A Method for Presuming Total Output Fluctuation of Highly Penetrated Photovoltaic Generation Considering Mutual Smoothing Effect

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Abstract

It is well recognized that total fluctuation of geographically diversified renewable energy (RE) is further less than the sum of individual fluctuation. The phenomenon is called "Mutual Smoothing Effect". It is quite important to evaluate the effect because amount and cost of countermeasures for maintaining soundness of power system highly depends on the evaluation of total fluctuation considering the effect. In spite of the importance, there is no established method to evaluate the effect yet.

We propose a method for presuming total output fluctuation of highly penetrated REs from irradiance data of limited number of monitoring sites considering mutual smoothing effect. By analyzing irradiance data measured at 15 sites diversified in Hokuriku region (a central-north part of Japan), existing photovoltaic (PV) output fluctuation is revealed to be coherent at slower swing period and random at faster. To represent this PV's fluctuation tendencies, "Transfer Hypothesis" is introduced, that means total fluctuation of REs transfers from coherent to random as fluctuation gets faster. Additionally, "Constant Transfer Swing Period" hypothesis and "-20dB/decade Slope" hypothesis are supplementary introduced. Those hypotheses are verified by direct and indirect methods using the measured irradiance data. Only 3 sites' data are able to presume total fluctuation of 15 sites' measured data successfully. Relationship of distance and transfer swing period of every 2 sites out of the 15 sites agrees to those hypotheses.

Finally we estimate total fluctuation characteristics of highly penetrated PV in Hokuriku region using proposed methods. By spectrum analysis, the fast fluctuation (one hour swing period or faster) is calculated as Pythagoras sum of spectrum components faster than one hour swing period in three ways. Each calculation result agrees each other and is slightly less than fast demand fluctuation. By time sequential analysis, it turns out that fast fluctuation of highly penetrated PV is quite smoothed out comparing with that of 15 sites' fluctuation.