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QUESTION N° : No.4

Evaluation of imbalance reduction by battery utilization and aggregation

In Japan, the total amount of renewable energy generation that started operation with FIT (Feed-in Tariff) system by the end of March 2021 is about 61.4 GW, 91% of which is solar power. From 2022, FIT shifts to the FIP (Feed-in Premium) system except for some small facilities. Under the FIP system, renewable energy power producers bear two risks: 1) market risk and 2) imbalance risk. In the demonstration project in Japan in FY 2021*, we tried to evaluate how much the imbalance risk can be reduced by utilizing the storage battery or by aggregation under the FIP system. There is a unique balancing market product called RR-FIT (Tertially 2) that covers the FIT forecast error (imbalance) in Japan. Under this situation this contribution provide information for forecast the commercial value and scale of Japan's RR-FIT as well.

The imbalance MAPE (Mean Absolute Percentage Error, %) is used as an index of imbalance.

Imbalance MAPE $=\frac{1}{N}\sum_{t=1}^{N}|\frac{I_t}{L}|\times 100$, $It = Rt - Pt$,

It: the amount of imbalance in a certain 30 min. at t
Rt: Final power supply (kWh) in a 30-min. at t
Pt : Planed amount of generation (kWh) as of the previous day in a certain 30 min. at t
L : Installed capacity (kWh in 30 min.)
N : Number of (Evaluation period)/(30 min.)

1. Imbalance reduction by charge / discharge control of storage battery

A simulation was conducted by using data from 102 resources in 7 areas (see Table 1). The condition setting for simulation are as follows,

- Assumed that one generation BG is formed with all the resources with valid data within the same area.
- The storage battery were 1h rated and their capacity were equal to the total output of the generation resources on the assumption. (for example, if the the power plant is 1 MW, the storage battery is set to 1 MW / 1 MWh.) The number of storage battery was set to one, and the charge / discharge efficiency was set to 95%.
- Regarding charge / discharge control of storage batteries, first, on the morning of the day of power generation, the power generation amount of the day is forecasted in 30 minutes slice. Difference between the forecasted power generation amount on the morning and the power generation plan developed on the day before are used as the forecasted amount of imbalance. A charge / discharge schedule for the storage battery

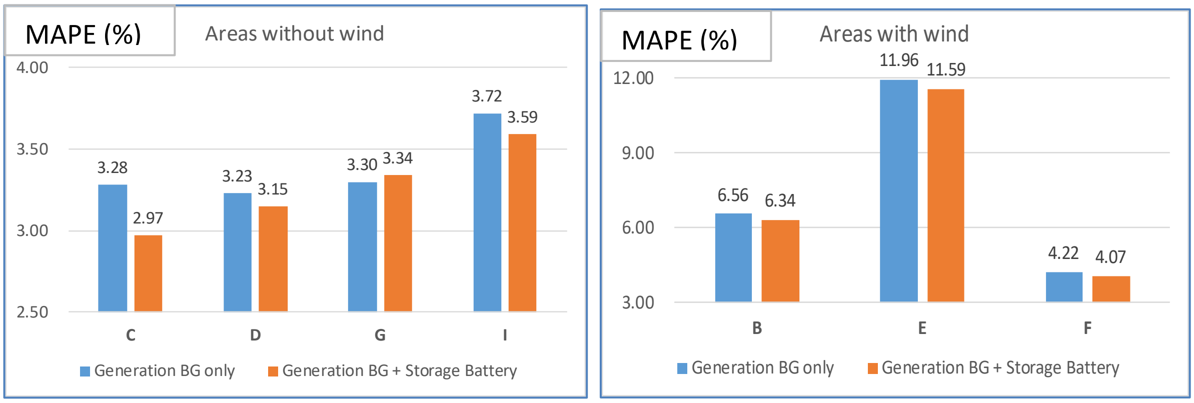
is created accordingly, and the storage battery is controlled every 30 minutes so that the imbalance value becomes zero.

Table 1: List of areas and resources

Area	No. of resources	Wind in BG	Total capacity of renewables (MW)
B	12	Yes	76.16
C	25	No	97.71
D	5	No	3.74
E	11	Yes	15.34
F	7	Yes	67.70
G	10	No	9.11
I	32	No	64.28

The results are as shown in Fig.1.

- The MAPE of Area C, D, G, and I, which composed power generation BG with PV only, was in the 3% range.
- The MAPE of B, E, and F, which are areas containing wind power, tended to be large. And the MAPE in area E, which has many wind power sites, was particularly large.



(a) Areas without wind power (b)Areas with wind power

Fig. 1: Imbalance MAPE reduction by storage battery

- The storage battery generally reduced MAPE by about 0.1-0.3%. There is room for improvement in the charge / discharge plan of the storage battery, and it is thought that MAPE can be further improved by this optimization.
- The imbalance increased in area G. The reason seems to be that an event occurred in which the storage battery was moved in the opposite direction to the actual amount of power generation due to the forecast error of surplus / shortage imbalance.
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2. Imbalance reduction by BG size

Evaluated data from 119 PV resources in 7 areas. The size of BG was set as shown in Table 2.

Table 2: BG size setting for PV resources

Area	Maximum No. of PV resources	Total capacity(MW)	BG Size (No. of resources)				
			XS	S	M	L	XL
B	16	102.26	8	11	16	–	–
C	35	128.71	5	9	18	24	35
D	5	68.74	3	5	–	–	–
E	7	22.82	4	7	–	–	–
F	6	67.70	3	6	–	–	–
G	18	18.07	4	9	18	–	–
I	32	80.28	8	12	16	24	32

The results are shown in Fig.2. By increasing the BG size, the imbalance MAPE also showed a decreasing trend. The resource group in area E was affected by snowfall, and the forecasting error for each resource in area E varied widely.

It was confirmed that the imbalance of renewable energy generation can be reduced by the optimal charge / discharge control of the storage battery, and by increasing the scale of BG by the aggregator.

* Publicly solicited by the Ministry of Economy, Trade and Industry (METI) in Japan in FY 2021. The official name of the project is " FY2021 Subsidy for Demonstration Project for Establishing Next-Generation Technologies Using Distributed Energy Resources such as Storage Batteries (Renewable Energy Aggregation Demonstration Project within the Renewable Energy Generation Aggregation Technology Demonstration Project) "

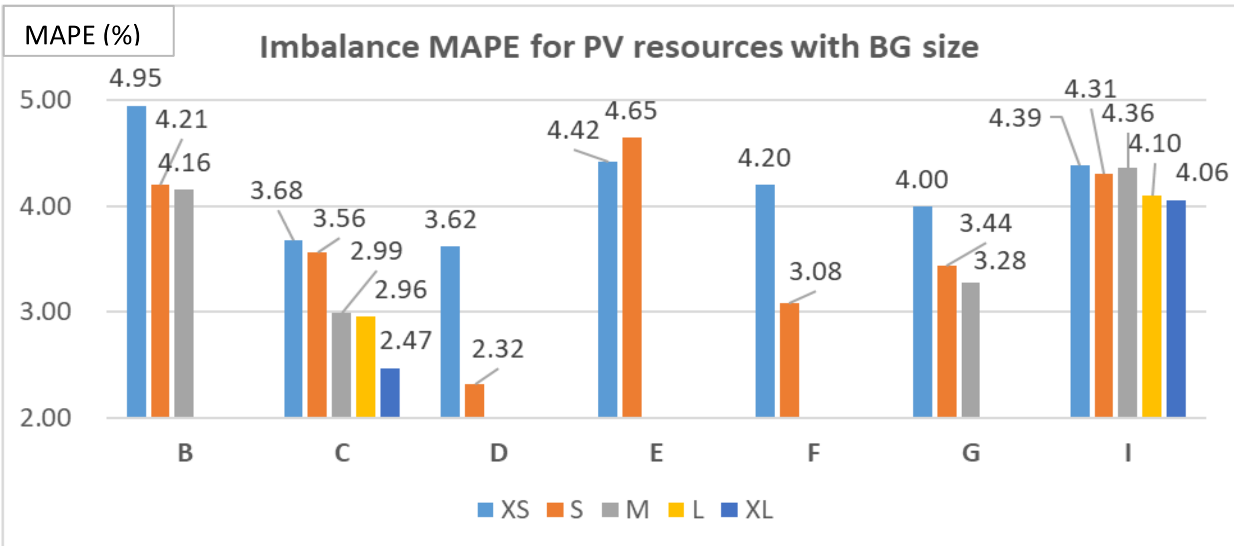

Fig. 3: Imbalance MAPE for PV resources with BG size