SANYO'S SMART ENERGY SYSTEM WITH A 1.5-MEGAWATT HOUR LITHIUM-ION BATTERY AND 1-MEGAWATT PHOTOVOLTAIC SOLAR SYSTEM

Hiroshi Hanafusa

SANYO Electric Co., Ltd., Smart Energy System Division, Moriguchi, Japan

ABSTRACT

SANYO has developed a Smart Energy System (SES) that can generate, store, and consume green energy effectively and efficiently. At the SANYO Kasai Plant in the prefecture in Japan, we installed a 1-megawatt (MW) photovoltaic (PV) solar system, a 1.5-megawatt hour (MWh) lithium (Li)-ion battery system, energy management systems that efficiently control equipment, and an SES, which combines and coordinates all of these systems to maximize energy efficiency. The key component of the SES is the Li-ion battery system using 300,000 Li-ion cells typically found in laptop computers. The newly developed battery management system can control numerous cells as if they are just one single battery. We realize carbon zero-emissions in the on-site administration building and are able to reduce 15% peak demand of the whole factory by using our SES.

Keywords: battery management system, lithium-ion battery, solar

1. INTRODUCTION

Renewable energy such as photovoltaic (PV) and wind turbine generation is expected to play an important role for future energy solutions. Additionally, electrical energy storage is needed to stabilize the electricity grid fluctuation caused by the intermittent weather conditions as they relate to renewable energy sources. In order to become a leading company in the energy and environment business, the Panasonic/SANYO Group is promoting the development of new products and technologies. The aim is to help solve environmental and energy problems on a global scale with the company's outstanding technological capabilities. In late 2010, SANYO set up a huge technology demonstration site in Kasai, using its own products such as PV panels, lithium (Li)-ion batteries, and newly developed energy management systems.

2. SMART ENERGY SYSTEM IN KASAI GREEN ENERGY PARK

In the Kasai Green Energy Park (Kasai GEP), we installed a 1-megawatt (MW) Mega Solar System, a 1.5-megawatt hour (MWh) Li-ion Mega Battery System, an energy management system that efficiently controls each piece of equipment, and a smart energy system (SES) that combines and coordinates all of the systems using an SES controller, as shown in Figure 1.

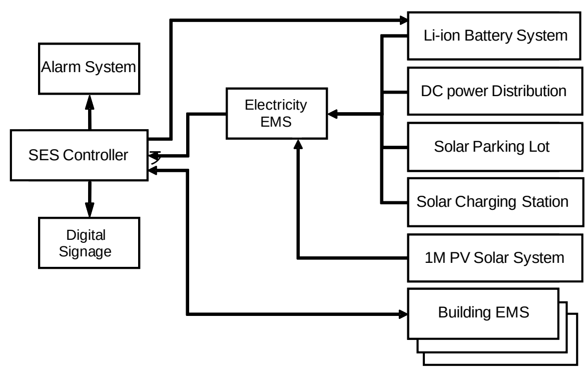

Fig. 1. Construction of Smart Energy System.

By using all of these systems to maximize energy efficiency, we are able to reduce approximately 2,480 tons of carbon dioxide (CO_2) emissions every year without sacrificing any convenience. The core component of the SES is the SES controller. It monitors the conditions for electricity generation and storage with PV modules and storage batteries, while keeping track of the amount of electricity used by devices and equipment in real time. Through integrated control of technologies for energy generation, energy storage, and energy saving, the SES can use power efficiently without waste.

3. CONSTRUCTION OF THE LI-ION BATTERY SYSTEM

The 1.5-MWh Li-ion battery system consists of a 1.3-MWh large-scale battery storage system using 240,000 pieces of 18650 standard cells and a DC distribution system from PV modules with 200-kWh Li-ion batteries. A new battery management system has been developed that deals with a large quantity of data such as voltage, current, and temperature for each cell instantaneously through advanced network technologies and then balances and controls each cell at the same time. This battery management system can control numerous cells as if they are just one single battery.

Fig. 2. Photo of Li-ion battery system in the energy storage building.

Figure 2 shows 1.3-MWh Li-ion battery system in the energy storage building. Economical late-night electricity is mainly used to charge batteries. In order to ensure stable operation of the whole battery system, the Li-ion battery system consists of multiple elemental units that have 5 series-4 parallel of Li-ion boxes. A battery management unit controls 20 boxes. Each box has 312 pieces of 18650 cells. One series string consists of 5 units that have 160-kilowatt hours (kWh) and is connected to 1 power conversion system (PCS), as shown in Figure 3. The battery management unit (BMU) accurately detects the conditions for the Li-ion batteries based on the electric voltage, electric current, and temperature, and maximizes the performance of this large-scale storage battery as a whole.

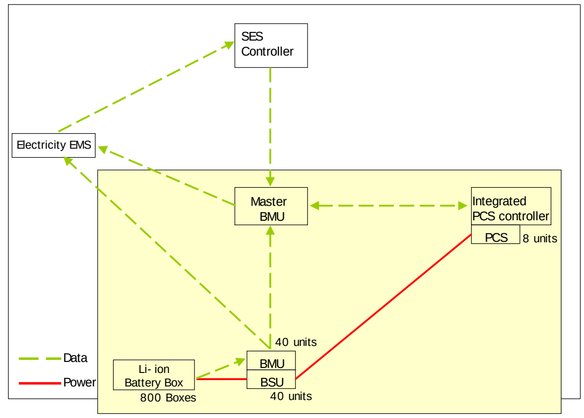

Fig. 3. Configuration of the Li-ion battery system.

4. EFFICIENCY OF THE LI-ION BATTERY SYSTEM

Energy efficiency is critical when using a battery system. In order to evaluate the actual efficiency of the Li-ion battery system, the comparison of electricity between input and output was measured.

Figure 4 shows transition of electricity through each device at the condition of SOC25%→SOC75%→SOC25%. Actual efficiency of the Li-ion battery system is about 98%; however, the efficiency of a PCS is about 94%, and the total efficiency after PCS is about 87%. It is still much higher than that of the NAS battery and lead-acid battery [1].

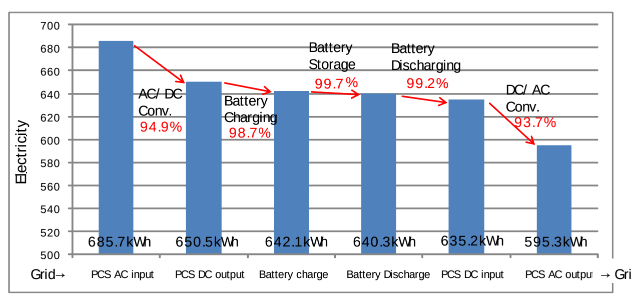

Fig. 4. Transition of electricity through energy devices.

5. DC POWER DISTRIBUTION THROUGH LI-ION BATTERY SYSTEM FROM PV SOLAR

Green buildings can take advantage of DC power distribution with PV generation (Figure 5).

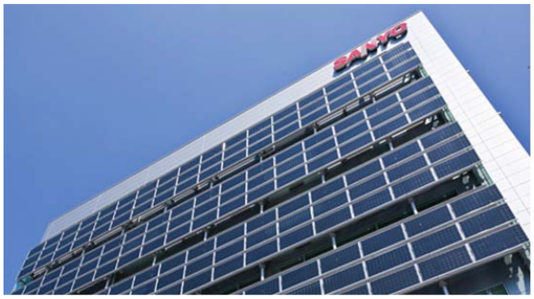

Fig. 5. PV solar deployed vertically on the side surface of a building.

DC power from PV solar can be directly used in DC devices such as LED lightning and laptops. Then, surplus DC power is stored in energy storage and provided to DC devices from storage at night. If PV solar generates more electricity, DC power is converted into AC power and consumed by AC devices. In the administration building, unconverted DC power from PV modules is the main source of electricity for charging batteries and direct consumption.

Fig. 6 shows the system configuration. A direct charging method from PV solar to Li-ion battery has been developed. Approximately 100% of the electric power consumed in the administration building can be offset by the electric power generated by all of the PV systems in the Kasai GEP and by the power consumption reduction effect of the Administration Building EMS.

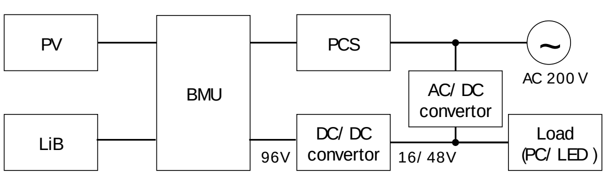

Fig. 6. System configuration for DC power distribution.

6. PEAK SHAVING BY THE LI-ION BATTERY SYSTEM

Fig. 7 shows the total energy consumption data of the factory. The green part means the amount of energy saving by EMS, and the grey part is the electricity purchased from the grid. The SES can reduce demand charge by peak shaving. During daytime, PV solar generation, the orange part, saves the electricity purchased from the grid. However, PV solar could not provide enough electricity for peak shaving any more around 4 p.m., since our factory had the peak time around the sunset time. The SES controller decided to let the battery system discharge electricity to keep the peak load shaving. Then, the battery was charged using lower-costing electricity from the grid during the night. The SES reduced peak demand by over 15%. Our factory has a different peak time according to its production planning. Lots of operational patterns have been devised to determine when and how long the batteries have to charge and discharge. Kasai GEP is the ideal site to develop these kind of battery control technologies.

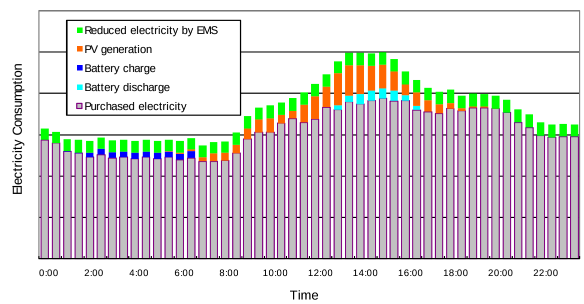

Fig. 7. Peak shaving by the SES.

7. CONCLUSION

The SES has proven to be useful for reducing carbon emissions and reducing peak demand without any inconvenience for employees or factory operation.

By making the energy usage conditions and facility information visible, the operations staff can identify inefficiencies and inconsistencies in factory and office energy use, and take actions to improve the environmental performance of the site. Furthermore, the staff can get a real sense of the site's energy consumption visually through the large-screen displays installed around the site (Fig. 8), which will raise the employees' environmental awareness at the Kasai GEP. indirectly leading to the reduction of CO_2 emissions.

Fig. 8. Digital signage for the SES.

8. REFERENCES

[1] Research Institute on Building Cost, No. 68, pp. 70-73, 2010, http://www.ribc.or.jp/research/pdf/report/report21.pdf;

9. ACKNOWLEDGMENTS

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BIOGRAPHICAL NOTE

Hiroshi Hanafusa joined the SANYO Electric Central Institute in 1981. He contributed to the development of semiconductors such as system LSI for digital camcorders for 10 years and acquired his doctor’s degree. He acted as CCD general manager and various other administrative innovation project leaders. He was the project leader of new energy business development from April 2009, led the development of the SANYO Smart Energy System, and founded the Energy Solution Business Division, which is the previous body of the Smart Energy System Division of SANYO today.