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Estimation of Photovoltaic Power Prediction Technology Using Unit Commitment Model

UDAGAWA, Yusuke[1*] ; OGIMOTO, Kazuhiko[1] ; FONSECA, Joao[1] ; OOZEKI, Takashi[2] ; OHTAKE, Hideaki[2] ; IKEGAMI, Takashi[3] ; FUKUTOME, Suguru[4]

[1]The University of Tokyo, [2]The National Institute of Advanced Industrial Science and Technology, [3]Tokyo University of Agriculture and Technology, [4]JP Business Service Corporation

Japanese Strategic Energy Plan, established in 2010 and renewed in 2014, shows the basic energy plan of Japan. According to the plan, about 120 GW of renewable energy would be installed, mainly consisting of 53 GW of photovoltaic (PV), 10 GW of wind energy, and 55.6 GW of hydropower generation (including 27.7 GW pumped storage hydro).

Renewable energy can contribute to reducing carbon dioxide emissions and advancing sustainable development. Since they are domestic energy resource, the installation of renewable energy can also improve our energy security. With the importance of the installation, the feed-in tariff scheme for renewable energy was introduced on 1 July 2012. Due to the high premier price (JPY 42/kWh for 10 years for small systems less than 10 kW and JPY 40/kWh for 20 years for larger systems in FY 2012), PV and wind energy systems has installed increasingly. Recently, the installation of 13GW of PV and 0.27 GW of wind energy were achieved by January 2014.

On the other hand, we must focus on the demerit of the installation of renewable energy, especially PV and wind energy whose generation depends on and varies with the condition of weather. Thereby, to introduce a large amount of renewable energy may make it difficult to have stable power system operation (e.g. the variability of PV and wind energy destabilize the frequency of power systems). We have to be careful to make sure that we anticipate what the future power system might be.

The development of PV and wind power prediction technology is very important issue to utilize variable renewable energy sources (v-RES), achieving the large scales penetration of the v-RES into power grid and providing high stable power system.

Under the situation where there is need for many researchers to try to develop the technology, various approaches (e.g. day-ahead forecasting using numerical weather prediction model, intraday forecasting based on statistics, and short-term forecasting using satellite data) have been done. Forecast improvement is generally evaluated by comparing to measured data and calculating the variability (e.g. the mean error (ME) and the root mean squared error (RMSE)). These statistics cannot accurately evaluate the effect of using prediction data on power system operation. The effect should be evaluated from the point of view of financial indicator (e.g. fuel cost, start-up cost, and operation and maintenance cost) and keeping the stability of power system operation (e.g. supply and demand balance, operating reserve which is referred to as load frequency control capacity, unserved energy, and, surplus and curtailment of v-RES). A unit commitment (dispatch simulation), which determine the least cost solution i.e. schedule of what generators need to be online i.e. start (generate power) to meet the expected (actual) demand, is performed by system operators on actual system operation. These model and simulation are appropriate tool to evaluate the impact of the prediction on power system operation. Our developed model optimize the schedules of the thermal power plants and the pumping systems to minimize the operational cost of power system. We estimated the relationship between forecast error, forecast accuracy, and operational cost using the model.

Keywords: Renewable Energy, Photovoltaics, Prediction Accuracy, Prediction Error, Power system, Supply-Demand Balance