Development of Large-scale Energy Storage Systems and the Strategy of Global Deployment

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Abstract

NEC has been developing an energy storage system for industrial and grid use. We have been applying our expertise in this regard in developing the energy management system of the "Yokohama Smart City Project (YSCP)" selected as "Next-Generation Energy and Social Systems Demonstration Areas" implemented by the Ministry of Economy, Trade and Industry in Japan. We have also conducted the overseas field trials of a large-scale energy storage system using a lithium-ion battery technology in collaboration with the U.S. Electric Power Research Institute (EPRI). Furthermore, we have started to examine the introduction of an energy storage system for the Italian electricity company Enel and a self-sustained power supply system for the Indonesian islands.

Keywords

energy storage system, lithium-ion battery, global, renewable energy, smart grid

1. Introduction

An energy storage system is an "electricity storing technology." When electrical energy is accumulated in an energy storage system, the electric power load is equalized and an efficient use of energy is enabled. An energy storage system may also be used to provide emergency backup power. Since an energy storage system offers a broad range of versatility, its technology may be used in many different domains in order to meet the needs of various consumers. Such as in commercial facilities, factories and housing as well as in power plants, where renewable energy is used, and for grid applications including power transmission and distribution equipment, etc.

NEC has been working on the development of energy storage systems for industrial and grid use as well as home energy storage systems. Storage batteries are expected to be used for many applications; e.g. as an Energy Management System (EMS) that takes energy efficiency into consideration for backing up industrial usage, off peak control adjustment of demand fluctuations (adjusting the supply and demand) and for output stabilization of power generation equipment. A response to the proposed full-scale introduction of renewable energy has also been highly regarded recently for grid applications. Since the amount of power generation, such as via solar or wind power, depends on the amount of solar radiation or the wind direction, its value is subject to fluctuations. Storage batteries are designed to instantaneously stabilize the voltage and frequency of the grid due to the equalization of supply and demand balance and to thereby offset any sudden changes in supply or demand.

Field trials have been started in various locations globally so that we may demonstrate the potential utility of these storage batteries (see **Fig.**). Currently, we have been working for the Energy Management System of the "Yokohama Smart City Project (YSCP)" in Japan and have also collaborated with the U.S. Electric Power Research Institute (EPRI) on overseas projects. We also plan to participate in various field trials on a global scale.

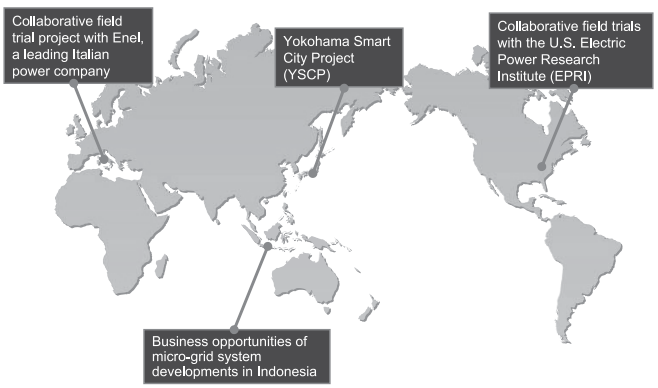

Fig. Global development of energy storage systems.

2. Features of the Large–Scale Energy Storage System and Collaborative Development with BEMS

2.1 Features of Large–scale Energy Storage System

Currently, pumped-storage power generation is the main system used generally as an energy storing system in the Megawatt (MW) class. A pumped-storage power generation system obtains electric power by pumping water to an upper reservoir by using inexpensive off peak power at night and then discharging the water by gravity in the daytime to drive the turbines. However, pumped-storage power stations can only be constructed in certain locations with suitable differences in height between the water resource and the reservoir. Such a constraint poses geographic restrictions and does not allow wide usage. The large-scale energy storage system, NAS battery (sodium-sulphur battery), was marketed in 2002 to solve this problem. The NAS battery is the world's largest energy storage system and is mainly used in the peak shift (purchasing electric power is equalized using an inexpensive night electric power) of industrial and commercial buildings and for backup power in cases of power failure. It has been introduced in five countries worldwide and the total amount of equipment is more than 300MW (at 2GWh). There is a growing expectation globally that the next large-scale energy storage system to follow the NAS battery system will be the lithium-ion battery system commercialized by our company.

The lithium-ion battery solution currently has two technical issues that require immediate solution; the technical issues regarding "large capacity" and "long service life" must be resolved with regard to the safety and economy issues.

Firstly, we describe issues with regard to increasing battery capacities. "Electric Vehicles (EVs) and Hybrid Electric Vehicles (HEVs)" are the largest application markets for lithium-ion batteries at the present time. These applications are also expected to experience significant market dissemination and their battery capacities are expected to be approximately 20 kWh at maximum. On the other hand, as mentioned above, the battery capacities required for a peak shift in the amount of power consumption of buildings of urban areas, collective housings, commercial facilities and factories are expected to be several MWh, i.e., several tens of times larger than for the EVs. For this reason, it is important to develop technologies to operate such a battery system safely and stably. It is required that the battery technologies (battery material, structure and manufacturing technologies) and the monitoring of the control system technology are capable of handling many batteries in order to realize such large capacities. Aiming to establish these technologies, we are actively participating in field trials that are being conducted inside and outside Japan, such as in large-scale commercial facilities and for the commercial electricity to be distributed via the grid (see below for more details).

Next, the "long service life" technology is described. One of the demands for energy storage systems is the capability of supplying stable and high-quality power for over 10 years, like that achieved by conventional power supply systems. Such energy storage is expected to be installed at the power facilities of power companies in countries where collaborative engineering experiments are currently carried out with NEC, especially at the facilities in the grid networks. Markets for lithium-ion batteries used to be notebook PCs, cell phones and digital cameras etc. However, the useful lives of such products are approximately five years at maximum. When considering this constraint and in order to support systems with longer useful lives safely and stably, it is imperative to establish a new technology by adopting the existing technologies used for car batteries.

On the other hand, for monitoring and controlling the components inside the energy storage battery system as well as linkage with upper Energy Management Systems, we will optimize and employ our proven technologies accumulated in the fields of communications and control software system technologies.

The market for large-scale energy storage systems has not yet matured. However, it may develop rapidly in accordance with the emergence of the smart grids. To cope with such an event, we plan to accelerate the development of key technologies that support our target businesses while taking the safety factors into consideration as a main factor.

2.2 Collaborative Development with BEMS Using Lithium–ion Battery in YSCP

As one of our programs of the "Yokohama Smart City Project (YSCP)" selected as the "Next-Generation Energy and Social Systems Demonstration Areas" implemented by the Ministry of Economy, Trade and Industry, NEC is developing an Energy Management System employing lithium-ion batteries. This is being undertaken in collaboration with electrical and electronic equipment manufacturers that possess superior technologies in the energy field.

This program is carried out while linking with the proposals regarding the YSCP master plan submitted by the city of

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Yokohama to METI. We are playing an important role among participants in the group conducting the field trials of the "Energy storage complex system technical development" project in Yokohama City.

We are developing an Energy Management System to support enterprises that integrates the Building Energy Management System (BEMS) developed by other electrical and electronic equipment manufacturers and the large-capacity energy storage system. It features our lithium-ion battery technology adopted for the battery system of EVs. Field trials have been scheduled to take places over the five year period from 2010 to 2014. We plan to develop an energy storage unit and PCS (power conditioner) to introduce the BEMS development and demonstration fields in 2011.

This system allows the business operators of large office buildings and factories to integrally manage and control the use of storage batteries of several hundred kWh. It thereby enables them to optimally use the commercial power supplied by the electric power companies as well as the power generated by the household power generators. When using this system, business operators can efficiently use energy sources depending on the status of demand. They will thereby contribute not only to reduce energy costs and CO_2 emissions, but also to set targets to reduce electric power costs by 25%.

The functions of the system are designed for buildings having two or more power supplies and heat sources to improve the energy efficiency of all the facilities when BEMS controls are integrated with the multiple energy systems. In this process, when the controls are integrated in response to requests by the Community Energy Management System (CEMS), the "demand response" [*1] achieves. In addition, the flexibility of the energy control is increased by applying a large-scale stationary storage battery system that utilizes the advantages of the lithium-ion battery. Moreover, while employing the EVs as a charging and discharging auxiliary device, we aim to enhance the introduction effects of the BEMS. Furthermore, we are able to verify rationalization of energy usage and also to improve techniques related to the investment returns on the storage battery system when the electric power can be interchanged between two or more buildings by applying the mutually cooperative controls of BEMS. When the above functions are realized, a low-carbon building is achieved; furthermore, we are aiming thus to construct BEMS in such a way as to contribute to a low-carbon society at the local level.

3. Global Strategy

An electricity supply/demand situation may vary greatly depending on geographical conditions or regional (country) strategies. For example, it may depend not only on differences in the frequency and voltage coming from historical circumstances, but also on differences in the types of power generation, transmission and distribution systems as well as on local government policies regarding the introduction of renewable energy. Therefore, the required system differs from an energy storage system that depends on regional policies and it is also constantly changing as the environment changes.

In such circumstances, we are considering the acquisition of a platform aimed at global expansion and are currently conducting developments and field trials with local partners that targets global markets. We also plan to implement a policy of continuous future expansion.

In addition to the YSCP as mentioned above, we currently take part in various domestic field trials. These are: the collaborative field trials of large-capacity lithium-ion energy storage system with the U.S. Electric Power Research Institute (EPRI), the collaborative development of a next-generation smart grid system with Italian leading electric power company, and "A research project commissioned as part of an infrastructure system export promotion (potential business investigations of smart communities in the global market)" in Indonesia. All of these projects are introduced in detail below.

3.1 Collaborative Field Trials of a Large–capacity Lithium–ion Energy Storage System with EPRI

Our company conducts collaborative demonstration experiments of large-capacity energy storage system using the lithium-ion battery technology with the U.S. Electric Power Research Institute (EPRI), at the EPRI laboratory located in Knoxville, Tennessee. EPRI is the largest electric power technology research institute in the U.S. (**Photo**).

The experiments are for exploring the scope for applications expansion of energy storage systems and the evaluation of large-scale energy storage systems for the grid. We also develop an energy storage system of 25kW/50kWh that is applied for the prospective smart grid experiments at an early stage as well as collaboratively conducting a variety of evaluation tests in U.S. environments.

[*1] Controlling the power consumption of the demand side by the power industry company according to the demand of electric power grids or its system.

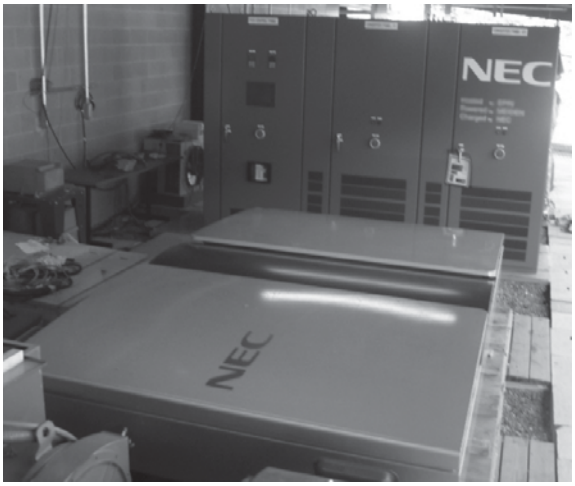

Photo The unit employed in the collaborative field trials with EPRI.

In the U.S., energy storage systems are expected to be widely applied for the stable output of wind power and photovoltaic (PV) power generation, electric power fluctuation adjustments of power distribution systems, and for the nighttime electric power storage of commercial and residential buildings, EPRI evaluates various energy storage systems that support power projects for the smart grid.

We have been promoting optimal and low cost power management via the development of manganese lithium-ion secondary battery. With the best use of this battery technology, we have established strong cooperation with EPRI in proceeding toward the realization of a large-scale energy storage system by which high reliability, large capacity and long service life will be achieved. We are expecting to take the initiative in the energy industry based on these achievements.

3.2 Activities in Italy

(1) New energy strategy of the EU (European Union)

In November 2010, the European Commission announced a new energy strategy "Energy2020" for the next 10 years and had the following targets called "three 20% goals."

- Greenhouse gas emissions will be reduced by 20% in 2020 compared to 1990.
- The renewable energy component of the final energy consumption will be raised by 20%.
- Energy efficiency will be raised by 20%.

The priority issues of "Energy2020" are set to achieve the above goals and lead the European Commission to propose future specific measures. The issues contain an energy infrastructure building scheme to cope with the pan-European level. The core of the scheme is to introduce renewable energy power sources, such as sunlight, wind power and hydraulic power, and also to introduce grid networks to support the scheme.

(2) Electricity situation in Italy

While the EU sets strategies as mentioned above, Italy has been promoting a policy for spreading the photovoltaic (PV) power generation for an even longer period and the photovoltaic (PV) power generation installed capacity as of September 2011 exceeded 10,000 MW. When power from renewable energy is more widely available and the unstable power supply originating from natural power sources is increased, it will become an important issue not to affect the electric power quality. Since the Italian nuclear power plants were closed in 1987 as influenced by the Chernobyl nuclear power plant accident, there has been a tendency toward electric power shortages and not enough new power generation facilities have become available. However, Italy has been compensating for power shortages by importing electric power via the inter-European transmission grid, from France, Switzerland and the like. There are also other transmission grid links including to Slovenia and Greece. However, stable power supplies are becoming more and more important in response to the projected increase in natural energy sources. In addition, Europe frequently has problems due to momentary power failures caused by voltage drop etc.

Under these circumstances, there is an increased need to improve the electric power quality of the power grid in Italy.

(3) Collaborative demonstration experiment project with Enel

In April 2011 we agreed to build strategic partnerships with Enel Distribuzione (hereinafter "Enel"), an affiliate of Italian leading power company Enel SpA, in order to perform collaborative developments on new solutions technologies aimed at realizing the smart grid. As its first project, the lithium-ion battery system developed by NEC was installed in a substation under the control of the Enel distribution network and our plan to conduct field trials is currently under way. We confirmed the effectiveness of the project in a power distribution network environment via the field trials held

under the Italian electric power regulations. Supplying (discharging) correction power to maintain power quality (such as voltage, frequency, etc.) using storage batteries, and storing the surplus power generated by renewable energy power sources, etc. While we contribute to resolve issues and improve the electric power quality in Italy, it will also offer an opportunity to collaboratively gain expertise that may potentially benefit future business developments. Since the foundation of the reliability of our lithium-ion battery technology has been obtained by mounting them on EVs, it is expected to offer an opportunity for future business expansion even for the stationary-type systems.

3.3 Activity in Indonesia

(1) Electricity situation in Indonesia

In Indonesia, high economic growth has been continuing even after the global recession. In order to fulfill the rapidly increasing electricity demand at the same time as also preventing global warming, which is an international trend these days, has urgently required the introduction of renewable energy. While the growth of the electricity demand from 2010 to 2019 is expected to be on average more than 9% per annum, it is our target to decrease the energy derived from fossil fuels and increase the power generation rate using renewable energy up to 15% by 2025.

On the other hand, since the electrification rate is still at about 60%, sufficient electric power is not yet being supplied in many areas, and 1/3rd of the population of 230 million is not yet using electric power.

Indonesia consists of as many as 17,000 islands, although there is a tendency toward electrification the rate is low in the regions and in many isolated islands where electricity is not used. The building of large-scale transmission networks and the construction of large power plants has not yet commenced, but a small-sized independent power system is under way.

(2) Micro-grid system development in Indonesia

Under such circumstances, we participated in 2010 in the "Research project commissioned by the infrastructure system export promotion" of the Ministry of Economy, Trade and Industry, in cooperation with the electrical and electronic equipment manufacturers having a strong interest in the energy fields. Since then, we have been investigating the potentiality of business growth in Indonesia in the context of the proposed global expansion of small-scale micro-grid power generation systems by targeting remote island communities.

The micro-grid system uses photovoltaic (PV) power generation and our energy storage battery and micro-grid (distributed power sources) technologies for facilitating installation of packages of scalable system blocks. The operation of diesel generators can thereby be suppressed in the islands in order to reduce fossil fuel usage and to promote the use of renewable energy sources.

NEC is a company experienced in marketing large-scale laminated manganese lithium-ion batteries. Moreover, our lithium-ion battery technology has achieved the highly-efficient charge/discharge performance, safety standard and long service life that are required for automotive applications. Such a track record for our products has received high acclaim. Optimal lithium-ion battery applications will be investigated in the scheduled field trials of the project.

Our efforts include the conflicting themes of the rate of electrification improvements of newly emerging countries versus the prevention of global warming via the development of storage battery systems, which are essential for the introduction of large-scale renewable energy supplies.

Supporting the increase in the electrification share of the newly emerging countries while preventing global warming, is a conflicting theme. However, NEC will tackle this theme by developing the storage battery systems that are essential for the introduction of large-scale renewable energy supplies.

4. Conclusion

While the demands for energy storage systems will multiply as described so far, market needs are however likely to continue to be diversified at present and also in the future.

Meanwhile, we have already started to develop systems to meet the needs of the power supply and demand situations of various countries through the various field trails being conducted inside and outside Japan. We will continue our efforts to increase our market share by actively entering the emerging markets.

*NAS Batteries are trademarks or registered trademarks of Tokyo Electric Power Company (TEPCO).

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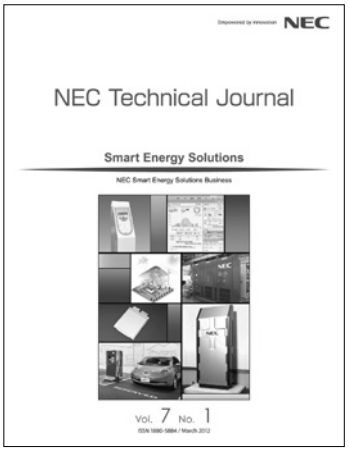

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