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

Assessment of the Value of Next-generation Demand Management

Background and Objective

In the wake of the Great East Japan Earthquake, electricity saving has become more entrenched and various attempts to utilize Demand Response (DR), such as encouraging peak shaving or load shift of electricity demand through the electricity rate, have attracted public attention for considering electricity demand. Moreover, DR is expected to be utilized for the stabilization of electricity supply systems including the response for rapid installation of photovoltaic (PV) systems or regulatory reform of the electricity market.

In this project, we analyze behavior on energy saving and assess the feasibility of electricity demand management by DR, from both the viewpoints of the electric utility and customers, in order to choose the desirable method of demand management for the future and for identifying any issues which must be solved or necessary schemes.

Main results

1 Ex-post analysis of electricity saving measures in the residential and commercial sector during 2011-14

Based on a questionnaire survey on energy saving conducted between 2011-2014, we found awareness of electricity saving and the level of saving behavior had been declining even though the saving level had been maintained in the summer season for both office buildings and households (Fig. 1 and 2). The factor for energy saving has also been changing so that the effects of switching to energy-efficient appliances and increased electricity prices covered the decline in awareness of electricity saving and the level of saving behavior. This result is important for electric utilities to estimate electricity demand (Y14013) (Y14014).

2 Technology trend of demand analysis and exploratory verification for the utilization of smart meter data

Considering the increased introduction of smart meters, we completed a regression analysis to disaggregate the converted data of actual records for four households in units of 100 Wh and one hour interval into i) temperature-sensitive demand, ii) variable demand, and iii) static demand, and confirmed the temperature-sensitive demand was in relatively good agreement with air conditioner demand (Fig. 3). This method is anticipated to be used to propose advice on energy saving or new services which are useful for life (Y14003).

3 Cost-benefit analysis of voltage stabilizing measure in distribution network with large-scale introduction of PV systems

Reactive power compensation is a measure against the voltage-rise in distribution networks caused by reverse power flow from roof-mounted PV systems. The idea of installing a reactive power compensator in low-voltage distribution networks has been previously proposed, because it is close to the PV location. This research proposed four installation schemes (Table 1) and a cost comparison method of the low-voltage reactive power compensator. In this method, the most cost-effective installation scheme can be selected, calculating the equipment capacity needed for voltage stabilization. As shown in Fig. 4, pole-mounted case and consumer-end case have the least equipment capacity due to optimum location minimizing total capacity. In these cases, reactive power compensators are installed where voltage-rise problems occur; hence, the cost-effectiveness is high at low PV penetration when voltage-rise problems occur locally (Y14010).

4 Current utilization status of demand-side resources for ancillary services in the U.S.

We researched the trends of utilizing demand-side resources for ancillary service in the U.S. to find out if demand resources have the ability to provide ancillary services through literature researches of 6 ISO/RTOs (Table 2). Electric Reliability Council of Texas is worthy of attention as a reference case of future Japanese frequency regulation due to its power system scale and installation scale of renewable energy resources. Another notable ISO will be the California ISO where a significant amount of photovoltaic has been installed. We extracted key points when ancillary services provision from demand-side resources are applied in Japan; i) stepwise introduction of demand responses into the ancillary service market, and ii) enhancement of the reliability evaluation method of demand-side resources (Y14011).

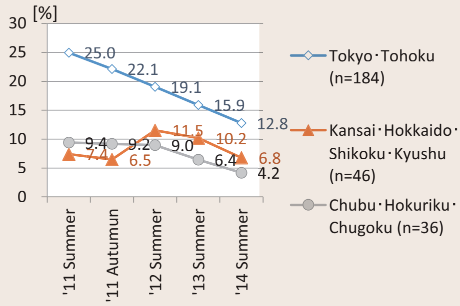

Fig. 1: Rate of overall reduction in office buildings in summer

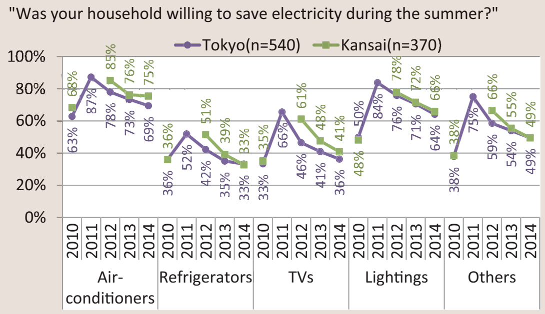

Fig. 2: Awareness of electricity saving in households

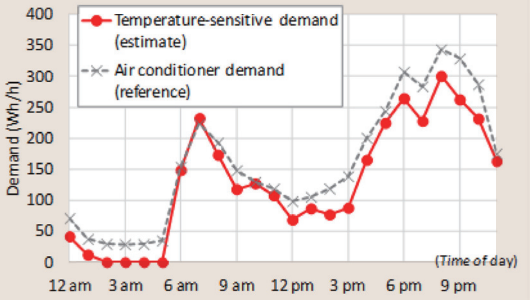

Fig. 3: Yearly averaged temperature-sensitive demand and air conditioner demand

Table 1: Case settings for installation of reactive power compensator

Case	Type of reactive power compensator	Installation location
High-voltage line	Static Var Compensator (SVC)	● Terminal node of high-voltage line ● Discrete capacity with 300kVA
PV-node installation	Use inverter owned by consumers or install equipment for reactive power compensation	● Consumer end where PV is installed
Consumer-end installation		● Optimal location among all consumer end to minimize total capacity
Pole-mounted	Pole-mounted equipment	● Optimal location among all power pole to minimize total capacity

Pole-mounted case and consumer-end case have the least equipment capacity, followed by PV-node installation case, and then high-voltage line case. The suppressive effect on voltage-rise by compensating reactive power depends on the reactance value. Because service wire has a small reactance value, the pole-mounted case, in which equipment is installed before the service wire, and consumer-end case, in which equipment is installed after the service wire, have almost the same capacity.

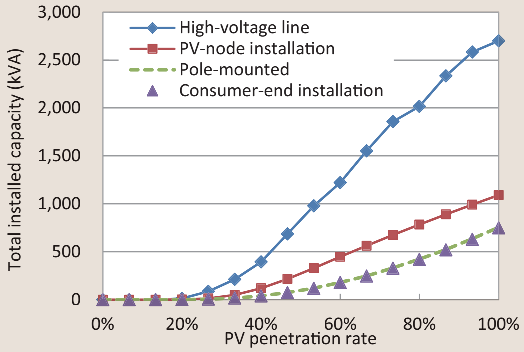

Fig. 4: Total installed capacity of reactive power compensator: average value of randomly-generated 1,000 scenario

Table 2: Current status of utilizing demand-side resources for ancillary services in each ISO/RTO

ISO/RTO		ERCOT	PJM	NYISO	ISO-NE	MISO	CAISO
Peak demand [MW] (year)		68,305 (2013)	163,848 (2011)	33,956 (2013)	27,379 (2013)	130,000 (2013)	46,847 (2013)
Capacity ratio of wind power and photovoltaic to peak demand (year)		16.1% (2013)	6.5% (2012, 2013[1])	4.3% (2013)	4.7% (2013)	9.2% (2013)	22.3% (2013)
Participation of demand side resources on ancillary service market		Yes	Yes	Yes	Yes	Yes	No
Participation capacity of demand side resource	Frequency regulation	37 MW (2014)	2.46 MW (2013)	100MW[3] (2012)	—	—	—
	Spinning reserve	3,300 MW (2014)	605,521MWh[2] (2013)		—	—	—

ERCOT: Electric Reliability Council of Texas, NYISO: New York ISO, ISO-NE: ISO New England, MISO: Mid-Continent ISO, CAISO: California ISO

[*1] Some states aggregated data in 2012 and others in 2013

[*2] This unit represents the product of contract capacity [MW] and contract period [hour].

[*3] Summation of capacities of regulation and reserve

In the spinning reserve market of ERCOT, where a significant amount of wind power generation has been installed, demand resources account for 50% of the required amount of spinning reserve most of the time, contributing substantially. On the other hand, utilizing demand-side resources for frequency regulation is still in the testing stage.