Sumitomo Electric's Activities for New Power System Business

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Amid the global changes in the fields of environment and energy, Sumitomo Electric Industries, Ltd. has started new business for energy systems and services. This paper explains the paradigm shifts that the energy field has been going through, and introduces the Company's efforts in response to the shifts, including its organizational changes as well as the development of new products and technology such as vanadium redox flow batteries and concentrative photovoltaics.

Keywords: redox flow battery, CPV, POWER DEPO, *s*EMSA, PLC

1. The Global Energy Situation

1-1 Macroenvironment

Total energy consumption (primary energy) has continued to increase globally together with economic growth and development. From a total of 3.8 billion toe (tonne of oil equivalent) in 1965, it has increased by an average of 2.6% per year and reached 12.3 billion toe in 2011. Regarding regional differences, the growth is most remarkable in developing countries (outside the Organization for Economic Cooperation and Development: OECD) and the proportion of the energy consumption by developed countries (OECD countries) has fallen by around 25% from 70% in 1965 to 45% in 2010 (Fig. 1).

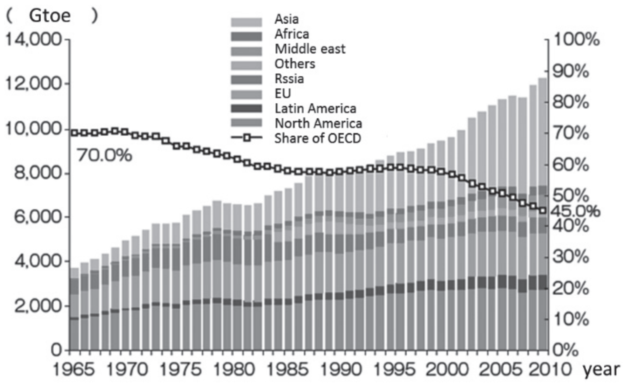

Fig. 1. Trends in energy consumption globally

On the other hand, in terms of the environment, global warming has been going on due to the increasing emissions of greenhouse gases resulting from energy consumption. There has also been a worsening of the air pollution problem in developing countries due largely to the increasing use of fossil fuels.

For global warming, the United Nations Framework Convention on Climate Change was adopted in 1992 and the Conference of the Parties (COP) has been held every year since 1995. At the 3rd meeting (COP3), which was held in Kyoto in 1997, agreement was reached on the Kyoto Protocol to set clear targets for the reduction of emissions with binding power on the developed countries. This was the first major step taken towards the reduction of greenhouse gas emissions by the world as a whole. The Paris Agreement was adopted at the 21st meeting (COP21) held in Paris in 2015 as a new international framework for 2020 onwards. This agreement has led to movements such as the setting of a temperature increase within 2°C and agreements related to funding between developed and developing nations.

With regards to air pollution, problems caused by particulate matters 2.5 micrometers or less (PM2.5) are becoming serious in countries with high energy consumption such as China and India, and there have also been concerns about the effects on neighboring countries including Japan. One of the main causes of air pollution is the large-scale consumption of fossil fuels by inefficient equipment, and implementation of countermeasures is an urgent issue.

Efforts have been made globally to find a solution that can meet the increasing demand for energy in connection with economic growth while tackling global warming and air pollution, which are conflicting issues. These efforts include measures on the supply side, such as the promotion of renewable energy integration and the improvement of power generation efficiency, and also measures on the demand side to reduce energy consumption by enhancing the efficiency of electric equipment.

1-2 Paradigm shifts in the power sector

Since the 1970s, various measures have been promoted mainly in developed countries with the objective of achieving the efficient operation of electric power infrastructure and systems. These measures include the opening of infrastructure and systems to private sectors as well as system reform through the introduction of market competition. In Japan too, the phased system reform started with the liberalization of the wholesale electricity market in 1995 and reached to the full liberalization of the retail power sector in 2016. As a result, the price of electric power has started to change due to the introduction of competition and market trading.

On the other hand, after the Great East Japan Earthquake, in addition to the international measures for environmental problems, efforts have been made for the introduction of renewable energy resources, reduction of energy consumption, and increasing use of distributed power sources to achieve a stable supply and efficient use of energy (Fig. 2). To promote these changes, feed-in-tariff (FIT) for renewable energy integration and other subsidies were introduced, which has diversified the parameters for the electricity price.

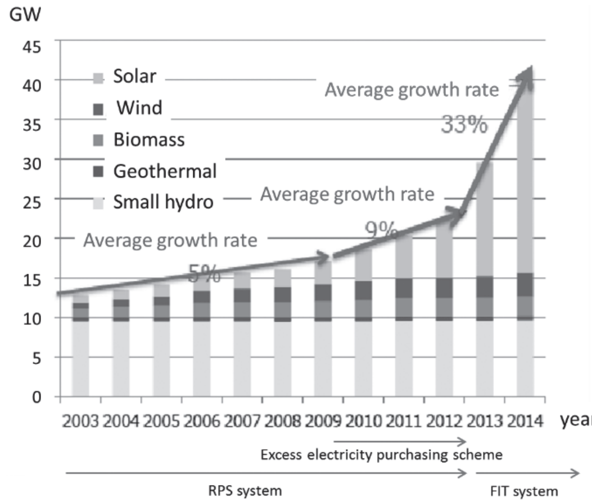

Fig. 2. Trend in equipment capacity for renewable energy, etc., in Japan

Furthermore, the development of information and communication technologies, such as the IoT and Big Data, and their fusion with power systems has led to the concept of Negawatt power,*[1] in which surplus energy obtained by reducing energy consumption is handled as an energy resource. It has also led to the concept of virtual power plants (VPP), in which resources such as multiple distributed power sources and Negawatts are grouped together and handled as if they were a single power source. These concepts have further complicated the price setting of electric power.

Also, as solar and wind power generation is intermittent depending on weather conditions, there is a risk that the amount of power generation may fluctuate, leading to instability in the electric power system. In recent years, the proportion of renewable power generation has increased and the impact caused by its intermittent behavior can no longer be ignored. Even in Japan, there have been some cases where the connection to electric power systems was suspended. The necessary techniques have been considered on system and technology sides to further promote renewable energy integration. These include the reinforcement of the electric power system and the expansion of its operation area, as well as the stabilization of the system through the introduction of new power storage technologies such as storage batteries.

2. Measures for New Power System Business

2-1 The promotion of new power system business

To respond to this paradigm shift in the electric power sector, Sumitomo Electric opened the Power System R&D Laboratories (currently the Power Systems R&D Center) in January 2010. We have started initiatives focused on the development of the next generation of electricity generation technology, large-scale storage batteries (as a key device in electric power control), high efficiency power conversion technology, and new power control technology through the combination of information and communications technologies.

In April of the following year, we established the Energy Business Planning Department within the corporate staff section because development of new power system business is a cross-cutting initiative that relates to each of the various sectors such as power, information communications, and automobiles. This department began marketing and development activities as well as development of new business models such as power services. Furthermore, we established the Energy Systems Equipment Development Division (currently the Energy System Division) in March 2013 to further improve the products developed at the Power System R&D Laboratories.

On the other hand, the electric power cable business, which is one of the original businesses for the Company, also responded to the changes in the market environment and began to support the new demand through the supply of submarine power cables to be used for offshore wind power generation. New value has been created by the synergistic effect of the power cable business that has been built up since the foundation of the Company and the power system business that has started new initiatives. The Company is now working to take a great leap forward as an all-round power systems manufacturer that offers smart energy systems in an all-in-one solution (Fig. 3).

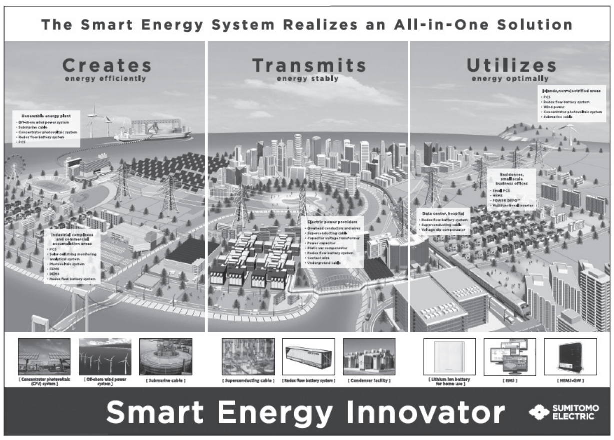

Fig. 3. Concept of new power system business

The following is an introduction to the products and technologies related to the new power system business that we are currently working on.

2-2 Redox flow battery (RFB)

A redox flow battery (RFB) is a storage battery that its safety and operational aspects are suitable for large-scale use. There are great expectations as a storage battery that can respond to various needs such as power system stabilization, business continuity plan (BCP) measures for major consumers, and demand response (DR) measures.

In 2012, we constructed a large-scale RFB system at the actual level of 1 MW × 5 h (5 MWh) in our Yokohama Works, and we are now conducting demonstrations and experiments with various operation modes (Photo 1). We are steadily building up results in preparation for the practical application of the technology through the participation in the Yokohama Smart City Project and a demand response verification led by the Ministry of Economy, Trade and Industry (METI). We also put a new container-type battery system into operation in October 2016 and started demonstration.

Photo 1. RFB system at Yokohama Works

In addition, we were accepted jointly with the Hokkaido Electric Power Company for the FY2012 Large-Scale Storage Battery System Demonstration Project implemented by METI. We put the world's largest RFB system (15 MW × 4 h, 60 MWh) into operation in 2015, and are currently implementing demonstration experiments regarding its stabilization effect on the electric power system (Photo 2). Furthermore, regarding overseas projects, we have been selected by New Energy and Industrial Technology Development Organization (NEDO) for the demonstration project in San Diego, United States. This is an area where the needs for storage batteries in electric power systems are increasing due to advancement in renewable energy utilization. With the major power company SDG&E as a demonstration partner, we are planning to install and operate a 2 MW × 4 h (8 MWh) RFB system in March 2017, and we will test the largest storage system in the United States.

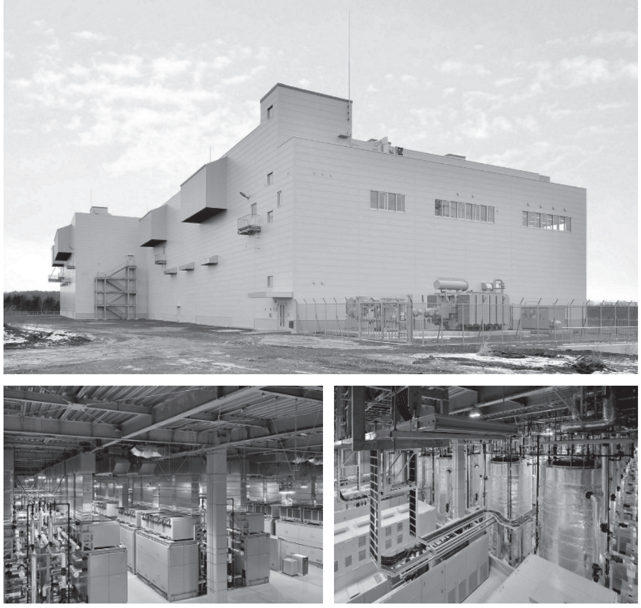

Photo 2. Large-scale storage battery system at Minami-hayakita Substation, Hokkaido

2-3 Concentrator photovoltaic (CPV) system

A concentrator photovoltaic (CPV) system uses compound semiconductor cells with a high conversion efficiency. An optical lens is used to concentrate the direct solar radiation, and the power generation module is mounted on the tracker that accurately follows the movement of the sun. Due to these features, the energy output of the CPV system per area is extremely high compared to a fixed crystalline PV system.

Furthermore, compound semiconductor cells are far less susceptible to high temperatures in terms of conversion efficiency. This will make the CPV system as effective power generating equipment for high temperature regions where conventional crystalline-silicon-based solar cells are not suitable.

As the development of the CPV system requires technology for optics, sensing, electrical wiring, and communications control, we have combined all the expertise on materials, components, design, and manufacturing that our company has accumulated. As a result, we achieved a module conversion efficiency of approximately 30%, which was at the top level in the industry and roughly double the performance of standard crystalline-silicon-based solar cells. Furthermore, our CPV system is more cost effective than other companies' products due to the thin and light modules, which reduce load and improve work efficiency while enabling an increasing number of modules to be mounted on each tracker.

The main target of our CPV business expansion is the regions with high direct normal irradiation and high temperature, which are located in the sun-belt area, namely Africa, the Middle East, Australia, the west coastal region of the Americas. We have so far installed demonstration equipment in each of the target areas and have been working on the sales promotion. As a result of such activities, we have received an offer to participate in a joint demonstration project of a 1 MW CPV power generation pilot plant with the Moroccan Agency for Sustainable Energy (MASEN), which takes the initiative in the policies for the introduction of renewable energy in the Kingdom of Morocco. We concluded a contract with MASEN in May 2016 for the demonstration project, and the plant went into operation in November 2016 (Photo 3).

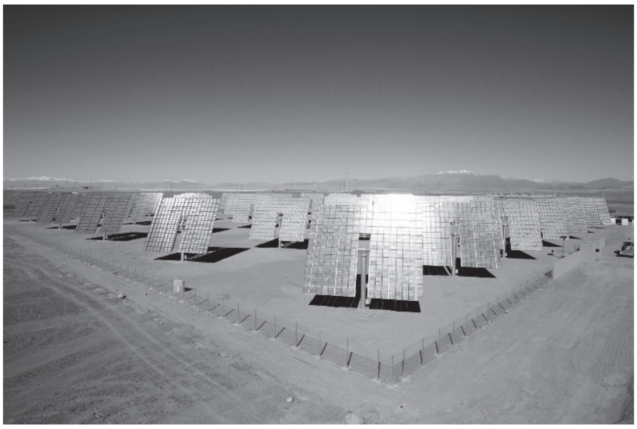

Photo 3. 1 MW CPV power plant in Morocco

The plant is located on the premise of the MASEN research factory in the outskirts of Ouarzazate, a city just south of the Atlas Mountains in central Morocco. We will use the data obtained from this demonstration to promote the CPV business development, not only in Morocco but also in the various regions with high solar radiation.

2-4 Application of power line communications (PLC)

For the construction of new power systems, information and communications technology is essential. Using the power line communication (PLC) technology that we have previously developed, we are to release new groups of products.

We have produced PLC modules to be mounted on smart meters. The smart meter adds a communications function to a power meter, which conventionally only measures electricity. The smart meter sends its measurement data to destinations such as power companies and forms the foundation of new power infrastructure. The PLC module we have developed uses existing power lines for communication without requiring any modification, ensuring communication even in areas with difficulty in receiving radio waves.

Applying the PLC technology, we have also developed a monitoring system for photovoltaic generation plants (Fig. 4). Solar panels at a photovoltaic power plant are installed in a series/parallel arrangement and a sensor is used on each individual series arrangement (string) to monitor the power generation status in detail. The monitoring system uses the PLC technology on the power lines to transmit collected data to the monitoring stations. Using existing power lines without any modification, the system requires no dedicated communications lines, making the system economical. It can also be retrofitted into existing photovoltaic generation plants that do not have a monitoring system. The introduction of the monitoring systems has proceeded at photovoltaic generation plants in recent years because failure in power generation immediately causes loss of electricity sales and earnings.

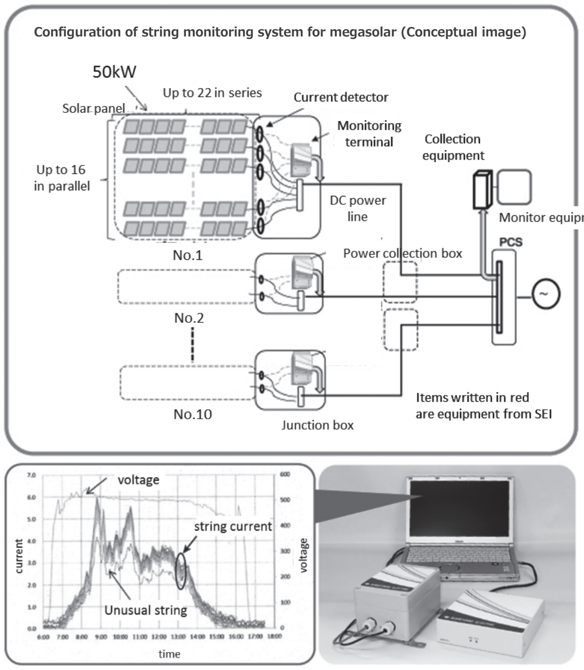

Fig. 4. String monitoring equipment

2-5 Distributed power sources

Power systems from now onwards will need to use photovoltaic power generation and other renewable energy sources, which are subjected to large fluctuations over time, and therefore will be required to use stabilization equipment such as rechargeable batteries. It will be necessary to connect these elements to the electric power system to achieve efficient operations. To respond to these requirements, Sumitomo Electric has developed a power conversion technology that has a high conversion efficiency and reliability.

By applying this technology, we have developed the POWER DEPO II high-efficiency storage battery for residential use, which can be linked to the independent output of a photovoltaic power generation system (Photo 4). One main feature of this product is that it includes a large capacity 2.9-kWh lithium ion battery in a compact unit, making it ideal for home and office use. It can supply electricity to information appliances and household electrical products over a long period of time. The battery can also coordinate with a photovoltaic power generation system to provide a steady supply of power. It can be useful for reducing electricity charges as it can be charged with the cheaper electricity available overnight and then supply

Photo 4. POWER DEPO II

electricity during the daytime. As it can also supply electricity in case of power outages due to disasters or other reasons, the system is expected as a BCP measure.

2-6 New power services

On conventional electric power supply systems, the electric power supply and demand were balanced by making adjustments on the supply side in response to the fluctuating demand. In comparison, the recent advances in information and communications technology have made it possible to balance the supply and demand on the demand side by making smart changes to the consumption patterns depending on the situation of electric power demand. This method is called Demand Response (DR).

Sumitomo Electric has worked to advance DR technology. We have participated in the demonstration project led by METI for DR automation systems and the demonstration project for the Negawatt trading. In 2015, we succeeded in supplying the Negawatt power at a high accuracy within 15 minutes after the DR order was sent. This was achieved at our Yokohama Works using 3 redox flow batteries (totaling 5 MWh), 6 gas power generators (totaling 4 MW), and 15 concentrated photovoltaic (CPV) units (totaling 100 kW) with the energy management system (*s*EMSA) we have developed.

We are also working on demand response demonstrations for charging electric vehicles (EVs) and plug-in hybrid electric vehicles (PHVs), which are expected to function as a distributed power resource in the future. For example, in the United States, we have participated in the demonstration project conducted by the Toyota Motor and Duke Energy for the optimal charging of PHVs (Project Plug-IN).

Furthermore, in 2016, we participated in the demonstration project for virtual power plant (VPP) construction that was subsidized by METI. A virtual power plant uses information and communications technology to comprehensively control the energy equipment such as storage batteries and photovoltaic power generation installed on the demand side and to make them function as if they were one single power plant (Fig. 5). This is a growing business in Europe and America, where reforms of the electric power system are advancing. Through these demonstrations, Sumitomo Electric will accumulate expertise in energy management technology for power systems and power trading, and thereby raise the value of its products.

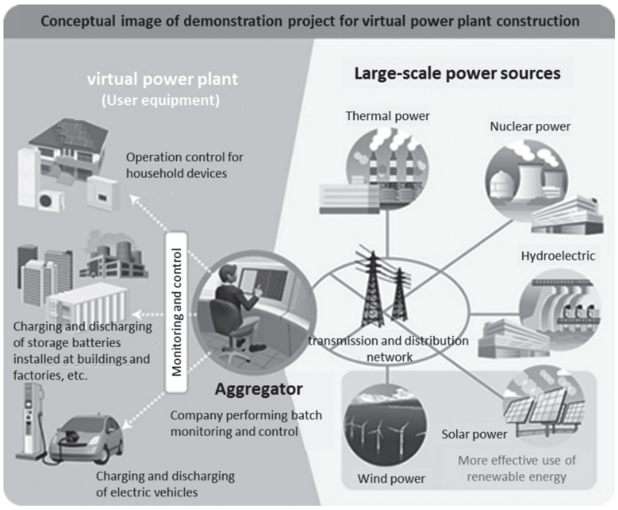

Fig. 5. Conceptual image of VPP

3. Future Developments

As outlined above, power systems are going through a period of dramatic change due to various factors such as changes in the global environment, development of information and communications technology, and advancement of market reforms for electric power. Sumitomo Electric sees these changes as an excellent opportunity for its business expansion. While reinforcing its power cable business, which has been a major business of the Company since its foundation, we will promote the development of technologies anticipating the changes in power systems. We will continue working to contribute to society by offering new technology and products that are needed by the market in response to the paradigm shift in the electric power field.

Technical Term

∗1 Negawatt: The idea of regarding surplus power resulting from users' energy-saving efforts as generated power.

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