Priority Subjects — **Development of a Supply/Demand Infrastructure for Next-Generation Electric Power**

Evaluation of the Feasibility of Demand Response Suitable for Japan

Background and Objective

Recently, some electric utilities or demonstration projects of smart community have begun various attempts to utilize Demand Response (DR), such as encouraging peak shaving or load shift of electricity demand by electricity rate, as a form of experimental critical peak price. However, knowledge of participation rate for DR program, the amount of load shaving, or the degree of customers' response to rate change has not been sufficiently accumulated.

In this project, we assess the feasibility of DR as a new application for securing grid stability as well as peak shaving from a viewpoint of acceptability and cost benefit. We also supply useful information for electric utilities such as the possible variation in rate menu or service and global optimization of energy utilization including renewable energy.

Main results

1 A Field Test of DR Load Control in Japanese Office Buildings

We studied the customer-side costs, benefits and acceptance of automated DR (ADR) and manual DR (MDR) controls through a field test of such DR controls targeting an actual office building. MDR can control an air conditioning load in a more moderate way than ADR, due to the fact that office workers in MDR-controlled floors can manually set an acceptable office temperature themselves. The experiment results show that, ADR can control the electricity-consuming equipments with certainty but is very likely to decrease the subjective working efficiency of workers in the controlled area. On the other hand, variation in the load reduction of MDR can be seen. MDR may be a more cost-effective approach than ADR, though uncertainty of the MDR controls remains as an issue. (Y12025).

2 Possibility of Practical Use of Building Energy Management Systems (BEMS), Demand Monitors and Controllers to Demand Response in the Commercial and Industrial Sector

The possibility of BEMS, demand monitors and controllers to ensure demand curtailment in DR programs is discussed. Their usage for demand curtailment is classified into two types: I. customer collects electricity usage information, conducts the data analysis, and plans DR strategies prior to DR events, and II. customer prefers to take actions regarding DR strategies in response to a warning from BEMS, demand monitors or controllers (Table 1). BEMS, demand monitors and controllers play important roles in every step of DR activity. Applications such as transfer of DR signals with electricity suppliers and DR aggregators, and data analysis for planning DR contracts and strategies are promising (Y12022).

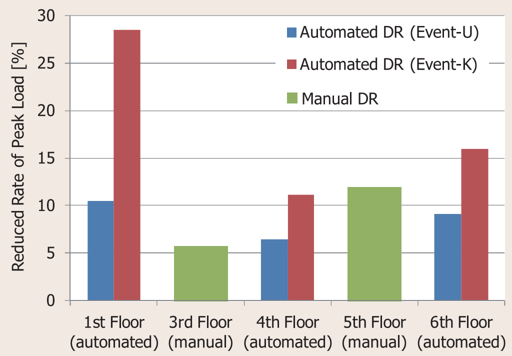
3 Applicability of Demand Response to Voltage Control in Distribution Systems with Large Integration of Photovoltaic Generator (PV)

Using our comprehensive analysis tool for power distribution systems, we quantitatively evaluated the possibility of implementing a DR program against the voltage rise problem in distribution systems with large integration of PV. According to our simulations, we must install DR with a PV penetration of more than approximately 30%. The operation days and times of DR increased in proportion with PV penetration rate, depending on the arrangement of loads and PVs. We found that with evenly distributed loads and PVs (Case1), the operation days and times were significantly less than if arranged on the end side of the distribution line (Case2). Furthermore, we calculated the costs which could be allocated to DR investment through comparison with conventional measurement (Fig. 2) (Y12008).

4 Issues Regarding Penetration of Home Energy Management System (HEMS)

We conducted a review of past demonstration projects on HEMS since 2001 and sorted out the remaining issues regarding penetration of HEMS. The most serious issues for market penetration are summarized as the following three aspects; uncertainty and continuity of energy saving, a high installation cost, and the level of understanding of customers toward energy saving (Table 2). It is important for the penetration of HEMS to solve these issues using various measures (such as auto-control device or continuous and effective information supply of energy saving) and to add further values to HEMS as well as fostering consumers' understanding, although its necessity or usefulness for customers are still uncertain (Y12011).

Other reports: (Y12018), (Y12021)



Event-K : Temperature is raised by 2°C during 1PM-4PM automatically
Event-U : Temperature is raised by 1°C during 1PM-4PM automatically
Manual DR : Degree is set manually by office workers during 1PM-4PM

Fig. 1: Reduced rate of peak load

This figure shows an experiment result for a six-storied office building in Yokosuka City. Only 1st floor uses non thermal-storage type air conditioner, therefore its reduced rate is larger than the others. Among the floors using the storage type air conditioners, the reduced rates are consistent with the raised width of temperature settings for automated DR, however, they are different by the floor for manual DR. The interview survey for office workers suggests automated DR decreases the subjective working efficiency more than manual DR, although they may not be comparable directly because the temperature can be changed for manual DR.

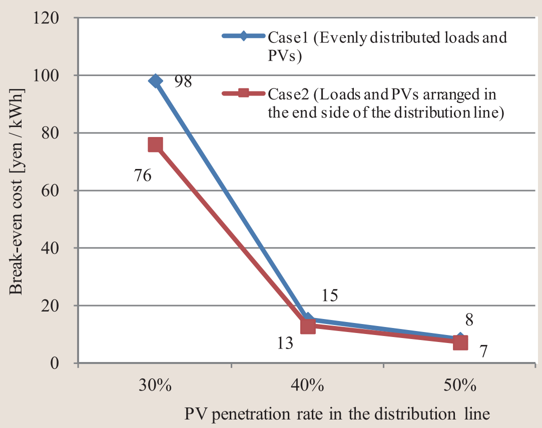


Fig. 2: Maximum expense for the DR program

Economic Benefit (Break-even cost)

$$= \frac{\text{The avoided cost by implementing DR}}{\text{The reverse power flow which must be reduced by DR}}$$

A break-even cost is the cost of the distribution system (Static Var Compensators) which can be avoided by implementing the DR program, that is, the maximum expense for the DR. It is useful for judging whether installation of a DR program is cost-effective.

Table 1: Classification of usage of BEMS, Demand Monitors and Controllers in Electricity Demand Curtailment after the Great East Japan Earthquake

Our interview survey (111 accounts) and postal questionnaire survey (3,031 accounts) for C&I customers, reveal the usage of BEMS, demand monitors and controllers for DR activities. The interview survey shows that the difference of usage of BEMS, demand monitors and controllers though their kW demand reductions was as large as 25% at a mode.

Type	Description	Example of Answers
Before-warning type	Preparing demand reduction strategies acted before the warning from demand monitor	We have learned to curb the warning through the adjustment process of air-conditioner's operation for electricity saving. (large customer, communication infrastructure constructor)
After-warning type	Preparing demand reduction strategies acted after the warning from demand monitor	We made demand reduction strategies in the summer of 2011. Automatic and manual actions were taken after the warning. (large customer, electronics devices manufacturer)
Irrelevant type	No connection between demand reduction and demand monitor	We already have achieved 40% energy conservation, so the warning can not be sounded. (small customer, retail)

Table 2: Issues regarding penetration of HEMS, and current evaluation results for resolving the issues

○ : Has been resolved or will be resolved in the near future/ △ : Resolved/ × : uncertain
※ Because we sorted out the issues from the viewpoint of customers, we excluded communication standards.

Issues		Contents	Evaluation
Effect of energy saving		There is the dispersion, but around 10% of energy saving effects are anticipated on the average. However, all is an effect by the HEMS or is opaque. The continuity of the effect is uncertain, too. It is an urgent problem.	△
Cost/advantage	High installation cost	High installation cost compared with the required pay back years and the willingness-to-pay	×
Cost/advantage	Installation in existing house	Burden of wiring work/Introduction cost stands out.	×
Cost/advantage	Advantage for consumers	Uncertain advantage/ effective public relations	×
Cost/advantage	Value added service	Attractive killer contents	×
Cost/advantage	Business model	Establishment of business model	×
Level of understanding of consumers for energy saving		To improve energy saving consciousness /proactive behavior/continuity	×
Technology /function	Comfortableness	Customizable	○
Technology /function	User-friendliness	User-friendliness	○
System	Assist	Subsidy	○
System	Protection of personal information /cybersecurity	Fear of leaking of personal information/ fear of appliances breakdown and fire by wrongful control	△