Clarifying the economic value of adjusting power consumption

June 10 2019

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Since the output of renewable energy such as photovoltaic generation tends to fluctuate, the power system can be viewed as a large-scale complex system with uncertainty. To stabilize the balance of supply and

demand of electricity, we need an energy management system to control this. In recent years, energy management systems have been actively researched against the background of the liberalization of power and the spread of smart meters that visualize the power consumption. Koichi Kobayashi, associate professor at Hokkaido University, Shun-ichi Azuma, professor at Nagoya University, and Nobuyuki Yamaguchi, associate professor at Tokyo University of Science etc. developed demand response analysis and control technologies focusing on time-varying power generation costs.

Demand response is one of the methods in energy management systems. Demand response is defined as "when the supply-demand balance is tight, consumers conserve the power consumption and change the power consumption pattern according to the setting of the electricity price or the payment of incentives (rewards)." The cost-effectiveness has not been clarified.

The introduction of the "aggregator" that controls the power consumption of consumers has attracted much attention. In this framework, aggregators trade between electric power companies and consumers, instead of direct trade between consumers and electric companies. Aggregators manage hundreds of consumers and control their power consumption in response to requests from electric companies. By the introduction of aggregators, control of the whole power system becomes easier.

During a day, the cost-effectiveness of demand response fluctuates depending on the demand and supply of electricity. It is expected that this fluctuation becomes larger by the spread of renewable energy. Demand response is aimed at maintaining the balance between supply and demand, and its cost-effectiveness has not been focused. However, in the future, it will be important to evaluate the economic value of demand response, focusing on the power generation cost and the

adjustment cost (the cost required to adjust power consumption) at each time. Furthermore, it is necessary to develop control strategies that maximize the economic value of demand response.

In order for demand response to produce the economic value, the unit price of power generation costs needs to fluctuate greatly during the day. If the difference between the highest and lowest generation costs is large compared to the adjustment costs, then demand response produces the economic value. In this research, more specifically, we derived the condition that "demand response produces the economic value if the difference between the highest price and the lowest price is more than twice the adjustment cost." Because it is a simple condition, it can also be used as a guide to calculate the rewards to consumers.

Next, in order to maximize the economic value, a control method for demand response is developed based on model predictive control in which the optimal control strategy is found by the prediction via a mathematical model. In the simulation, the effectiveness of the proposed method is presented by using the data from the Japan Electric Power Exchange as a forecast value of the power generation cost and the power consumption.

More information: Kodai Miyazaki et al, Design and Value Evaluation of Demand Response Based on Model Predictive Control, *IEEE Transactions on Industrial Informatics* (2019). DOI: 10.1109/TII.2019.2920373

Provided by Japan Science and Technology Agency

https://phys.org/news/2019-06-economic-adjusting-power-consumption.html