Evaluation of Demand Response Programs

Background and Objective

The electric utility in Japan has been tackling with various load leveling measures such as time-of-use (TOU) rates or contracts for adjustment to peak demand using thermal storage air conditioners. On the other hand, the "Demand Response (DR) program," which encourages voluntary energy conservation or load leveling on the demand side by using the Energy Management Systems (EMS), has been operated recently in the U.S., and its further expansion is expected to be the main service of the smart grid.

In this project, we clarified the effects of applying the DR program in Japan on peak demand saving of each customer and utility-wide load and supply cost. Also, we analyzed the issues of comfortableness as well as economics, through the field experiment of DR control in actual office spaces.

Main results

1. Evaluation of DR Potential for the Commercial and Industrial Demand

Based on questionnaire survey, DR potential of commercial and industrial customers in Kanto area was estimated. According to the building type, factories of which contract demand is over 500kW have large DR potential. From the viewpoint of DR strategy, DR potential of partial stop of production process, changing set point of air-conditioning in office and dimming lighting is large. Financial incentive, which is desirable for customers, was estimated at 1,257 Yen/kWh (3 hours on weekday in summer) for 1 GW demand reduction in Kanto area [Y10020].

2. Evaluation of Residential DR Pilot Program in the U.S.

The results of the major pilot programs of residential demand response in the U.S. suggest that we can expect peak reduction by 10 to 20%. Critical peak pricing (CPP)*1 is more effective as compared to a simple time-of-use pricing, and enabling technologies, such as programmable thermostat, in large customers with central air conditioning have been proved to be effective in reducing peak demand. Yet, customers have some psychological reasons not to choose dynamic pricing. Peak time rebate*2 would be popular in the future, for customers think it easier to accept [Y10005].

3. Analysis of the Impact of Introducing DR Programs on Generating Cost in Japan

The impact of a summer-peak cutting DR program on the power generation cost of the Japanese power system until 2040 was estimated as part of the cost-benefit analysis, using CRIEPI's long-term power generation system expansion model. When the peak demand is cut by 1.0%, the averaged unit generation cost decreases by 0.19% compared to the reference case without the DR. The avoided cost of the DR program, or the power generation cost saved by reducing 1kW of peak demand, is about 8500 Yen/kW on average, which is approximately equal to the annualized unit construction cost of an LNG power plant.

4. Field Experiment of Demand Response Control in Japanese Office Spaces

To study the acceptance of peak-cutting DR control of air conditioners for commercial sector, a field experiment was conducted in two office spaces located in Tokyo during summer in 2010. Thermal environment of the controlled spaces and workers' comfort were surveyed with electric load measurement. The results showed that, the DR control affected thermal environment of the spaces; however there was a difference in workers' thermal sensation between two office spaces. This means that workers-acceptable DR control level of air conditioners is different from the viewpoint of thermal comfort.

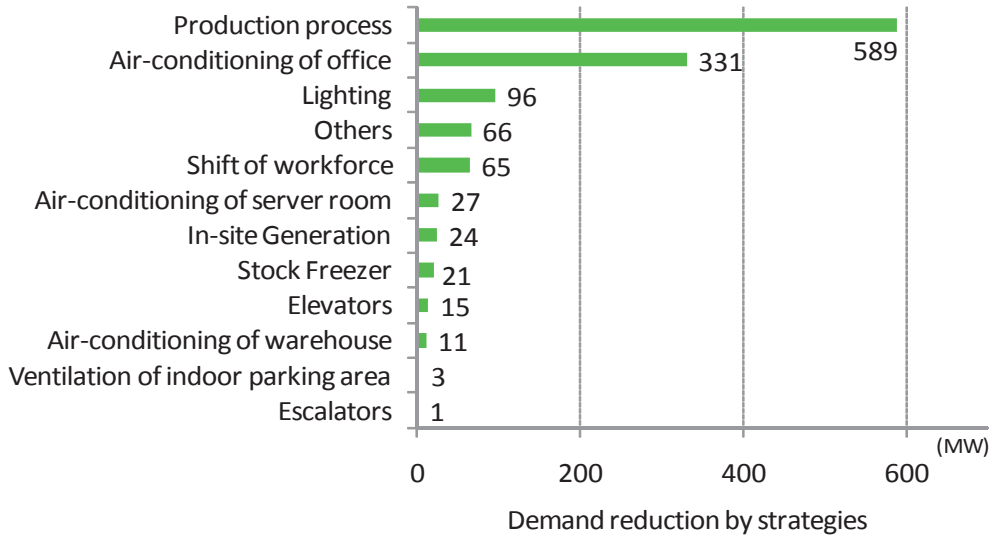

Fig. 1 DR potential classified by strategies

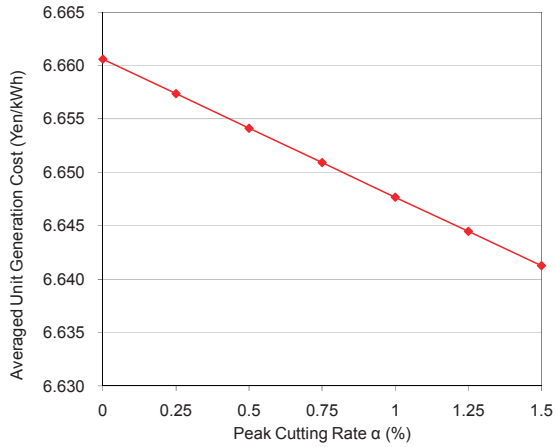

Fig. 2 Averaged generation cost

(Average of evaluation period during 2010-2040)
Averaged generation cost was calculated by the following equation:

Averaged generation cost (yen/kWh)

$$= \sum_{T=2010}^{2040}\left(RR_T \times TC_T\right) / \sum_{T=2010}^{2040}\left(RR_T \times PE_T\right)$$

where,

RR_T : Coefficient of present value conversion in year T

TC_T : Generation cost in year T (yen)

PE_T : Generated power in year T (kWh)

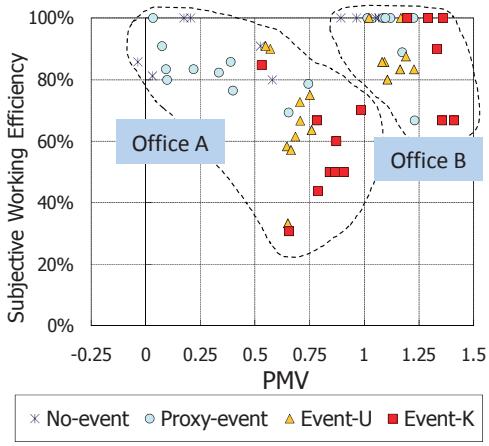

Fig. 3 Relationship between PMV and workers' subjective working efficiency

Predicted Mean Vote (PMV) is one of indoor thermal comfort indices, in which -3 means "Cold", +3 means "Hot" and 0 means "Neutral". The range of thermal comfort is from -0.5 to +0.5.

No-event: Dates without control needs

Proxy-event: No control the preset temperature

Event-U: Control the preset temperature, repeating 27 deg C for 20 min and 26 deg C from 10 min

Event-K: Control the preset temperature, making 28 deg C fixed

*1: Critical Peak Pricing (CPP) is a time-of-use rate that specifies a very high price for electricity use during the peak hours (typically 4 to 7 times as high as standard rate) only when a critical peak problem is anticipated.

*2: Peak time rebates are retail rate schedules in which customers remain on fixed rates but receive rebates for load reductions from the baseline demand during critical peak periods.