

Development of Micro Smart-Grid Demonstration System

Smart Management for Efficient Use of Renewable Energy

June 15, 2011

Sumitomo Electric Industries, Ltd.

Sumitomo Electric Industries, Ltd. has developed a micro smart-grid demonstration system and begun testing on the premises of its Osaka Works (1-1-3 Shimaya, Konohana-ku, Osaka). In this newly developed demonstration system, four types of renewable power generators and a storage battery are DC-interconnected, and natural energy and power demand fluctuations are sophisticatedly managed, thereby ensuring stable and efficient power supply for facilities and equipment (loads).

1. Configuration and Features of Micro Smart-Grid Demonstration System

(1) System configuration

[1] In this system, three types of photovoltaic, a small wind power generator and a small redox flow battery are interconnected by DC power cables 1 km in total length. Generated electric power is used by some lighting fixtures, home appliances and a charging station for a superconductor electric vehicle in Osaka Works.

[2] DC electric power generated by each generator (maximum total generating capacity: about 10 kW) is increased to a higher voltage by a DC-DC converter, transmitted via DC power cables, and either stored in the redox flow battery, or fully inverted to AC and supplied to the above-mentioned loads (equipment) via a smart distributor and intelligent taps.

(2) Overall system features

[1] The demonstration system is not connected to any commercial power network; its power sources comprise only photovoltaic and wind power generators. An energy management system,

described later, monitors and controls fluctuations in renewable generation and electric power consumption. The storage battery balances the fluctuations. Consequently, the overall system achieves the most efficient and stable use of power.

[2] The DC interconnection of the demonstration system involves fewer DC-AC inversions than conventional AC interconnection. Since DC-AC inversion is subject to energy loss caused by inverter power consumption and by inversion itself, reduction in inversions means more efficient use of renewable energy. Furthermore, in DC power transmission, power loss via cables is lower than in AC power transmission.

Meanwhile, we expect some 10% in combined energy-saving effects from [1] and [2].

[3] The demonstration system accommodates flexible connections of various renewable generators and storage batteries, and is usable in a variety of power systems of various sizes according to each specific requirement.

2. System Components

(1) Generators

The system incorporates two types of commercially available photovoltaic, an in-house developed concentrating photovoltaic (CPV), and a commercially available small wind-power generator.

The power generation efficiency of CPV is about twice that of silicon solar panels currently on the market, since CPV cells are made from a special compound semiconductor material. Installed at an elevated position, concentrator panels provide usable space below them. Expectations are high for CPV as a next-generation photovoltaic.

The newly developed CPV (1 kW power) uses Sumitomo Electric Group's material technologies. Its panels are thinner and lighter than those of the conventional CPV.

(2) Storage battery (small redox flow battery with 10 kWh capacity)

In a power system using power generated by renewable energy, the storage battery plays the critical role of storing and discharging electric power in response to fluctuations in generated electric power.

Redox flow batteries are suitable for irregular, highly fluctuating charge/discharge operations, enabling accurate monitoring and control of stored electric power. Accordingly, they are optimal storage batteries for smart grids designed for efficient use of solar, wind power and other renewable energy resources. Sumitomo Electric is focusing its product development efforts on redox flow batteries, for use in smart grids on a fully commercial basis.

(3) Energy management system

DC-DC converters are installed at connections between generators and DC power cables and between storage battery and DC power cables. DC electric power is collectively converted to AC by the DC-AC inverter immediately before loads (equipment). Each of these units has power control and communication capabilities, via the central control server in the energy management system. More specifically, via a hybrid wired/wireless network the server acquires data on the amounts of electric power generated, stored and consumed and manages the electric power flow so as to achieve optimal supply-demand balance. Loads (equipment) are controlled to create economic benefit without causing user inconvenience. The central control server centrally manages measurement data so as to give operators a real-time view of electric power generation, storage and consumption, in addition to providing past generation and consumption data.

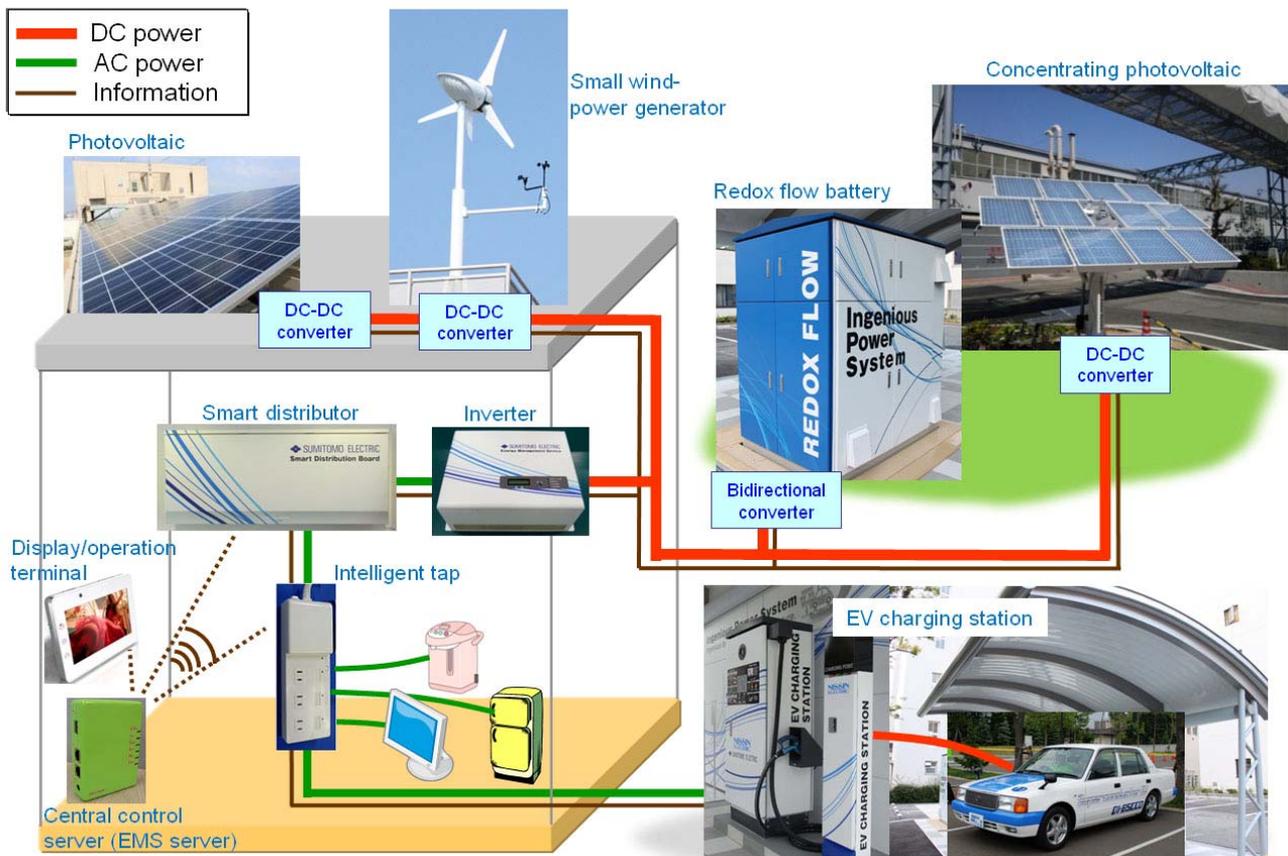
The DC-DC converters, DC-AC inverter, smart distributor control unit that supplies power efficiently to each load (equipment), and the intelligent tap connected to the smart distributor were all developed in-house by Sumitomo Electric.

(4) Loads (equipment)

Electric power generated by this demonstration system is presently consumed by home appliances, such as a lighting fixture and TV set. It will also be used to power the superconductor electric vehicle charging station developed jointly with Nissin Electric Co., Ltd., a consolidated subsidiary of Sumitomo Electric. That charging station also accommodates commercially available electric vehicles.

We will test the demonstration system for about one year, to assess effectiveness in energy-saving performance and other features by collecting and analyzing data, including relations between amount of electric power generated and solar radiation, wind and other weather conditions. At the same time, we will use the system to promote the development of smart grid-related products. Under the brand “ingenious power system,” Sumitomo Electric, while paying attention to the government’s future energy policies, intends to propose optimal, renewable energy-based micro smart-grid systems that meet diverse household- to community-level needs.

Overall configuration of micro smart-grid demonstration system



Terminology

1. Smart grid

Power transmission network enabling optimal coordination of power supply and demand through power flow control on both supply and demand sides. The smart grid facilitates energy saving, reduces cost and improves reliability and transparency.

2. DC interconnection system

System used to form power distribution networks via DC power cables, instead of conventional AC power cables. DC interconnection reduces energy loss in cables and power converters.

3. Concentrating photovoltaic (CPV)

Photovoltaic system incorporating a small-size photovoltaic cell for energy conversion, directing high-intensity sunlight converged by a lens or the like to photovoltaic cells.

4. Redox flow battery

Storage battery charges/discharges through oxidation-reduction of vanadium or other ions. A redox flow battery comprises a charging/discharging cell section and a tank full of metal ion electrolyte. Battery features include long service life, safety and stability. Redox flow batteries excel in smoothing out fluctuations in electric power generated by wind power and the like, and offer great promise as large megawatt-class storage batteries.

5. Energy management system

An energy management system saves energy and reduces electric power cost through optimal management and control of power generation, and storage facility functionality. For example, the system stores low-cost electric power during the night, when power consumption is low, and uses the stored electric power during daytime hours when electric power demand and cost are high,

thereby leveling power consumption from the grid and reducing electric power cost. Moreover, the energy management system is useful for improving users' life patterns, since it provides real-time visual representation of power consumption and various other types of information.

6. Converter/Inverter

A converter is a device that converts AC power to DC power, or performs DC voltage conversion.

An inverter is a device that converts DC power to AC power. These are essential for power system construction, and are important as determining factors in overall system efficiency.

7. Smart distributor/Intelligent tap

A distributor is a device that distributes AC power to multiple lines serving different purposes. The distributor has many circuit breakers, each setting an upper power feed limit. A smart distributor has various additional sensors and communication capabilities for measuring power consumption, and sends data to a central control server in real time. An intelligent tap measures power consumption at each socket and transmits power consumption data to the central control server, and/or turns circuit breakers on and off at the server's request.

8. Superconductor electric vehicle

The world's first electric vehicle powered by a superconducting motor using the bismuth-based high-temperature superconductor developed in 2008 by Sumitomo Electric.

* Ingenious power system is a trademark of Sumitomo Electric Industries, Ltd.