Fuji Electric's Efforts Involving Next-generation Energy and Social Systems

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ABSTRACT

In order to realize the "Fuji Smart Network System" as a next-generation energy and social system, Fuji Electric aims to realize power stability, energy savings and reduced carbon emissions in a targeted area by employing geographical distribution, and to construct a system that does not affect power transmission systems. The system aims to resolve energy-related problems within each region by addressing, through region-wide initiatives, increased voltage resulting from the adoption of large amounts of solar power, energy conservation by direct and indirect load control using smart meters, and the interchange of heat and gas or other energy sources. Fuji Electric is participating in planning for Kitakyushu City and Keihanna Science City in Japan, and having been commissioned by NEDO, is conducting a basic survey for overseas.

1. Introduction

To achieve a low carbon society, the adoption of renewable energy, electric vehicles (EV), energy saving homes, zero-emission buildings, and the introduction of high efficiency equipment in factories have been studied extensively. Recently, in addition to the introduction of stand-alone energy-saving and energy-creating equipment, efforts aiming to utilize bidirectional communication, such as with a smart meter, in order to utilize energy effectively throughout a region have been attracting attention.

In Japan, region-wide optimal energy management that includes electric utilities, companies that generate renewable energy, and consumers, the effective utilization of not just electrical energy, but also heat, gas and the water environment, as well as demonstration projects for creating eco-friendly urban spaces and transforming consumer lifestyles are being promoted. Overseas, infrastructure improving projects for electric power, heat, gas, the water environment, transportation and the like are actively being carried out for cities and industrial parks.

Fuji Electric is participating in projects to construct a next-generation energy and social system in Japan in order to create a smart community that is an eco-friendly city, and is also actively conducting a survey of overseas smart communities.

2. Next-Generation Energy and Social Systems

Below, definitions of a smart grid and smart community are presented, and national initiatives and demonstration projects for next generation and energy and social systems, as well as Fuji Electric's participation in demonstration projects are described.

2.1 Definitions

(1) Smart grid

To resolve the power quality-related issues that accompany the large-scale introduction of renewable energy, a smart grid provides an information network for controlling power and performs real-time adjustments of the supply and demand of energy, and the following benefits can be obtained as a result.

(a) Stable utilization of power is ensured and the risk of a large-scale power outage is reduced

(b) Energy savings and efficient energy utilization are promoted integrally with customers

(c) Optimization of electric power facility maintenance and management

(2) Smart communities

A smart community is a new type of "city planning" that aims to achieve a low carbon footprint as well as increased convenience for its residents and to foster urban renewal. Smart communities are next-generation type local communities and are built using the latest technologies, such as smart grids. Smart communities are formed by creating living spaces that achieve both improved comfort and energy savings through the effective utilization of energy, the introduction of renewable energy, and the renovation of transportation systems, and the information networks that link these smart communities also play an important role.

2.2 Fuji Electric's vision of next-generation energy and social systems

Fuji Electric aims to build a geographically-distributed type next-generation energy and social system that achieves power stabilization, energy savings and a smaller carbon footprint for a target region, and that

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does not negatively affect the power distribution system.

The next-generation energy and social system aims to resolve energy-related problems within each region by addressing, through region-wide initiatives, the increase in voltage resulting from the adoption of large amounts of solar power, and to realize energy conservation by direct and indirect load control using smart meters, and the interchange of heat and gas or other energy sources.

Figure 1 illustrates Fuji Electric's concept of a geographically-distributed type next-generation energy and social system. This concept is fundamental to the "Fuji Electric Smart Network System," to be described later, and is applied to smart grids and smart communities.

2.3 National initiatives and demonstration projects

Japanese national initiatives include the mass adoption of renewable energy centered mainly on solar power (targeting 28 GW of solar power generation and 4.9 GW of wind power generation by 2020), direct and indirect load control through bi-directional communication using smart meters (targeting installation in all homes by 2020), the application of storage cell technology as represented by electric vehicles, and the support of the overseas exporting of infrastructure based on the new technologies acquired here. In June 2006, for the purpose of demonstrating these technologies, a "Regional Energy Management Development and Complex Storage System Technology Development Project" was made public, and demonstration projects of the next-generation energy and social system were decided to be carried out for 5 years beginning in 2010 in Kitakyushu City, Keihanna Science City, Yokohama City and Toyota City.

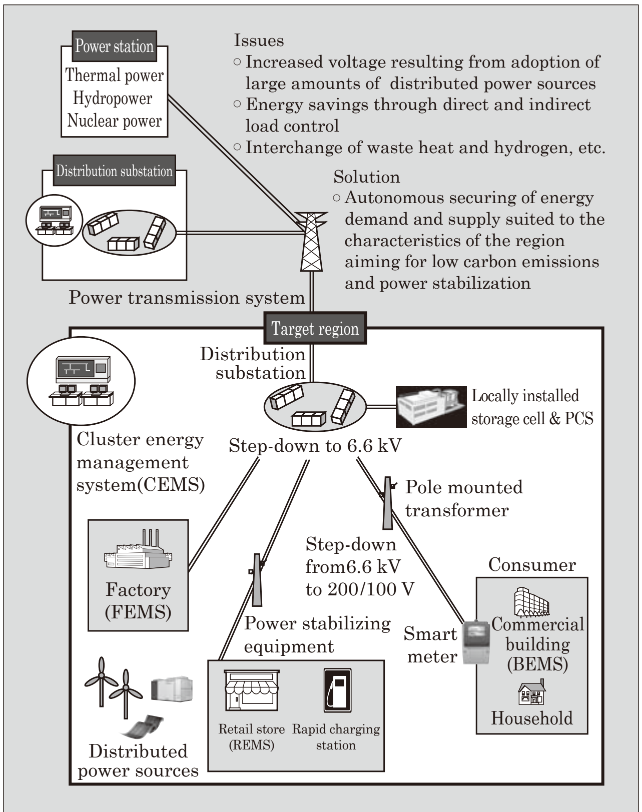

Fig.1 Fuji Electric's regionally distributed next-generation energy and social system

2.4 Fuji Electric's participation in demonstration projects

Sharing a vision of the future with national and local governments, Fuji Electric is participating in demonstration projects and offering various proposals to promote development both in domestic and global scale.

Fuji Electric has participated in the following recent demonstration projects.

(1) Smart grid-related demonstration projects
  (a) Kyushu and Okinawa isolated island micro-grid demonstration system (2009)
  (b) Next-generation optimizing control technique experimental project for energy transmission and distribution systems (2010)
      Voltage control of centralized-type next-generation power distribution automation system
  (c) Fuel cell system for commercial buildings in a US-Japan smart grid demonstration project in New Mexico (2010)
  (d) Demonstration of effect of introducing load balancing equipment (2011)
  Indirect and direct load control using smart meters
(2) Smart Community-related demonstration projects
  (a) Next-generation energy and social system demonstration (2010)
    (i) Kitakyushu city
      ○ Regional energy management system development project
      ○ Complex storage cell system technology development project
    (ii) Keihanna Science City
      ○ Complex storage cell system technology development project
  (b) Study of feasibility of introducing smart community technologies to an industrial park in Java, Indonesia (2010)

3. Fuji Electric's Efforts

The targeted scale, power quality, energy management and local production for local consumption are four essential perspectives for next-generation energy and social systems. Based on these perspectives, Fuji Electric's technologies that contribute to lower carbon emissions and improved power stabilization are described, and demonstration projects, both in Japan and overseas, that apply these technologies are introduced below.

3.1 Four perspectives and the corresponding technologies

Fuji Electric has been involved in developing and delivering next-generation energy technologies and social systems for many years. These technologies have included, for example, distribution automation systems, power system control systems, energy management systems (EMS), distributed power sources, balancing control, power quality stabilization, power instruments, power distribution equipment, and inverters, converters and the power conditioners (PCS) to which they are applied.

In recently requested social infrastructure-related projects in Japan and overseas, in addition to higher efficiency and optimization through managing, monitoring and controlling the entire energy supply chain, from supply to delivery to the consumer, the information networks that provide support have also become essential elements.

Fuji Electric is approaching the next-generation energy and social systems from the following four perspectives.

(a) Targeted area

Various sizes exists, but compact cities, industrial complexes, industrial parks, islands, and non-electrified areas are targeted.

(b) Power quality

So as not to adversely affect the power transmission system, fluctuations in voltage and frequency caused by distributed power sources that have been installed in a targeted region are to be absorbed within the targeted region to stabilize power.

(c) Energy management

Through the efficient utilization of electric power and heat by consumers, i.e., households, charging stations, stores, commercial buildings and factories, and the utilization of information networks to acquire information in real-time, energy management aims to cross-utilize energy within a region.

(d) Local production for local consumption

Energy control of a target region is implemented in collaboration with the power transmission system, regional cogeneration system, distributed power source system and the like, and aims to achieve local production for local consumption.

Based on these four perspectives, Fuji Electric's technology to be utilized in the next-generation energy and social system is classified as carbon emissions-lowering or power stabilizing as shown below.

(1) Carbon emissions-lowering technologies

(a) Cluster energy management systems (CEMS) that manage entire energy in the targeted region

(b) Retail, building and factory energy management systems (REMS, BEMS, and FEMS) that target the consumer

(c) Smart meters and wireless multi-stage relay technology provided with customer power usage prehension, stop and release, guidance display and response input functions

(d) Technology relating to distributed power sources such as lightweight flexible film-type solar cells, commercial 100 kW phosphoric acid fuel cells, micro tubular turbines for low-head hydropower generation, and binary geothermal power generation that efficiently converts low-temperature

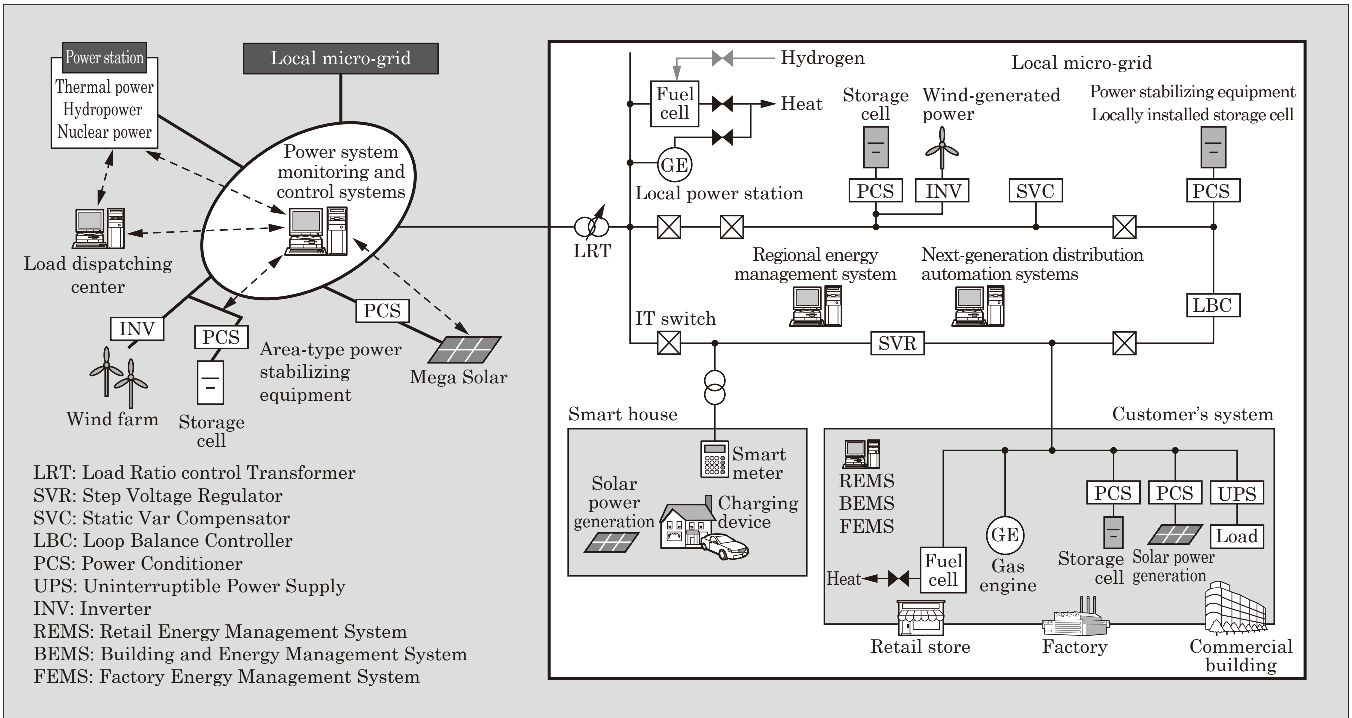

Fig.2 Overall view of the "Fuji Smart Network System"

thermal energy into electrical energy

(2) Power stabilizing technologies

(a) Next-generation power distribution system technology provided with functions for fault point detection and recovery, power flow monitoring, and voltage and frequency adjustments.

(b) Technology relating to high-efficiency power conditioners (PCS) and power stabilization equipment to control the discharging and charging of locally installed storage cells as equipment for implementing power control within a grid

(c) Technology relating to load ratio control transformers (LRTs), IT switches, static var compensators (SVCs), step voltage regulators (SVRs) and uninterruptible power supplies (UPSs) which, as distribution equipment, aim to stabilize the on-grid power quality

(d) Micro-grid technology and balancing control technology for performing high-speed optimized control of energy supply and demand in a closed grid as in the case of isolated islands

The linking of these technologies is shown in the overall view of the Fuji Smart Network System in Fig. 2.

Fuji Electric has developed essential products and technologies for realizing the Fuji Smart Network System, and is conducting field demonstrations in Japan and overseas. The results of these projects are incorporated into a compact "Social Infrastructure Package Focused on Electric Power," and application is being promoted to: (1) environment friendly cities and smart communities, (2) industrial complexes where high levels of energy integration exist, and (3) isolated islands and non-electrified areas where there are low levels of energy integration.

3.2 Demonstration projects in Japan

(1) Next-generation energy and social system demonstration projects

(a) Regional energy management

Fuji Electric is participating in the development of a "regional energy management system focused on regional energy-saving stations" in Kitakyushu-city, and is promoting urban development that aims to achieve lower carbon emissions in the Higashida district of Kitakyushu-city.

This district is an advanced model district for energy supply and demand, and aims to become a local community in which energy saving behavior is incorporated into daily life and business activities.

The relevant technologies for reducing the carbon footprint and controlling all the energy utilized

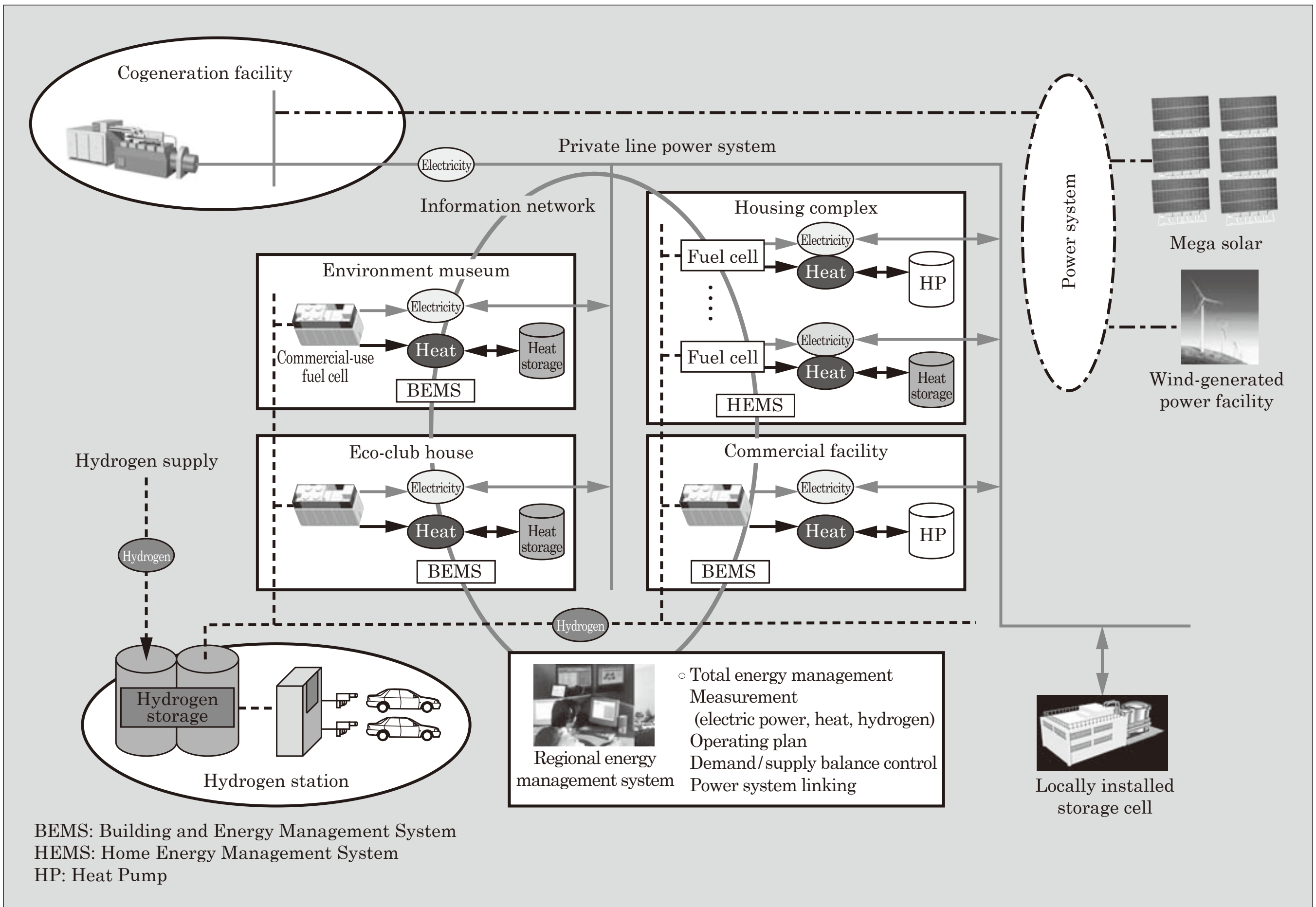

Fig.3 Overall view of Kitakyushu City next-generation energy and social system

in the district include linking technology for renewable energy and cogeneration systems, technologies for supplying power to electric vehicles and for utilizing power from discharging electric vehicles, power stabilizing technology that utilizes locally installed storage cells, technology for visualizing the energy consumption of each consumer, and demand suppression measures based on dynamic pricing and an eco-point system. In the demonstration project, as shown in Fig. 3, energy suppliers and consumers in the targeted region are connected to an information network, and a regional energy management system measures the supply and demand of electric power, heat and hydrogen, creates an operating plan, controls demand and supply, and incorporates the power systems. The results of this demonstration project, in terms of comprehensive energy management, are expected to be used as a model case of an environment-friendly compact city that will be deployed overseas in the future.

The regional energy management system being developed to reduce carbon emissions in this demonstration project has the following three characteristics.

(i) The system acquires, through a dedicated line or general acquisition procedure, and centrally manages comprehensive energy data required for regional energy management according to the need (high-speed response, frequency, etc.) for that data.

(ii) Multiple independent systems can be installed, according to requirements of the targeted region, in order to implement control requiring real-time performance such as for power generation, charge and discharge commands, ascertainment of energy utilization for each consumer, and business processes such as energy demand and supply planning

(iii) Acquired information is provided to an external service provider so that new services can be created.

Table 1 lists the main functions and Fig. 4 shows the system configuration of a regional energy management system.

(b) Demand-side energy management

In support of the next-generation energy and social system for consumers, Fuji Electric is participating in the “development of an energy controller for a facility grid” in Keihanna Science City, and is advancing demonstration projects for technologies that lower carbon emissions of complex buildings, including rental offices, halls, hotels and restaurants.

This demonstration project has the following two objectives.

(i) By installing storage cells, solar cells, fuel cells and smart meters within a complex building, which is considered to be a single closed grid, and utilizing the storage cells, fuel cell and heat pumps efficiently, the project aims to achieve the effect utilization of the renewable energy and heat within the building.

(ii) By promoting energy savings and reduced carbon emissions through indirect load control, and enhancing the environmental awareness of tenants and other building users, the project aims to contribute to the goal of achieving zero emissions for the entire complex building.

Fuji Electric is also moving forward with verification of the control method for achieving the specified target value of demand through linking information with the regional energy management system for Keihanna Science City.

Demand-side energy management is realized by installing a compact building-use energy controller in a complex building. This controller directly controls energy devices such as storage cells and fuel cells in a complex building, and through a smart meter, also

Table 1 Functions of a regional energy management system

	Regional energy management system
Functions	Comprehensive energy management for an entire region, combining energy demand forecasting and weather forecasting, power system control at the time of adoption of new energy, storage cells and EVs
	Stabilization through coordinated operation with the power system
	Real-time ascertainment of energy usage status for each customer
	Demand-side management through customer load control and dynamic pricing
	Standard procedure for connecting to customers and energy equipment
	Creation of new services by utilizing energy consumption and CO_2 visualization data

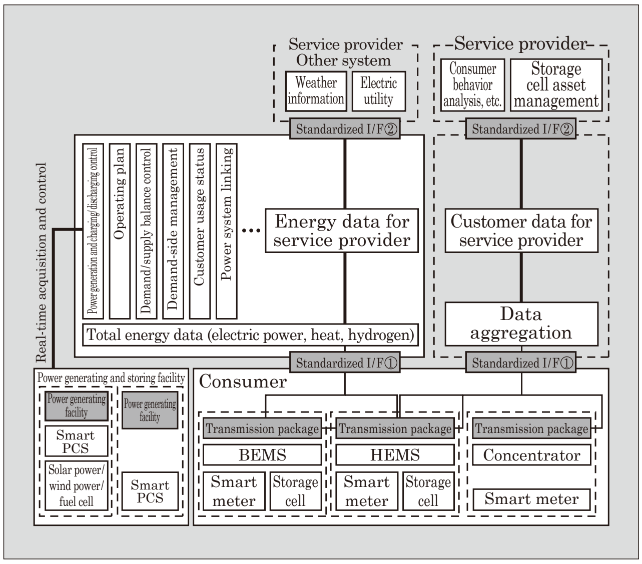

Fig.4 Configuration of a regional energy management system

performs indirect load control for the tenant. Through linking to building management systems centered on conventional monitoring or visualization, the energy usage within a building can be made even more efficient. Table 2 lists the main functions of building-use energy controllers, and Fig. 5 shows a system configuration.

(2) Demonstration project of optimal control technology for next-generation power transmission and distribution systems

One technical challenge for smart grids is how to prevent a voltage increase when many distributed power sources including solar cells are connected to the power distribution system. To overcome this challenge, Fuji Electric has for many years advanced the development of equality control for voltage suppression with solar power generation and the like. Next-generation distribution automation systems overcome this challenge by utilizing centralized control of power conditioners connected to voltage regulators and solar cells from the central monitoring and control systems.

In the power distribution sector, as preparation for the introduction of a large number of distributed power sources, next-generation distribution automation systems provided with a centralized control function for voltage regulators, and distributed generator-use power conditioners equipped with power stabilizing, reactive power adjustment and power storage functions will be utilized both in Japan and overseas. Fig. 6 shows a comprehensive view of optimal voltage control technology.

Table 2 Functions of an energy controller for buildings

	Energy controller for buildings
Functions	Load leveling with storage cells (peak cut, peak shift)
	Control and operation of storage cells (power) and heat pumps (heat)
	Indirect load control via smart meters at customer sites
	Charging control based on EV operating plans
	Utilization of waste heat from fuel cells
	Coordinated control with air conditioning
	Achievement of targeted demand with regional energy management

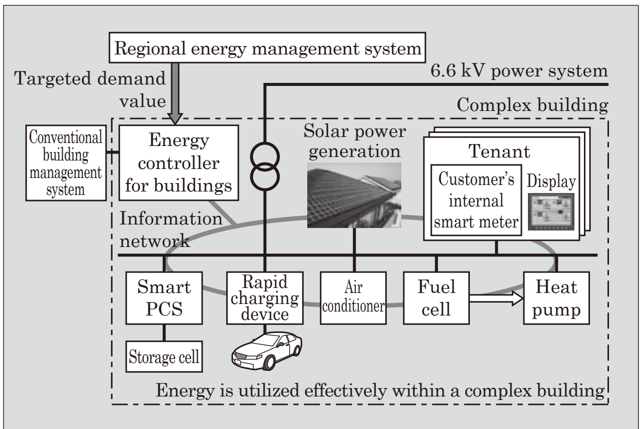

Fig.5 Configuration of demand-side energy management system for complex buildings

3.3 Demonstration projects overseas

Fuji Electric, Sumitomo Corporation, Mitsubishi Electric and Tokyo Electric Power Services Co., Ltd. have been commissioned by the New Energy and Industrial Technology Development Agency (NEDO) to conduct a basic survey of power infrastructure exports that utilize smart technology and that target Southeast Asian industrial parks where a high level of energy integration exists and where greater energy savings and lower carbon emissions are anticipated.

Industrial parks in Southeast Asia are experiencing an influx of Japanese companies and have the following characteristics.

(a) Power quality at a level equivalent to that of Japan is requested for stable manufacturing
(b) Compared to Japan, the energy management of plants has much room for improvement in terms of energy conservation and reduction of carbon emissions
(c) The amount of contracted electrical power corresponds to the amount of power managed by a single power distribution substation, and is similar in scale to that of the district targeted for energy management

In light of these three characteristics, among the smart grid technologies being developed for next-generation energy and social system demonstration projects, the technologies for lowering carbon emissions and improving power stability listed in Table 3 are thought to be applicable to Southeast Asian industrial parks.

Aiming to reduce carbon emissions and improve power stability of Southeast Asian industrial parks, Fuji Electric intends to apply these smart grid technologies to build an industrial park power supply infrastructure.

Fig. 7 shows a system model in which smart grid technology has been applied to an industrial park.

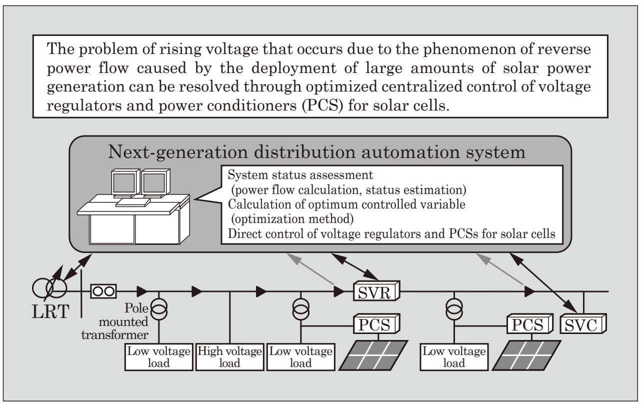

Fig.6 Overall view of optimal voltage control technology

Table 3 Smart grid technology suited for industrial parks

	Carbon reduction technology	Power stabilization technology
Factory	Factory energy management Peak-cut/demand control Direct/indirect load control Automatic measurement with smart meters Changeover to high-efficiency equipment Renewable energy equipment Inverter control, air conditioner control Information network within the factory	Uninterruptible power supply (UPS) Emergency in-house power generator Static var compensator (SVC) Step voltage regulator (SVR) Power capacitor
Industrial park	Regional energy management Peak-cut/demand control Direct/indirect load control Renewable energy equipment Information network within the industrial park	Emergency power supply system Power quality stabilizer Static var compensator (SVC) Step voltage regulator (SVR) Distribution automation system within the industrial park

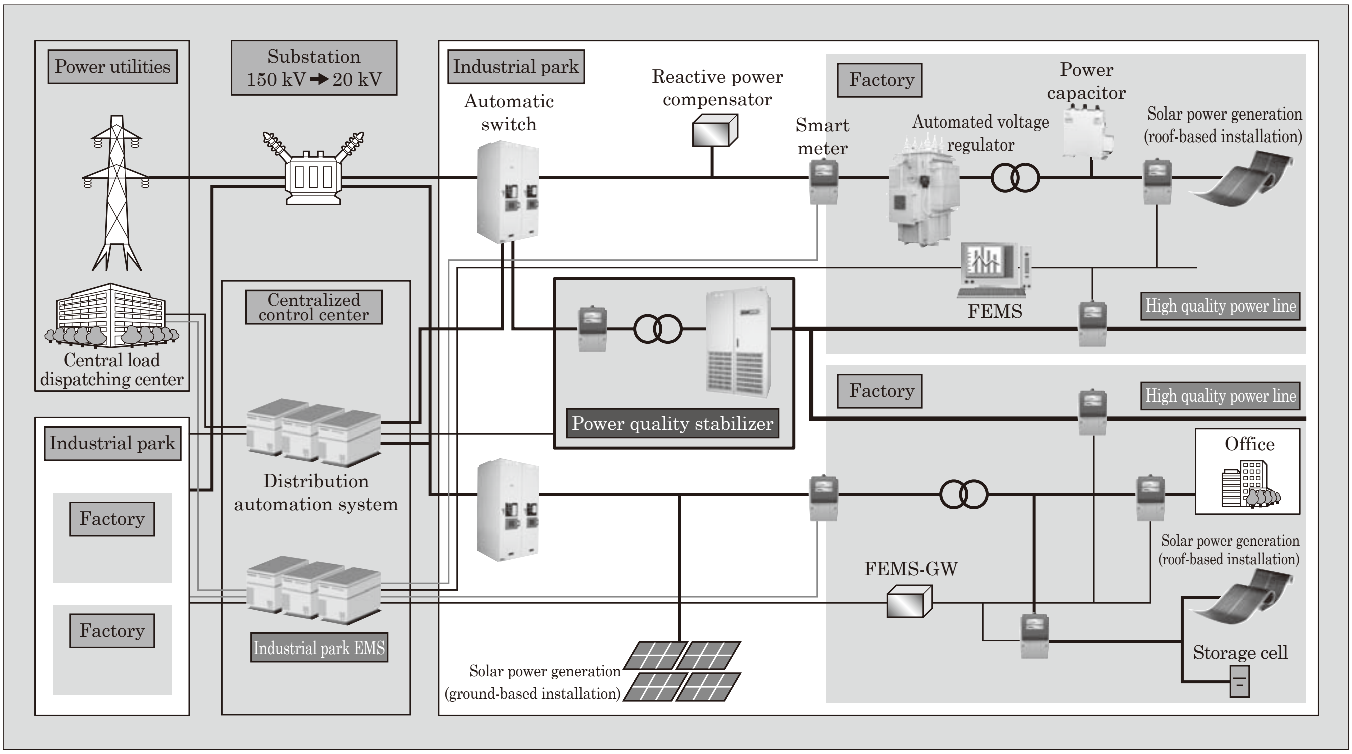

Fig.7 System model of smart industrial park

This model assumes that the district targeted for regional energy management is the entire industrial park, and with an energy management system, stabilizes power for the entire industrial park, saves energy and cuts peak power demand. The two main technologies utilizes are listed below.

(a) A “power quality stabilization device” installed at the industrial park supplies a high quality power source to multiple factories

(b) An “industrial park EMS” performs centralized control of factory demand restraint and energy management

4. Future Challenges

The ongoing demonstration projects described in section 3 are all component elements of the Fuji Smart Network System, and this system will be completed initially by leveraging the results of Japanese and overseas demonstration projects. The net result is the compilation of a next-generation energy and social system that aims for lower carbon emissions and improved power stabilization for consumers and targeted regions.

Fuji Electric will develop this system for consumers who are seeking energy savings and more effective utilization of electricity and heat energy, and also for designated energy districts and local governments possessing a vision of new energy utilization. For power companies, with the aim of improving stability and increasing the quality of power, Fuji Electric is promoting the introduction of next-generation distribution automation systems to meet year 2020 targets (solar power generation of 28 GW, wind power generation of 4.9 GW, and smart meters installed in all homes).

Overseas, Fuji Electric is aiming to develop this system as a “social infrastructure package focused on electrical power” that combines carbon-lowering technology and power stabilization for smart communities, industrial parks, islands, as well as the power distribution sector. The infrastructure for a smart community is required to consist of not only an energy infrastructure, but also a water environment infrastructure, an infrastructure for electric vehicles including the capability to control the status of charging device and the like, and an information infrastructure. Fuji Electric will proceed to construct this system by linking it to water treatment systems and retail store systems that have been developed over many years.

Moreover, because the business areas targeted by next-generation energy and social systems are new service areas, the profitability of companies that have a next-generation energy and social system and companies that operate and maintain systems are important, and Fuji Electric intends to participate from the business feasibility study and basic planning stages.

5. Postscript

In the future, it is expected that solar cells and smart meters will be used in many homes, distributed power sources and high efficiency devices that aim to reduce carbon emissions will be encouraged and electric vehicles will become widespread. Fuji Electric possesses many technologies relevant to the smart grids that will be utilized in Japanese society in the near future. In response to social requests concerning smart grids and smart communities, Fuji Electric will expedite the commercialization of the results of technical development and demonstration projects of the next-generation energy and social systems, and intends to contribute to the establishment of a social infrastructure for developing environment friendly cities and regions, adopting large amounts of renewable energy, and popularizing electric vehicles.