Validating the Performance of NEC's Tamagawa Building Smart Energy System

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Abstract

As part of the renovation of the office building at NEC Tamagawa Plant, we "smartized" the building's energy management system, targeting a 50% reduction in energy use compared to pre-renovation. As well as upgrading the energy-saving systems, we also introduced sensor-based energy management. This paper examines the various systems and technologies we used to achieve a dramatic reduction in energy use.

Keywords

energy management system (EMS), smart community, BEMS, energy saving

1. Introduction

Building 9 at NEC Tamagawa Plant (**Fig. 1**) was originally built in 1989. Twenty-five years later, the building itself and its attached facilities had deteriorated to the point where major renovations were required. We saw this as an opportunity to test out our concept for a "smartized" next-generation building as a symbol of our Energy Solution business, which is one of the pillars of our growth strategy. By incorporating a cloud-based BEMS (Building Energy Management System) into the building's main system, our goal was to significantly reduce power consumption. The renovations were completed in March 2015 and we subsequently began evaluating the performance of the new facilities installed in Building 9. The results of those validation tests are discussed in this paper.

Name	NEC Tamagawa Plant, Building 9		
No. of floors	Above ground: 8	Bulkhead: 1	
Gross floor area	18,086m^2		
Completion	November 1989	Construction	SRC
Application	Office		

Fig. 1 External view of Building 9.

2. Overview of the Smartization of Building 9

2.1 Smartization Concept

Since Building 9 also accommodates the offices of NEC's Central Research Laboratories, our principal goals included not only energy saving, but also maintenance of a comfortable environment, and improvement of intellectual productivity (**Fig. 2**). Consequently, the renovation did not stop at merely restoring the facilities;

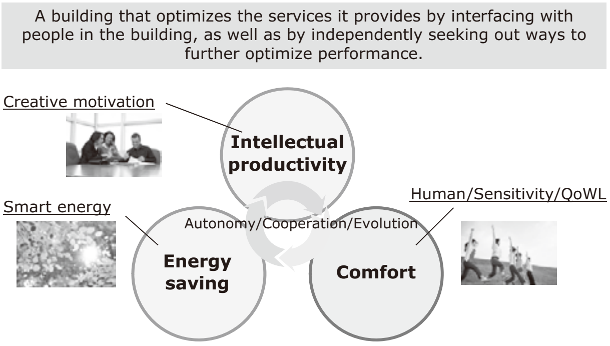


Fig. 2 What is a smartized building?

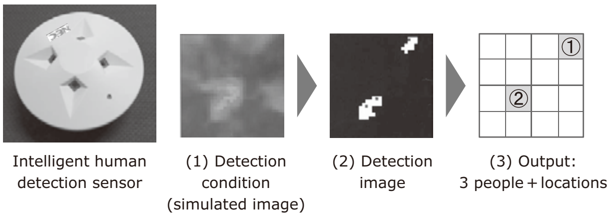


Fig. 3 Intelligent human detection sensor functions.

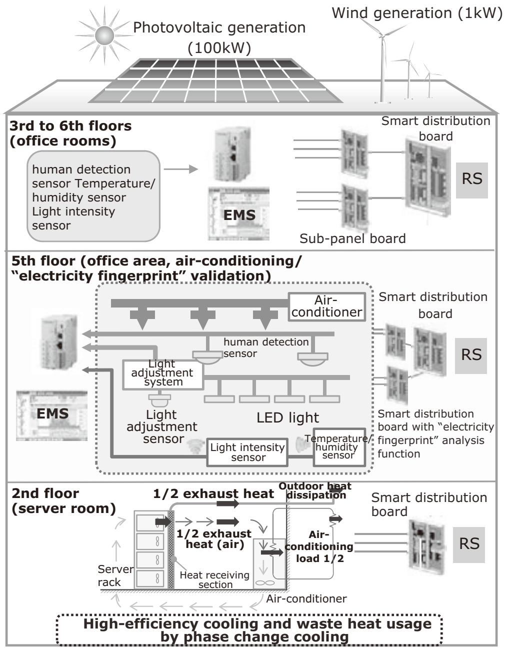


Fig. 4 Overall diagram of smartization validation.

instead, the principal objective of the renovation was to achieve an autonomous energy management system capable of analyzing data collected from numerous sensors installed at key locations around the building and using the results to optimally control lighting levels such as dimming and light colors, as well as the temperature and humidity settings of the climate control system.

2.2 Systems and Technologies Introduced

We installed a newly developed LED light system that can be operated remotely via a wireless connection. As this was a renovation of an existing building rather than construction of a brand-new building, it was an enormous advantage to not have to lay out wiring. In addition to turning light fixtures on and off, lighting levels for each fixture can be adjusted independently. Also multiple intelligent human detection sensors shown in **Fig. 3** are installed in each unit, making it possible not only to detect the presence and absence of people but also to grasp the number of them and their movements.

For electricity distribution on each floor, a smart distribution board was installed. This shows the amount of power usage according to circuit breakers. For climate control, VAV (Variable Air Volume) controllers for airflow adjustment and inverter-type air-conditioners were installed. All of these devices are linked to our energy cloud system which is capable of managing them with total precision. As a result, airflow, temperature, humidity, and carbon-dioxide concentration can all be fine-tuned for optimum energy-saving and comfort (**Fig. 4**).

Moreover, renewable energy power sources such as solar and wind were also installed to ensure that the building would have an independent, stand-alone energy source.

3. Validation of Smart Energy System

3.1 Visualization of Power Consumption

Taking advantage of the data provided by the smart distribution boards installed as part of this project, we developed and introduced a technology called “electricity fingerprint” analysis[1)] that uses current waveforms to specify what types of devices are connected to the power outlets on each floor. Whereas previously it was only possible to get a general idea of overall power consumption, this system allows power consumption to be visualized in detail. Management staff will be able to see which devices, such as PCs and monitors, are operating at any given time, enabling more precise targeting of energy saving measures. Continuous acquisition of data also makes it possible to track changes in power usage over the course of the day.

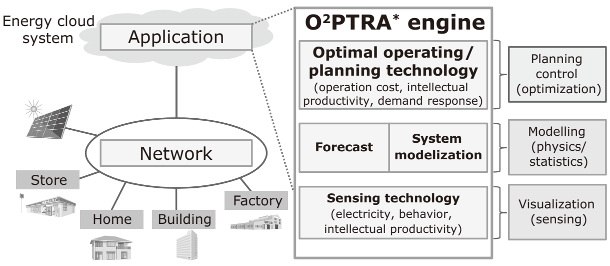
3.2 Phase Change Cooling System

We installed a phase change cooling system[2)] in the server room capable of cooling the room efficiently by natural circulation of the coolant alone. This system has also been introduced in the NEC Kanagawa Data Center. The system uses paired piping that connects multiple server racks via a single pipe to reduce climate control electricity consumption by about 65%.

3.3 Localized Climate Control

We are developing and validating technology that can optimally control the air conditioning in a large room by varying it as required in different sections of the room. By creating virtual zones (**Fig. 5**) and adding external information such as outdoor temperature and weather data to the data gathered from the newly installed temperature sensors, humidity sensors, and intelligent human detection sensors, as well as power consumption information collected by the "electricity fingerprint" analysis, each floor is modeled to predict environmental changes that are likely to take place (**Fig. 6**). Based on the results, operating plans for each area are developed to facilitate optimal control of each part of the room using the VAV controllers.

Once this technology has been finalized, it will be possible to control the climate system according to the presence/absence of people and the heat generated by devices, with an anticipated reduction in electricity use of about 10%. At the same time, by incorporating the



*Optimal Operation TRAcking

Fig. 5 Intelligent air-conditioning control.

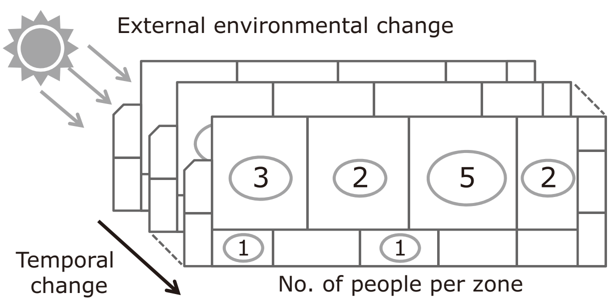


Fig. 6 Floor modeling of air-conditioning control.

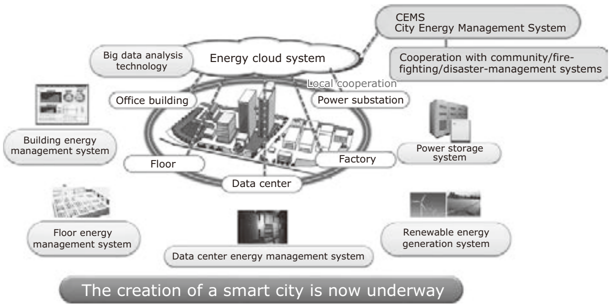


Fig. 7 Smartization in the future.

QoWL (Quality of Working Life) index - which indicates the degree of comfort experienced by people in the environment - we are also anticipating significant energy savings without compromising comfort.

4. Future Issues and Plans

To date, we have achieved a 46% reduction in overall energy use in Building 9 at NEC Tamagawa Plant compared to before the renovation. Our targeted reduction of 50% is clearly within reach and we expect to achieve this goal in the near future by improving the performance of the systems that have already been introduced and by moving quickly to bring online various new measures now under validation.

With the smartization of Building 9 as proof of concept, we intend to proceed with the smartization of all buildings at NEC Tamagawa Plant. The success of these smartization programs gives us the tools, techniques, and know-how necessary to sustain our commitment to the creation of smart cities that incorporate the comprehensive suite of leading-edge ICT products that have made NEC one of the world's leading innovators (**Fig. 7**).

Reference

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2) YOSHIKAWA, et al., "Cooling Technology to Reduce Air-Conditioning Power Consumption in Data Centers," NEC Technical Journal, Vol. 10, No. 2, pp. xx – xx, April 2016.

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