PERFORMANCE ANALYSIS OF VARIOUS SYSTEM CONFIGURATIONS ON GRID-CONNECTED RESIDENTIAL PV SYSTEMS

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ABSTRACT

Performance and loss analysis of residential PV systems are conducted using SV method. Performance of the various system configurations are quantitatively analyzed and compared in this paper. Difference of the module manufacturers shows more than 5 [%] differences in the performance ratio whereas array configuration shows less difference.

1. INTRODUCTION

Grid-connected residential photovoltaic (PV) system is one of the main applications in Japanese PV market. Approximately 50 [%] of the single houses are expected to have PV systems in PV2030 [1]. Under such high dissemination rate of residential PV systems in urban area, deterioration in the quality of electricity becomes serious. To investigate the issues of these PV systems, "Demonstrative research on clustered PV systems" has been conducted since December, 2002 in Ota, Japan. [2] Approximately 2.1 [MW] of PV systems which are composed of 553 residential PV systems are installed in the demonstration research area. Since the design of the roof is not always optimized for the PV system, various kinds of system configurations are used in the research area. System performances of each PV systems are quantitatively analyzed and comparison results of different system configurations are summarized in this paper.

2. ANALYSIS METHOD

Data from July, 2006 to June, 2007 are used for the analysis. Array output current and voltage, PCS output current, voltage and power and module temperature which are measured at a few selected systems are used for the analysis along with the irradiation data which is measured at the meteorological stations using pyranometer. One-minute averages of secondly measured data are used for the analysis.

Sophisticated verification (SV) method [3][4] is employed for the analysis. SV method can quantitatively separate the system performance loss into 12 loss factors which are;

1. Inverter
2. Module Temperature
3. PCS capacity shortage
4. Grid voltage
5. Operating point mismatch (high voltage side)
6. Fluctuation
7. PCS Off / PCS Standby
8. Reflection
9. DC circuit resistance
10. Shading
11. System peak power loss
12. Miscellaneous loss.

System peak power loss includes soiling, degradation and imbalance of the PV module's current-voltage (I-V) characteristics within the array. Operating point mismatch (high voltage side) includes non-dynamic maximum power point tracker error mainly occurred due to the stepped I-V curve of the array and intentional output regulation due to the PCS's protective functions.

Systems which have significant shading loss are excluded from the comparison.

3. SYSTEM CONFIGURATION

To compare all the different system configurations, array configuration are classified into 3 types, i.e. single array oriented south as type1, multiple arrays oriented south and/or east and/or west as type2 and array(s) not oriented south as type3. Manufacturers of the PV modules, those of the PCS's, presence of the DC/DC converter before the PCS's input and number of the PV module type are also used for the system configuration classification. Definitions of the classification and number of systems are summarized in Table I.

4. RESULTS AND DISCUSSIONS

Performance ratios of each system, average performance ratio for each configuration and average reference yield for each configuration are summarized in Fig. 1. Average performance ratios are also added in Table I. Configurations from 1 to 4 are the comparison of the different module manufacturers with their own PCS, configurations from 5 to 8 are similar comparison but only for modules because PCSs are from manufacturer E. The same comparison can be seen in array type 2, Type2 also include the comparison for the presence of DC/DC converter (9-10, 12-13) and number of module type (15-16). Loss analysis result using SV method is summarized in Fig. 2.

Table I Definition of system configuration classification

Configuration number	Array type	Module manufacturer	PCS manufacturer	With DC/DC converter	# of module type	# of systems	Performance ratio [%]
1	1	A	A	No	1	43	77.7
2	1	B	B	No	1	41	81.6
3	1	C	C	No	1	35	77.3
4	1	D	D	Yes	1	23	71.1
5	1	A	E	No	1	38	78.1
6	1	B	E	No	1	27	81.4
7	1	C	E	No	1	31	76.8
8	1	D	E	No	1	35	74.7
9	2	A	A	No	1	7	76.6
10	2	A	A	Yes	1	17	73.3
11	2	B	B	No	1	16	79.3
12	2	C	C	No	1	15	76.9
13	2	C	C	Yes	1	11	76.4
14	2	C	C	Both	2	6	75.2
15	2	D	D	Yes	1	3	71.2
16	2	D	D	Yes	2	31	66.1
17	2	A	E	No	1	9	78.1
18	2	B	E	No	1	28	79.1
19	2	C	E	No	1 or 2	11	76.4
20	2	D	E	No	1 or 2	14	75.1
21	3	All	All	Both	1	25	74.9

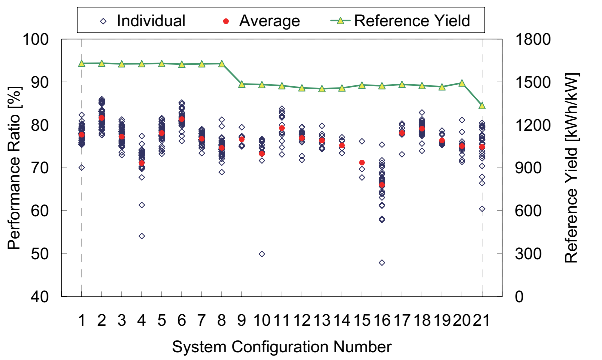

Fig. 1 Performance ratios of all the systems and average for each system configuration with reference yield.

As a result, differences of the performance ratios between array type 1 and type 2 are smaller than those among the module / PCS manufacturers whereas reference yield results approximately 10 [%] lower in type 2. Configuration 2, 6 and 11 which have PV modules of manufacturer B result highest average performance ratio. This is mainly because of the small value of the temperature coefficient, loss due to the module temperature is less than the other modules which is shown in Fig. 2. On the other hand, modules from manufacturer D result lowest performance ratio in all the comparison. This is mainly because of the low efficiency of the PCS and higher system peak power loss. Detailed analysis of the high system peak power loss needs to be performed in order to clarify the cause of low performance ratio.

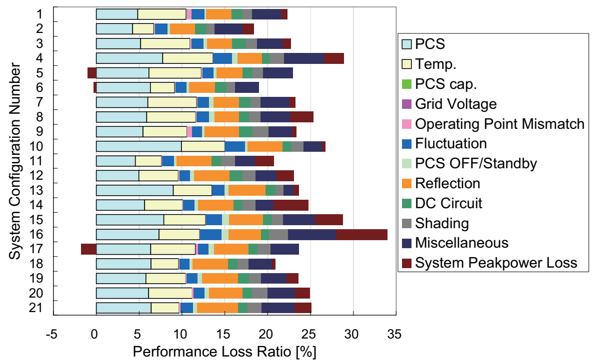

Fig. 2 Performance loss ratios for each system configuration.

5. CONCLUSIONS

Detailed performance and loss comparison among the various system configurations is summarized in this paper. Differences of the performance ratios between configurations are quantitatively analyzed.

This research is performed as a part of "Demonstrative research on clustered PV systems" which is a project of New Energy and Industrial Technology Development Organization (NEDO). Authors would like to acknowledge the financial support of NEDO and cooperative discussions with project members.

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