Carbon neutrality of cities, led by the energy management system

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[Short bio]

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Before assuming his current position in 2009, Professor Hayashi held positions as lecturer in the Faculty of Engineering, Ibaraki University and associate professor in the Faculty of Engineering, University of Fukui. He has also served as the Dean of the Advanced Collaborative Research Organization for Smart Society at Waseda University since 2014, and as the President of the Tokyo Branch of the Institute of Electrical Engineers of Japan since 2020. He was awarded the Commendation for Science and Technology by MEXT in 2019.

- How will your research contribute to carbon neutrality?

My specialty is energy management systems. Now I am working to create a system that controls and optimizes three operations: production, delivery, and use of electricity, through visualizations of the status of electricity generation and transmission. Japan has been obtaining its electrical energy efficiently by building large-scale centralized power plants such as thermal power plants in remote areas. Currently, as Japan moves away from fossil fuels and promotes the introduction of renewable energy toward carbon neutrality, it is shifting away from large-scale centralized power plants to small-scale decentralized systems.

How can we use electrical energy of renewable energy sources (such as solar power generation scattered throughout households and

communities) without any waste, which are ultimately irregular? The key to realize this is to develop a management method that collects information, analyzes it, and controls devices. We will contribute to carbon neutrality with it.

- What is the motivation behind this research?

A major turning point for me came with the Great East Japan Earthquake in 2011. At that time, the introduction of solar power generation for residential use was just getting underway, and the amount of power available for use was limited, so the only way to deal with power shortages was to patiently save electricity. Having experienced the situation myself, I began to think strongly about realizing "power saving without perseverance." Saving electricity without perseverance meant automatically controlling the devices in the home to reduce power consumption, or shifting the time period when power would be insufficient. Regarding home appliances, we began working with industry, academia, and government to create standards to improve the interconnectivity of the eight key Home Energy Management System (HEMS) devices (air conditioners, solar power generators, storage batteries, lighting, water heaters, fuel cell batteries, smart meters, and electric vehicle chargers and dischargers) designated by the Ministry of Economy, Trade and Industry. That project turned out to be tied to my original specialization, research toward achieving stable supply on the power network side. After that, the feed-in tariff (FIT) system was established, and solar power generation increased rapidly, but then there were issues such as the burden on power lines and the increase in voltage in certain areas. To deal with those issues called for a management system to coordinate the entire system, by means such as visualizing the amount of electricity and the status of its usage: in the houses ("points"); the power lines, which connect the points ("lines"); and the regions, which are connected by the lines ("planes"). Then when there is a surplus, change the location and time of use. Initially, we accumulated research results by means of computer simulations and equipment-based experiments, but now we are starting to work on actual applications for use in the community.

- What kind of research are you currently engaged in?

We chose Utsunomiya City, a city of 500,000 people, as a demonstration site, and now we are conducting research there on the use of surplus electricity from solar power generation in the region by public transport vehicles (buses) that have been converted to electric vehicles (EVs). We are simulating the optimization of recharging locations and times by combining bus route map data, open data on bus operations, and surplus solar power data gathered by smart meter measurements of all households in the city. In a sense the energy management embodies two approaches: reducing CO2 emissions by replacing gasoline vehicles with EVs; and reducing CO2 emissions by using electricity derived from renewable energy sources. The implementation of residential solar power generation is progressing year by year, to the point where a surplus is generated during the daytime. If the local government can collect that surplus energy and use it as a source of energy for public transportation and public facilities in the region, we can also expect to increase the value of the municipality as a promoter of carbon neutrality in addition to local production of energy for local consumption. As a researcher involved in energy management systems from the neutral standpoint of a university, I would like to present the results of analysis connecting various data related to energy as evidence for local government policy formulation, and to encourage the institutional reforms that are essential for the introduction of new technologies. Through such efforts, I hope to build a platform for energy management services that can be easily adopted by each local government, and work together with local governments to envision carbon-neutral cities of the future.

- Do you have a message for our readers?

The use of energy management systems is expanding to include homes, buildings, factories, and

even communities, but the scale of installation is still small. In order to support the reduction of CO2 emissions, I aim to create a versatile, low-cost energy management system that bridges the barriers between energy, transportation, and digital fields, through industry-academia-government collaboration. In addition, I aim to incorporate the findings of our research into programs such as the Graduate Program for Power Energy Professionals, selected by WISE Program of MEXT in their work to foster high quality doctoral students.