SUITABLE COMBINATION OF PHOTOVOTAIC CELL AND ELECTRICITY STORAGE SYSTEM IN THE SMART COMMUNITY CONNECTING THE COMMERCIAL AND RESIDENTIAL SECTORS

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Overview

Recently Japanese Government has determined the new target of GHGs reduction to achieve 26% reduction from the emission level in 2013 up to 2030. The discussions on the reduction target of GHGs were wandered so largely in recent 4 or 5 years and finally converged. However, in the long-run, Japan must basically strengthen her GHGs reduction measures, because she already agreed 50% (or 80%) reduction of GHGs in 2050. In addition, the Paris agreement on post Kyoto GHGs reduction was finally approved by many countries including various developing countries in December 2015.

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

In recent years, the storage system of electricity such as NAS and redox flow batteries is also being made a large progress. The smart community connecting both commercial and residential sectors is widely noticed. Therefore, in this study, we would like to analyze suitable capacity combination of photovoltaic cell (PV) and electricity storage system (ESS) in the smart community.

Methods

In this study, we made various simulations on the introduction of smart facilities such as PV and ESS as important functions of smart community connecting the commercial and residential sectors. First of all, the average electricity demand pattern in the commercial and residential sectors was estimated by month based on the METI report [1], EDMC data [2] and Cogeneration Comprehensive Manual [3]. We also surveyed present situations on PV and ESS on the basis of NEDO and METI reports [4, 5]. The average daily pattern of PV generation was estimated by month using NEDO Sunshine Database [6].

The number of households in the residential sector was assumed to be 1,000 and the total floor area in the commercial sector was also assumed to be 25,000 m^2. The capacity of PV for each house in the residential sector was assumed at 4 kW. In the simulation, first, we determined the starting point in which purchased electricity from the power company outside could be made absolutely zero (a kind of extreme case). There were two cases: one was PV maximum (PV capacity 40,000 kW and ESS capacity 20,000 kWh) and the other was ESS maximum (ESS capacity 39,000 kWh and PV capacity 5,500 kW). We analyzed suitable capacity combination of PV and ESS starting from the ESS maximum case.

The various differences of electricity charge between daytime and night were assumed. The investment return of smart facilities is checked by the simple payback years which is calculated by dividing the net initial cost (excluding cost covered by the subsidy) of required equipment by the annual profit brought by the reduction of purchased electricity and the sales of PV electricity to outside.

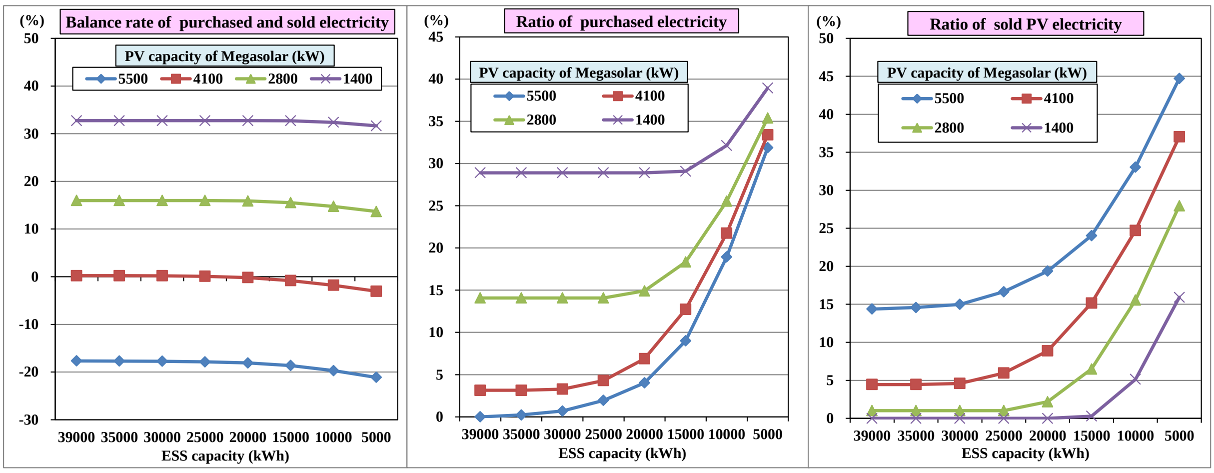

Fig. 1 Changes in various ratios related to purchaced and sold electricities

Results

Figure 1 shows various ratios related to purchased and sold electricity by the smart community. At the starting point of ESS maximum case, though the purchased electricity can be reduced to absolutely zero at any time, the payback year of 29.5 in this case is too long and the final remaining PV electricity sold to outside is also large. As judging from the balance ratio of purchased and sold electricity in the smart community shown in Fig. 1, the purchased electricity from outside is almost balanced with the sold PV electricity to outside through out the year if the installed PV capacity is 4,100 kW.

Figure 2 shows various ratios related to ESS performances. If the capacity of ESS is positioned at between 39,000 and 20,000 kWh, various ratios shown in Figs. 1 and 2 are not changed so largely. If the capacity of ESS is lower than 20,000 kWh, these ratios are changed drastically. The payback year of smart community is more improved as the capacity of ESS is lowered. Based on these results, the PV capacity of 4,100 kW and the ESS capacity of 20,000 kWh would be the most suitable combination. The payback year of this case is lowered to 21.6 and the operation rate of ESS rises to 61.6% as shown in Fig.1.

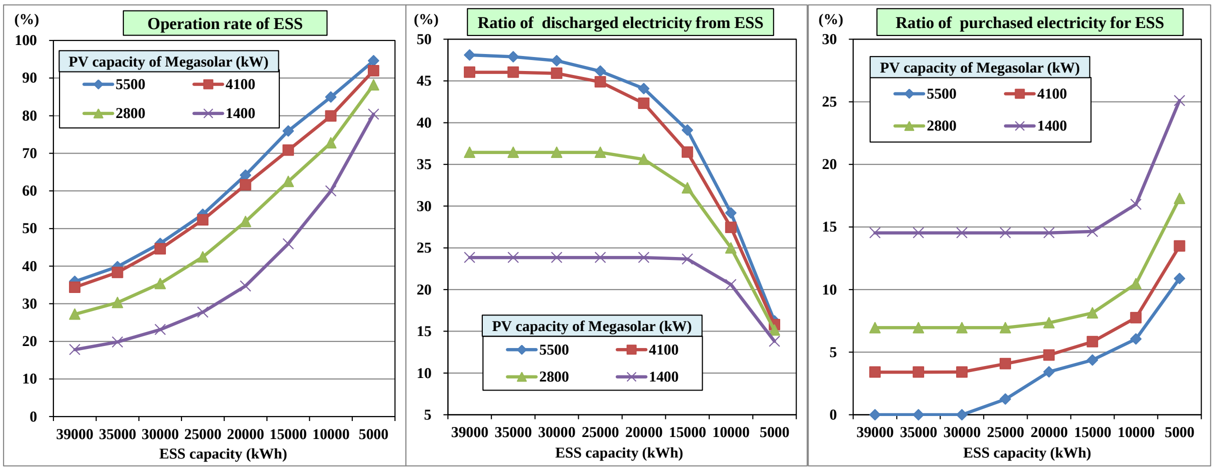

Fig. 2 Changes in various ratios related to ESS performances

Conclusions

The absolutely zero purchased electricity at any time is often pursued in the smart community as an achievable target. But the realization of this target is quite difficult and extremely inefficient. Instead of this target, the balancing between the purchased electricity and the sold PV electricity would be an important target which should be considered.

We also need to consider the balancing between the economics of smart community and the role of installed ESS capacity. In order to reduce purchased electricity more, the larger ESS installed capacity would be required. However the economics of smart community becomes worse rapidly as the ESS capacity become larger.

Under the present cost conditions, the economics of smart community would not be so preferable. For the expansion of smart community connecting the commercial and residential sectors, the cost reduction of smart facilities, especially for ESS, would be quite important.

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