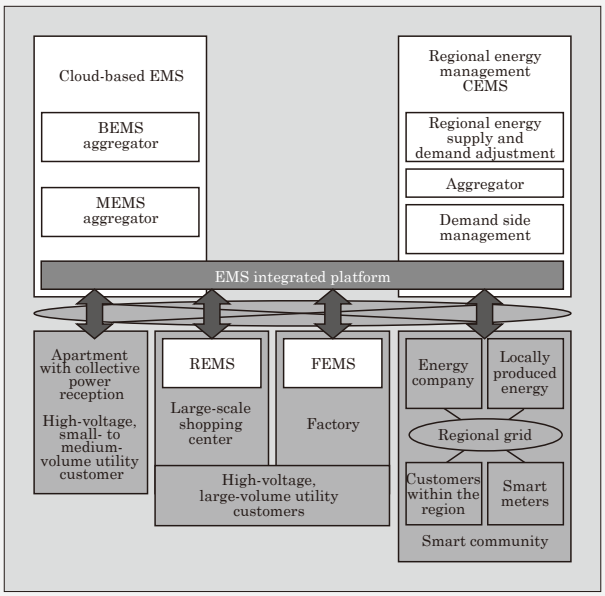

Fig.1 Global image of EMS

Furthermore, for high-voltage, small-volume utility customers such as elementary and junior high schools, small-scale stores and apartments with collective power reception, it is difficult to recover the cost if EMS equipment is introduced individually. Accordingly, the investment cost of EMS facilities is suppressed by providing an EMS service in a cloud[*10] environment.

2.2 Development road map for EMS

In Japan, the Act on the Rational Use of Energy (Energy Saving Act) has been revised several times since it was enacted in 1979. In 1997, Japan ratified the Kyoto Protocol with the aim of preventing global warming, and revised the act in a manner that enforces the regulations further, and has been promoting the introduction of renewable energy as a policy.

In addition, while economic society is developing globally, Japan expanded its electricity liberalization in stages from 1995 in order to meet a request for market liberalization. Meanwhile, Japan is actively corresponding to international standards in order to secure international competitiveness in the domestic industrial fields and expand markets.

Furthermore, consumption of petroleum and LNG is growing and their prices are increasing rapidly due to unstable social conditions in oil-producing countries in the Middle East and business expansion in emerging countries in Southeast Asia that has been seen since around 2000.

Fuji Electric has been providing various products and solutions related to energy-saving to customers since the first oil shock in 1973. In addition, Fuji Electric has been developing advanced EMS products by anticipating the surrounding environmental changes and development of information processing technologies. Figure 2 shows the development road map of Fuji Electric EMS as well as main technology and components. The next section explains the development background of main ele-

***6: CEMS**
Abbreviation of cluster energy management system. This is a system to optimize regional energy supply and demand. It is possible to perform direct or indirect control of load on the customers' side by sharing information with smart meters and energy saving systems of the customer.

***7: Smart community**
This stands for low-carbon, stable and economical social infrastructure by harmonizing with the natural environment. This infrastructure aims at having sustainable growth of the overall community in ways such as efficient use of energy, cyclic use of energy and environmental conservation.

***8: REMS**
Abbreviation of retail energy management system. This is a system to visualize energy supply and demand in the field of retail distribution and optimally operate facilities. It is necessary to implement energy saving in retail stores after securing safety and sanitation management of foods and amenities of users as the top priority.

***9: FEMS**
Abbreviation of factory energy management system. This is a system to perform advanced factory operation focusing on cost reduction of the product life cycle by linking with product management and supply chain management. It is possible to correspond to the regulations of energy-management-designated factories based on the revision of the Energy Saving Act in 1998.

***10: Cloud**
Abbreviation of cloud computing. This is a technology to store data on dispersed servers and computers via a network and use the software resources within them.

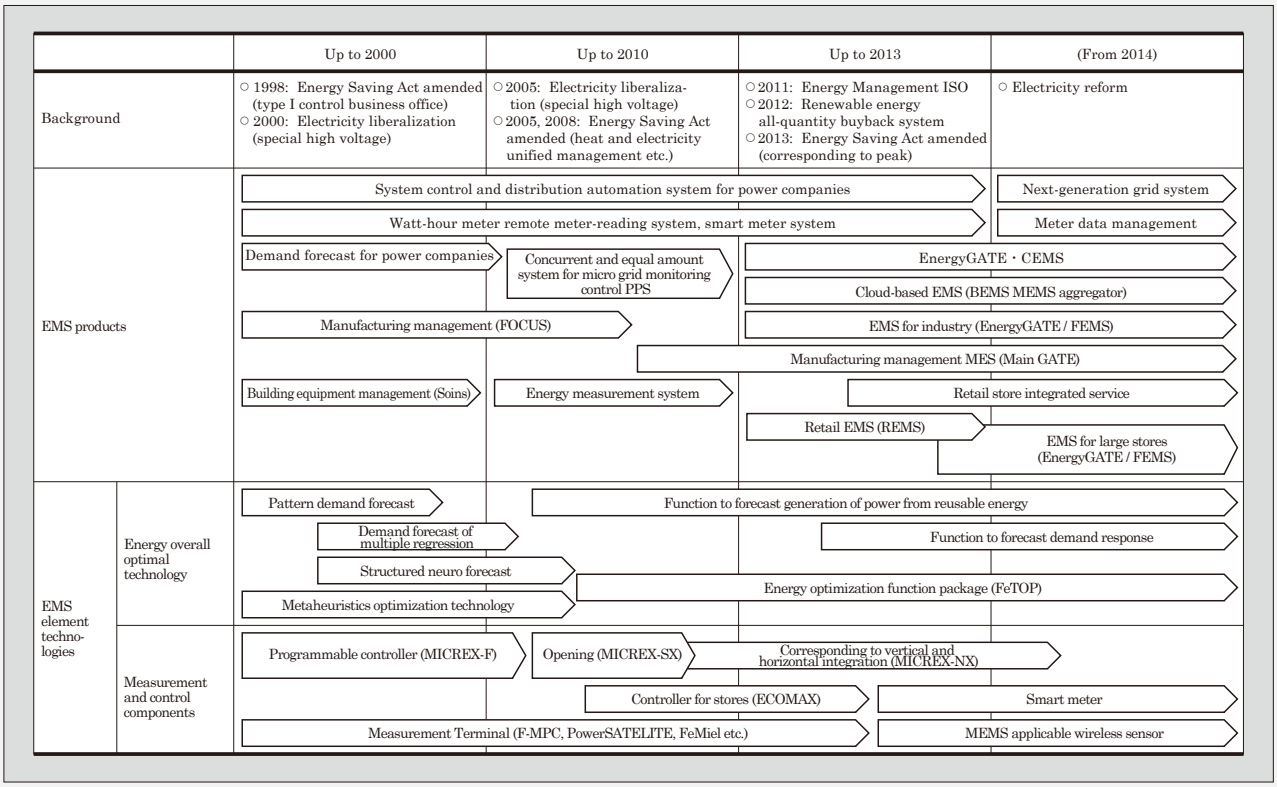

Fig.2 Development road map for EMS and main technologies and components

ment technologies that constitute EMS and EMS products.

(1) Measurement and control components

A measurement and control components, which constitute EMS, is used to measure and control energy use status of load equipment at a site. In 1985, Fuji Electric launched the programmer controller "MICREX-F" and provided a manufacturing and facility management system to monitor and measure the state of building and plant equipment, advance facility operation such as auto control, and labor saving. Furthermore, Fuji Electric develops a higher performance series such as the open interface "MICREX-SX" and "MICREX-NX" enabling easy data sharing with each type of system within the customers' premises in order to correspond to user needs and progress in information processing technologies.

After the revision of the Energy Saving Act in 1995, continuous energy saving became compulsory for small and medium-sized establishments in addition to large establishments, and as a result, the needs for simplified energy measurement systems have expanded. Fuji Electric responded to this trend and released energy measurement system with low-cost measurement terminals such as "F-MPC" and "PowerSATELITE."

Furthermore, in order to simplify the installation of measurement terminals on site, Fuji Electric developed a self-power supply system measurement sensor that applies wireless tags and smart meters that allow obtaining meter-reading information within a building.

(2) Energy overall optimal technology

Through several amendments of the Energy Saving Act, the main individual energy-saving policies have been already implemented. Thus operational improvement of overall energy equipment and manufacturing plans are needed to achieve further energy-saving. In addition, operation of utility customers' energy equipment is becoming more complicated owing to the increase of choices available to procure energy as a result of electricity liberalization and promotion of use of unstable renewable energy.

Fuji Electric released the optimization package "FeTOP" in 2003 to draw up overall optimal operation planning of complicated energy equipment. FeTOP is used to automate planning by using advanced information processing technology such as structured neural network and metaheuristics optimization technique. It is possible to minimize energy equipment cost such as electricity, heat and power, and environmental impact. It is possible to apply this package to a wide range of optimization processes including not only overall optimization of energy, but also water system control and power generation amount forecasts for renewable energy.

(3) EMS products

To achieve clean, stable, low-cost energy supply and demand, sharing information between energy suppliers and utility customers and achieving ener-

gy distribution control in a coordinated manner become a big challenge. In order to do so, promoting the introduction of EMS to utility customers and introducing CEMS to link these to energy providers and each type of energy service provider bidirectionally becomes a mandatory requirement.

Fuji Electric integrated energy measurement and control technology, energy optimization technology, information processing technology and the like, which have been provided to individual customers, and released the energy management system package "EnergyGATE" in 2011.

Figure 3 shows the software configuration of EnergyGate.

This package is targeted at both energy providers and utility customers. The characteristic of this package is its configuration where each piece of software for energy providers and utility customers are implemented on a common integrated EMS platform and provided.

The integrated EMS platform is provided with high-speed program cooperation service "Fuji Service Bus," which links EMS service software distributed in each server, and high-speed data sharing service "Field Connector," which controls data reference from each piece of software and control commands. With these functions, it is possible for EMS that is installed by energy providers and utility customers to achieve seamless and high-speed service software linking and data sharing[(2)] (refer to "A Framework for Optimal Planning Systems on the EMS Platform" on page 186).

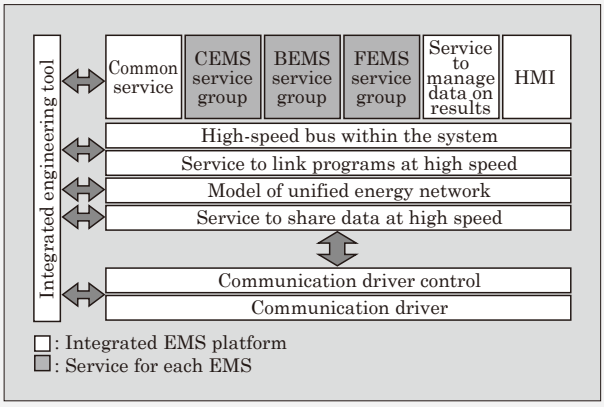

Fig.3 Software configuration of "EnergyGATE"

3. EMS Structure for Each Field

3.1 Regional energy management system

Since 2010, Fuji Electric has been promoting demonstration and evaluation of CEMS to perform regional supply and demand control in "Kitakyushu Smart Community Creation Project,"[*11] which was selected as one of the four regions of the "Next Generation Energy and Social Systems Demonstration Project" by the Ministry of Economy, Trade and Industry. This CEMS is equipped with advanced regional energy management functions such as a renewable energy power generation forecast that is linked with meteorological data, and an optimal supply and demand planning function to utilize regional renewable energy effectively in a concerned region (refer to "Supply and Demand Control System for Power Systems with Distributed Power Supplies" on page 191, and "Photovoltaic Power Generation Forecasting Technology for Supporting Energy Management Systems" on page 196).

In addition, Fuji Electric is conducting a real-scale demonstration of dynamic pricing[*12] to create utility customers' peak shift reaction by sharing information bidirectionally with smart meters, which are installed for all utility customers within the demonstration region, and utility customer EMS, a product that each participating company is demonstrating.

During the demonstration period until the end of FY2014, Fuji Electric is planning to evaluate each type of pioneering technology and social system in aspects such as their ability to maintain power quality of a grid when renewable energy is introduced in large quantity, use of hydrogen by utilizing characteristics of the region adjacent to the factory, and heat management, in addition to the above-mentioned Dynamic Pricing.

Along with the demonstration project, Fuji Electric is proceeding with a review of business models toward continuation of CEMS business after it has completed demonstrations and domestic and overseas deployment of demonstration results. A large amount of information on energy usage situations of utility customers is gathered in CEMS. As for reviewing the commercialization, it is positioned

***11: Kitakyushu Smart Community Creation Project**

This project is selected as one of the projects in "Next Generation Energy and Social Systems Demonstration Project" promoted by the Ministry of Economy, Trade and Industry from 2010. This project is being carried out at the Higashida district of Yahata-higashi ward in the city of Kitakyushu, Japan (120 ha) until 2014. One of the characteristics is that the Higashida district is conducting demonstration of real-scale dynamic pricing in the power supply region with a private line by Higashida Cogeneration Corporation in corporation with the Power Supply and Demand Union in the same district.

***12: Dynamic Pricing**

This is a system to change power rates per time period according to the change in supply and demand state. This system promotes power saving of utility customers by increasing the power rate during the time period when supply and demand are expected to be high.

in terms of the Data Aggregator business and securing profitability is evaluated. At this point, Fuji Electric is considering adding a CEMS operator to its regional energy management service business to optimize regional energy supply and demand and utilize large amounts of utility customers' information to expand each type of service menu with approval from utility customers.

Figure 4 shows an overview of service cooperation of CEMS as a data aggregator. It is possible to develop the utility customer energy usage information gathered by CEMS in services other than energy such as watching elderly people, transportation, and attracting customers to commercial buildings in addition to EMS services such as visualization of energy and energy saving (refer to "Social System Demonstration of Dynamic Pricing in the Kitakyushu Smart Community Creation Project" on page 152).

3.2 FEMS

Fuji Electric has been providing manufacturing management packages centering on the "MainGATE Series" to various types of industry and has been accumulating know-how related to the operation of various types of manufacturing equipment such as batch, line and continuous processes. The characteristics of FEMS for industrial fields are that it utilizes that know-how and realizes optimal operation of factory utility equipment that is linked to the manufacturing plan of the factory.

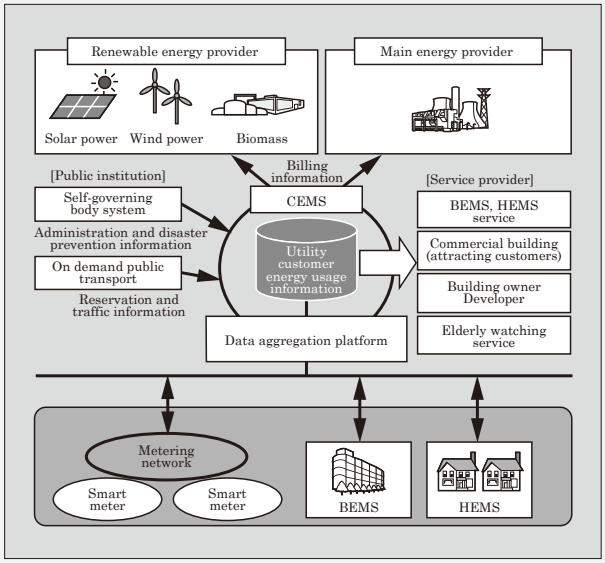

Fig.4 Conceptual image of service cooperation of CEMS as a data aggregator.

A large-scale iron foundry possesses an energy center and supplies energy such as gas, heat, and electricity related to iron manufacturing. Fuji Electric used the latest metaheuristics optimization technology by interlocking energy supply with the iron manufacturing process and developed an iron and steel EMS to draw up the optimal operation plan (refer to "'Steel EMS Package' Optimizing Energy Management at Steelworks" on page 165).

In addition, in the paper manufacturing industry, in which a large amount of heat consumption is the main constituent of the energy used, an increasing number of customers are implementing cogeneration[*13] when replacing deteriorated equipment after the Great East Japan earthquake, with the aim of securing power supply in the event of a disaster. Fuji Electric developed a heat management system to allow optimum operation of cogeneration systems and boilers to correspond to heat demand (refer to "Energy Optimization System for Cogeneration Plant of Paper Factory" on page 160).

3.3 Cloud-based EMS for buildings and apartments

High-voltage, small-scale users (contracted power of 50 kW or more but below 500 kW) consume a small amount of energy and it is difficult to recover the cost for introducing EMS equipment individually. By providing an EMS service such as visualization and energy saving in a cloud environment to small-volume utility customers, it is possible to control the cost for capital investment in EMS.

Figure 5 shows an overview of cloud-based EMS. Fuji Electric installs an energy-related information display terminal on the small-scale user side and provides an EMS service such as visualization of energy and energy-saving via communication network from an external EMS aggregator. Improvement of equipment operation by visualizing energy on the utility customer side is expected to bring an energy saving effect of about 10%.

In addition, the relevant energy information is aggregated and distributed regularly to the owner of the target facility and self-governing body that manages elementary and junior high schools.

Fuji Electric initiated the BEMS aggregator business for elementary and junior high schools

***13: Cogeneration**

This is a system where power generation equipment is installed on the utility customer side such as in the factory and building and utilizes the generated heat. By using LNG as fuel, a reduction in CO_2 of about 30% is expected compared to commercial power. Although introduction reached its peak due to a sudden increase in fuel price, enterprises are paying attention to it again as an autonomous power supply at the time of a large-scale disaster, and because of an incentive provided to peak-cut cooperation at the time when the power supply and demand situation gets tight.

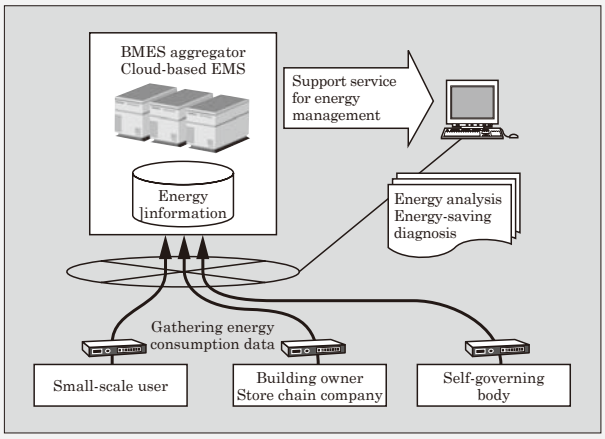

Fig.5 Overview of cloud-based EMS

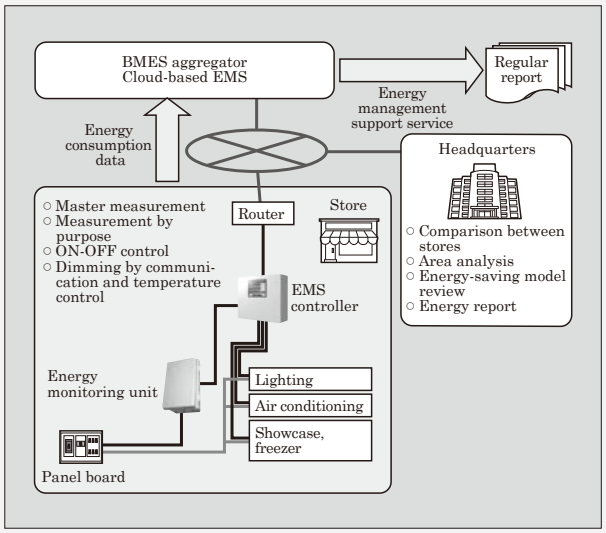

Fig.6 Example of REMS

and commercial buildings in 2012, and the mansion EMS (MEMS) aggregator[*14] business for high-voltage batch power receiving apartments in 2013 (refer to "Energy Management Support Service with Cloud-Based EMS" on page 176).

3.4 REMS

Energy-saving of distribution stores such as convenience stores and supermarkets is required to be compatible with unique factors such as maintaining amenity of in-store environment including air-conditioning and lighting as well as temperature control of refrigerated and freezer showcases for food.

Fuji Electric offers the line-up of store construction method "Ecolo Unit" considering the environment and cold chain devices such as refrigerated and freezer showcases. In addition, Fuji Electric has developed "ECOMAX Controller," which monitors energy in a store and automatically controls lighting and the temperature of display cases and air conditioning to support energy saving of the whole store.

Furthermore, Fuji Electric has built REMS which collects energy consumption data gathered from each store with cloud-based EMS by using BEMS aggregator, sends energy-saving guidance to each store, and sends energy management support information to a chain store headquarters. Figure 6 shows an example structure of REMS.

In addition, Fuji Electric developed and is conducting demonstrations and evaluations of EMS to perform dynamic pricing in the facility for large-scale shopping centers comprised of multiple tenants (refer to "The 'ECOMAX Controller' Realizes an EMS for Use in Stores" on page 181 and "EMS for Large-Scale Commercial Facility" on page 170).

4. Postscript

This paper describes CEMS for performing regional energy management, utility customer EMS, as well as technologies that constitute EMS.

EMS package of Fuji Electric, "Energy GATE" is considered to be providing an important solution for making the energy supply side and utility customers smart. Fuji Electric will continue making efforts to provide advanced energy services corresponding to new energy systems and the trend of standardization in anticipation of an expansion overseas.

Reference

(1) "Strategic Market Creation Plan". Prime Minister of Japan and His Cabinet. http://www.kantei.go.jp/jp/singi/keizaisaisei/pdf/rm_en.pdf, (accessed Jul. 16, 2013).
(2) Horiguchi, H. et al. Integrated Energy Management System Platform. FUJI ELECTRIC REVIEW. 2011, vol.57, no.4, p.146-151.

***14: Aggregator**

This is a system to provide each type of energy service such as visualization and energy procurement at low cost by arranging medium- to small-volume utility customers under the environment of electricity liberalization. It can solve the issue of medium- to small-volume utility customers having weak price negotiation power and thus is difficult to find merits to reduce individual energy cost.

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