Smart Buildings: Conserving, Creating, and Storing Energy—the Smart Office Building Trial Project

Keiichi Saito and Jun Takase

Abstract

A project is underway to implement NTT Group research and development and various energy-conserving policies and systems in an office building to investigate their effectiveness in conserving energy, and to evaluate their usability in actual operation. In this article, we introduce the systems used in this trial and the practical results obtained thus far.

Keywords: energy-saving, energy creation, energy storage

1. Introduction

To advance the NTT Group goal of implementing new systems that will realize a smart, energy-conserving society and a safe and secure living environment, we have implemented various energy-saving systems and devices, both existing and under research and development (R&D) within the NTT group, in some of our offices in the Granpark Tower in Minato Ward in Tokyo. The purpose of this trial is to check their practical energy-saving results and effectiveness, and to evaluate their usability and determine the best operating methods. This trial is being conducted as a flagship smart building project in collaboration with NTT Facilities and NTT Communications, who are tenants in Granpark Tower, and NTT Urban Development, which is the owner of the building.

2. Overview of energy-saving policies

The energy-saving systems being used in the trial are shown in **Fig. 1**. The core is the Remoni power monitoring system, which automatically controls and creates visualizations of the amount of electrical power used in the offices. The trial includes lighting equipment such as the Smart Lighting Controller (SLC), which enables installation of light-emitting diodes (LEDs) and lighting control, and a power-supply-and-demand management system, which uses a combination of solar panels and lithium-ion (Li-ion) storage batteries to control power peaks in the office.

3. Remoni system for monitoring power and reducing peak power use

The office floor is divided into several blocks consisting of meeting rooms, shared space, and individual office spaces. Remoni was installed to visualize the power consumption of lighting fixtures and outlets used for office equipment in each of these blocks. Then, Remoni functions were used in coordination with the SLC lighting controller to study measures such as automatically turning off low-priority lighting when power consumption exceeded a pre-configured peak power level. The configuration data were also linked to the supply-and-demand management system that controls peak power in order to study how the output from solar panels and Li-ion storage batteries can be applied automatically, and even how to expand services in the future to integrate multiple buildings through the use of communications, so that if one building exceeds the peak power value, other buildings can adjust their levels to smooth out the peak.

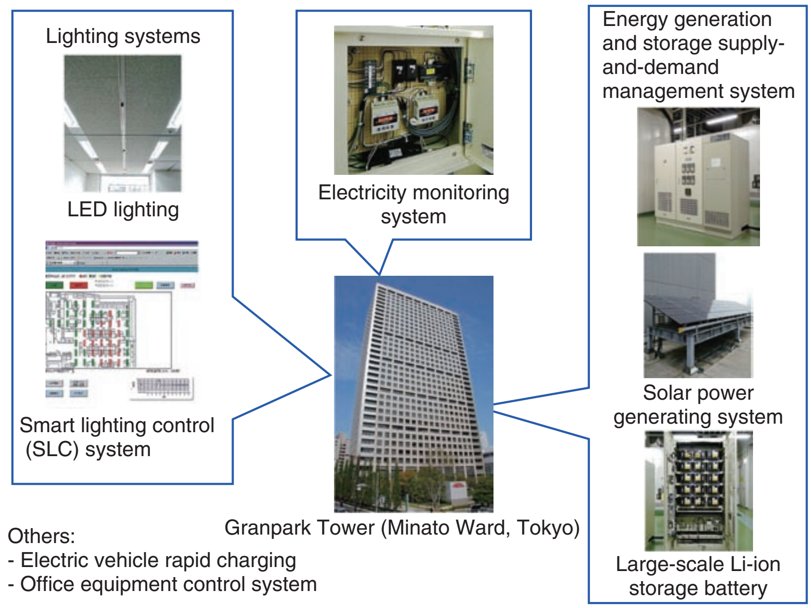

Fig. 1. Systems and equipment used in trial.

4. Lighting systems

Low-power LEDs were installed to replace conventional fluorescent lighting in offices, and the overall power consumption before and after the change was compared. The frequency of using the lights differs for each block in an office floor, so the effect of the switch is somewhat scattered. Nevertheless, it was confirmed that a power saving of over 50% can be achieved in blocks where lights are usually on during working hours. However, other measures to reduce power consumption by reducing the number of fluorescent lights in offices have already progressed, and switching to LEDs in areas where this has been done yields reductions of only a few percent. We have begun implementing measures such as thinning the LEDs while maintaining the lighting level. We have also installed lighting controllers on some floor blocks. These controllers enable lights to be turned on and off through the web from personal computers (PCs) at each desk. This allows conventional measures such as turning off all lights during lunch time or at a set time at the end of the day, but also promises further effects by enabling employees to turn out lights at individual desks from their PCs while they are out of the office or away from their desks for meetings or other reasons. The changes in power consumption for lighting before and after installing the lighting control system are shown in **Fig. 2**. The figure compares one month of data before and after installation (above and below). The horizontal axis shows power consumption through a single day, with the minimum to maximum power consumption represented as a color gradient from blue to red. A comparison of the upper and lower graphs shows that many regions that were red before introducing the system become purple or blue afterwards. We assume this is a result of encouraging individuals to turn out the lights. In the future, it will be necessary to study how to increase awareness about the importance of saving energy and to promote further operational measures that increase the effects of using this system.

5. Supply-and-demand management system

This system supplies power to some of the offices in the building using a combination of solar panels, which generate energy, and large Li-ion batteries, which store energy, together with the power supplied by the power company. In the trial, the amount supplied from the generated and stored energy is varied to reduce the peaks from the power system during normal times. However, the batteries can also be used as an emergency measure, providing backup power to the entire floor in the event of power outages due to a disaster (**Fig. 3**).

Solar panels with an output of 10 kW were installed on the roof of the Granpark building, approximately

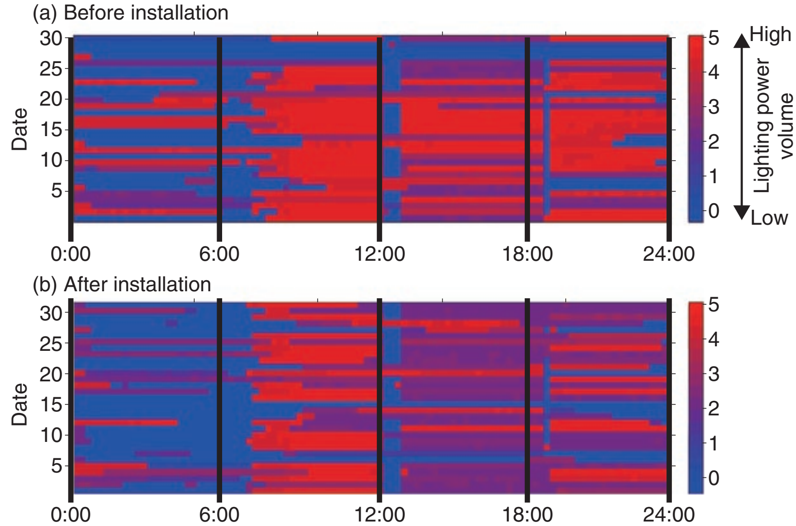

Fig. 2. Change in lighting power consumption before and after installing the lighting control system (five levels shown on color gradient).

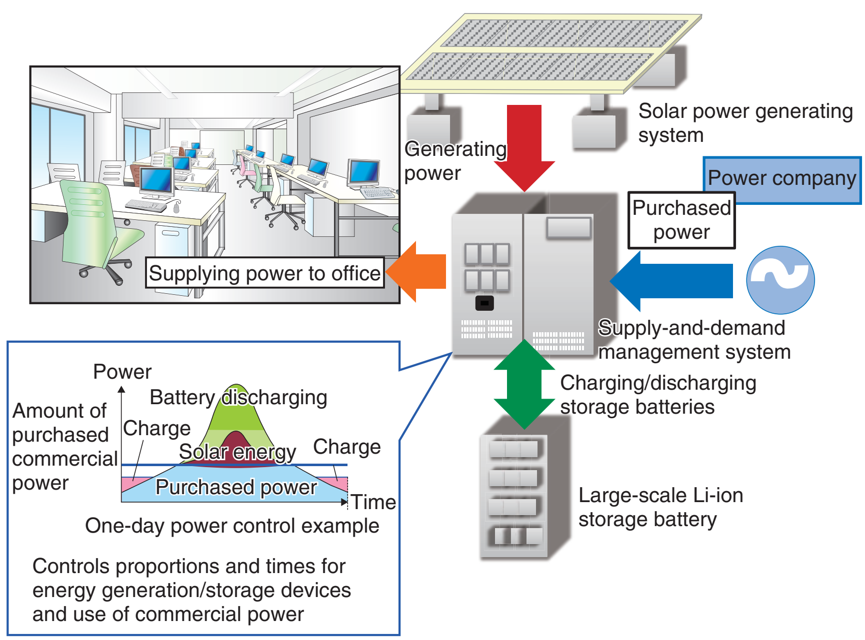

Fig. 3. Supply-and-demand management system overview.

140 m above the ground. The trial also involved investigating the use of specially designed mountings to deal with the strong winds that occur in such a high location, as well as implementing operational measures such as periodic inspections. The solar panels generate power at times that correspond closely to office work hours, so they basically supply power directly to the office floor through the supply-and-demand management system. Large-scale Li-ion storage batteries with a capacity of 25 kWh (12-cell module, where each cell has a capacity of 85 Ah (ampere-hours)) were also installed. In the trial, these

were charged overnight from commercial power and discharged during the assumed peak power times, providing approximately 80% of the power when combined with the solar panel generated power.

The capacity of the Li-ion storage batteries is limited because of the areas available to install them and because of other issues as well, and they can therefore become depleted during office peak times if solar panel output decreases due to rain or cloudiness. However, in this trial, we expect to obtain knowledge that will help identify optimal operating conditions, even if the battery capacity is limited. In the future, we will use this knowledge by linking it to automatic control of operations and adjusting battery discharge rates according to the predicted solar panel output, among other measures.

6. Other measures and future plans

Some other practical energy-saving measures include installing an office equipment control system that can reduce power consumption by externally adjusting clock frequencies and CPU (central processor unit) load in PCs installed on the office floor, and installing a rapid electric vehicle charging system that enables electric vehicles to be linked with storage batteries and to be charged even during peak commercial power times. We are currently analyzing the effects and usability of such measures.

We will continue our trials in the future. There are also plans to expand development into other areas such as linking buildings together and using communications to exchange data on their power use; adjusting the ratio of power sources used according to factors such as energy prices and the external state of supply and demand; and automating control of energy-saving measures to reduce power consumption.

Keiichi Saito
Senior Research Engineer, Environment Management & Provisioning Project, NTT Energy and Environment Systems Laboratories.
He received the B.E. and M.S. degrees in science and engineering from Waseda University, Tokyo, in 1989 and 1991, respectively. He joined NTT in 1991 and conducted research on Li-ion battery materials until 1995. He was then engaged in new business development until 2010. He is currently working on the promotion and development of services and systems related to energy and the environment.

Jun Takase
Smart Community Produce Team, NTT Research and Development Planning Department.
He joined NTT in 1997. In 1999, he moved to NTT WEST and engaged in the corporate sales department. He experienced the marketing and new business development, service creation department and took the present post in 2013.