DETERMINING STORAGE RESERVES FOR REGULATING SOLAR VARIABILITY ON THE ELECTRIC POWER GRID

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One of the foremost technical challenges of accepting high levels of solar photovoltaic (PV) energy onto the state power grids is the high speed variability of PV caused by cloud transients. Depending upon the magnitude and speed of these power output changes, significant levels of regulation reserves would potentially be needed, and may even make high-penetration targets impractical.

The issue is particularly pressing in light of aggressive state renewable energy targets. For example, to meet California's Renewable Portfolio Standard (RPS) goal of 33% renewables by 2020, industry experts anticipate that the resource mix will include about 5,000 megawatts (MW) of PV in only 10 years. The extent to which these resources will require regulation, however, is at present unknown, and the energy storage industry and grid operators alike will benefit from models and tools that address the issue.

This paper presents a unique approach to quantifying PV variability by using satellite-derived solar data. The methodology will allow grid operators to forecast PV fleet output and to quantify fleet variability, given the design attributes and locations of individual PV systems. The methodology uses advanced algorithms for tracking cloud patterns, calculating PV plant correlation coefficients, and quantifying diversification effects in a manner that could be used at the control area level.

Initial validation of the model was performed using a network of high-speed solar irradiance data loggers in and around Napa, California. The first test included a network of 25 devices spaced 100 meters apart in a grid representing the spread of a 4-MW plant. The second test redeployed these devices in a 4-kilometer (km) grid (see Figure 1) representing a 400-MW plant. The results were used to confirm the model accuracy and quantify the diversification (Figure 2).

The satellite imagery thus collected lends itself to solar plant forecasting, fleet output forecasting, and fleet variability forecasting. These methods could be used by the Independent System Operators (ISOs) and Regional Transmission Organizations (RTOs) for more accurately planning and scheduling regulation reserves— including storage resources— in anticipation of seasonal and daily periods of high variability. Accuracy in quantification of needed regulation would avoid the two extremes of grid instability on the one hand and overcommitment of resources on the other.

A sample calculation of required reserves is presented for the California ISO control area using the California Public Utilities Commission Long Term Procurement Planning/Renewables Integration figures. This calculation illustrates the procedure for calculating required regulation reserves for 471 PV plants having a combined capacity of 5,434 MW.

This ongoing work has direct implications for the energy storage community as it relates to the market needs for regulation in each of the continent's eight North American Electric Reliability Corporation (NERC) regions.

Fig. 1. 1 km × 1 km irradiance grid in Napa, California.

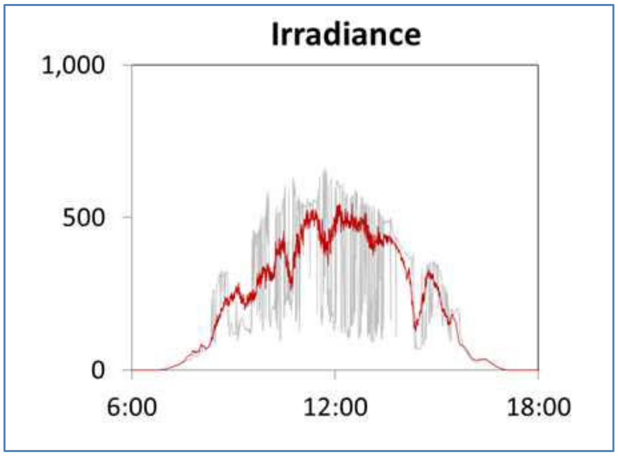

Fig. 2. Diversification effects for 25 sensors, November 21, 2010.

BIOGRAPHICAL NOTE

Conference presenter: Ben Norris has managed technical and economic assessments of grid-connected renewable and storage technologies in the electric power industry for 26 years. His experience covers photovoltaics, solar thermal electric, flywheels, advanced batteries, and fuel cells. He has developed methods for dynamically managing transmission line thermal ratings and for effectively using infrared imaging in transmission and distribution maintenance. Mr. Norris currently manages the Consulting Group at Clean Power Research in Napa, California. Clients include research organizations, financial institutions, utilities, and manufacturers in the United States and abroad. He studied Mechanical Engineering at Stanford University and served on the Board of Directors for the Electricity Storage Association for 8 years.