An Analysis on the Smart Community Connecting Commercial and Residential Sectors and the Future Subjects

by

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Abstract

In recent years, the progress of information and communication technologies is remarkable. The storage system of electricity is also being made a progress. Therefore, in this study, we would like to analyze economics of smart community connecting the commercial and residential sector using photovoltaic cell and electricity storage system under various conditions.

The electricity storage system has the largest problem of economics in smart community functions. Under the present cost situations on the electricity storage system, total economics of smart community become worse, as the size of electricity storage system becomes larger.

For the expansion of smart communities, the cost reduction of smart facilities is important as a future subject. Of these, the cost reduction of the electricity storage system would play a key role particularly from the viewpoint of technology.

Introduction

Recently Japanese Government has determined the new target of GHGs reduction to achieve 26% reduction from the emission level in 2013 up to 2030. Because of the East Japan great earthquake and Fukushima nuclear accident, the discussions on the reduction target were wandered so largely and finally converged into the present conclusion. However, Japan must intensify her GHGs reduction measures basically in the long-run, because she already agreed 50% (or 80%) reduction of GHGs in 2050 in the past Summits etc.

The first commitment period of Kyoto Protocol finished in 2012. The GHGs emissions in Japan have increased to the large extent from the 1990 level (the base level in Kyoto Protocol). Especially speaking, the continuous increases in GHGs emission in the commercial and residential sector were largely influenced to the whole increases.

In recent years, the progress of information and communication technologies is so remarkable and the large progress is also made in the storage system of electricity. Therefore, in this study, we would like to analyze the economics of smart community connecting the commercial and residential sector using photovoltaic cell and electricity storage system under various conditions. We also would like to discuss the future subjects of smart community.
Methods

In this study, we made economics simulations on the introduction of smart facilities such as photovoltaic cell and electricity storage system as important functions of smart community. Figure 1 shows the electricity supply and demand patterns for January, April, July and October used in this study.

First of all, the average electricity demand pattern in a house and an office building was estimated by month based on the METI survey report [1], EDMC survey data [2] and Cogeneration Comprehensive Manual [3]. We also surveyed present situations on photovoltaic cell, and electricity storage system [4, 5]. The average daily pattern of solar power generation was estimated by month using NEDO Sunshine Database (NEDO [2006]).

The number of households in the residential sector was assumed to be 15,000 and the total floor area in the commercial sector was also assumed to be 300,000 m². The capacity of photovoltaic (PV) cell for each house in the residential sector was assumed at 4 kW. The number of households installed a photovoltaic (PV) panel was changed from 0 to 15,000 by every 2,500 in the simulation. The capacity of photovoltaic (PV) cell in the commercial sector was changed from 0 MW to 240 MW every 40 MW.

The capacity of electricity storage system was also changed from 0 kWh to 240,000 kWh by every 40,000 kWh in the simulation. The charging of electricity storage system is made from 0:00 to 6:00 for cheap purchased electricity in midnight if necessary and from 7:00 to 18:00 for surplus PV electricity, and the discharging of electricity storage system is made in necessary hours judging from electricity consumption. The charging of surplus PV electricity has the first priority.

The assumptions on photovoltaic (PV) cell are as follows. The cost of photovoltaic cell was assumed to be 350,000 Yen/kW for the house use (small-scale) and 300,000 Yen/kW for the mega solar use (large scale) by examining various data on photovoltaic cells. The cost of electricity storage system was assumed to be 150,000 Yen/kWh by examining various data on electricity storage system.

According to the Photovoltaic Expansion Center, the subsidy system to the photovoltaic(PV) cell for the house use was as follows: (1) the subsidy from Japanese government is 20,000 Yen/kW if the cost of concerned PV system for subsidy is 410,000 Yen/kW or less and is 15,000 Yen/kW if the cost of concerned PV system for subsidy is between 410,000 and 500,000 Yen/kW, and (2) As for the subsidy from the local government, in the case of the Metropolis of Tokyo, there is no subsidy from the Metropolis but subsidy of average 50,000 Yen/kW with upper limit of average 200,000 Yen.

This subsidy system described above was assumed for the PV introduction in the residential sector in this study. The one third of initial cost of electricity storage system and photovoltaic (PV) cell introduced in the commercial sector was also assumed to be subsidized by the Government.

In addition, the various differences of electricity charge between daytime and night were assumed, as discussed bellows. In this study, several cases of the electricity charges different from hour by hour were assumed under the condition that the total electricity charge revenues to standard electricity consumption of average household based on the existing survey would be the same (neutral) among plural cases.

Final surplus electricity generated by photovoltaic cell was assumed to be sold at FIT (Feed in tariff) price of 37 Yen/kWh for the residential sector and the 32 Yen/kWh for the commercial sector (actual value
(Electricity demand pattern in the commercial sector)

(PV electricity supply pattern)

(Fig. 1  Electricity supply demand patterns assumed in this study)
in fiscal 2013).

The economics of the introduction of smart facilities is judged from the simple payback years which is calculated by dividing the net initial cost (excluding cost covered by the subsidy) of necessary facilities by the annual profit brought by the reduction of purchased electricity and the sales of surplus PV electricity under the FIT system.

Results

Figure 2 - 4 show changes in daily electricity supply-demand by the introduction of PV system (4 kW for 0 or 15,000 houses in the residential sector and 0 or 60 MW in the commercial sector) and electricity storage system (240 MWh) as for the winter season (January), the intermediate season (April) and the summer season (July), respectively.

In the case of no PV introduction both in residential and commercial sectors, the cheap electricity purchased from the power company in midnight and before dawn is fully charged into the electricity storage system. Especially in January, the purchased electricity from the power company is charged into the electricity storage system.

As shown in Fig. 2 - 4 in the case of no PV introduction ether in residential or commercial sector, the surplus PV electricity is directly supplied to the other sector in day time and the remaining surplus PV electricity charged into the storage system for discharging in evening or night time. In the case of PV 60 MW both in the residential and commercial sectors, the remaining surplus PV electricity is sold to the power company.

Figure 5 - 6 shows the estimated results on changes in economics of smart community using photovoltaic cell and electricity storage system under various cost conditions. The increase on the capacity of electricity storage system is quite important to reduce purchased electricity by using photovoltaic cell effectively in the smart community. Based on these results in this study, the purchased electricity could be largely reduced if the size of electricity storage system becomes larger.

However, under the present cost conditions such as the electricity storage cost 150,000 Yen/kWh, the economics of smart community become worse rapidly, judging from the payback years. It is considered that the infiltration of smart communities would be quite difficult in the present stage, because the cost burden of introducing smart facilities, especially the electricity storage system is too large.

The introduction of the electricity storage system only is not largely contributed to improve the economics of smart community, as shown in Figs. 5 and 6. The introduction of the photovoltaic cell can improve the economics of smart community, but as the scale of the electricity storage system becomes larger, the economics of smart community becomes worse, also as shown in Figs. 5 and 6.

Figure 7 shows differences in payback years caused by changing various conditions such as electricity charge, FIT price, PV cost and ESS (electricity storage system) cost. For the improvement of economics in the smart community, the differences of electricity charge among peak,
Fig. 2  Changes in daily electricity supply-demand patterns by the introduction of PV system in winter season (January)
Fig. 3 Changes in daily electricity supply-demand patterns by the introduction of PV system in intermediate season (April)
Fig. 4 Changes in daily electricity supply-demand patterns by the introduction of PV system in summer season (July)
(Note) RES: Residential sector, COM: Commercial sector, EL: Electricity, PV: Photovoltaic cell and ESS: Electricity storage system.

Fig. 5 Changes in electricity supply-demand in the smart community and changes in economics by the installed PV capacity in the residential sector

Fig. 6 Changes in electricity supply-demand in the smart community and changes in economics by the installed PV capacity in the commercial sector
<Base case>  
Electricity charge: differentiated by peak, day and night time. 
FIT price: 33 Yen/kWh (small-size), 27 Yen/kWh (large size). 
PV cost: 350,000 Yen/kW (small-size) 300,000 Yen/kWh (large size) 
ESS cost: 150,000 Yen/kWh.

<Change case 1>  
Electricity charge: flat on the whole day

<Change case 2>  
FIT price: 14 Yen/kWh (small size), 7 Yen/kWh (large size)

<Change case 3>  
PV cost: 120,000 Yen/kW (small-size) 100,000 Yen/kWh (large size) ESS cost: 50,000 Yen/kWh.

Fig. 7  Differences in payback years by changing various conditions and changes in economics

day and night time and the cost reduction of smart facilities such as PV and ESS are quite important. As compared with these factors, the influence of FIT price change is not so large, as shown in Fig. 7

Based on these results in this study, the purchased electricity could be largely reduced if the size
of electricity storage system becomes larger, but the economics of smart community become worse rapidly, judging from the payback years. It is considered that the infiltration of smart communities would be quite difficult in the present stage, because the cost burden of introducing smart facilities, especially in the case that the electricity storage system is too large.

Conclusions

The electricity storage system has the largest problem of economics in smart community functions. Under the present cost situations on the electricity storage system, total economics of smart community become worse, as the size of electricity storage system becomes larger.

For the expansion of smart communities, the cost reduction of smart facilities is important as a future subject. Of these, the cost reduction of the electricity storage system would play a key role particularly from the viewpoint of technology.

It is quite essential to strengthen peoples’ incentives to the introduction of smart house from the viewpoints of policy. It is also required to look FIT system over more carefully. The smart community would be expected to influence to peoples’ life style in the future

References