Subject 5: Operations, Performance and Reliability of Photovoltaics (from Cells to Systems)
5.1 Operation of PV Systems and Plants

Distributed PV Power Generation Forecasting for Distribution Management

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Summary

High penetration of distributed PV generation (DG-PV) assets has created a new energy management and control landscape in the power industry as it has substantially changed operating conditions in the distribution grid. In 2013, Green Power Labs (GPL) and San Diego Gas and Electric (SDG&E) developed an approach to integrate distributed PV generation forecasts with SDG&E's existing distribution management system (DMS) to help account for this growth. The developed technology provides forecasts for the over 20,000 DG-PV assets currently in the SDG&E service area for near real-time forecast horizons at the "electrical resolution" level of service transformers . Enabling distribution management systems with high "electrical" resolution DG-PV forecasting achieves improvement in the performance of existing grid assets and a reduction in the limitations on distributed PV penetration.

Purpose of the work

Currently, circuits in the SDG&E distribution grid feature, in many cases, over 10% and up to 40% DG-PV penetration, and the overall level of penetration on the grid is only expected to increase. As a result, existing energy management assets on the grid like on-load tap changers, capacitor and reactor banks face strong challenges in managing intermittent energy that leads to grid faults. Existing distribution management systems are unable to capture the effects of these DG-PV assets on the grid which limits the ability to effectively control operating conditions in the distribution grid. Integration of high "electrical" resolution distributed PV generation forecast in existing DMS was focused on enabling more efficient use of the energy management assets to improve reliability and help optimize utility operations.

Approach

Based on its existing SolarSatData^{TM} technology platform for PV generation forecasting at the utility-scale level, GPL developed a new methodology and technology for high "electrical" resolution forecasting of distributed PV generation at the service transformer level to be integrated into SDG&E's distribution management system. The developed DG-PV forecasting

technology is able to model the PV power output of an individual site using only the limited data of the site's configuration that is typically available, namely the location and installed capacity. This was achieved by creating a dataset containing over a year's worth of GHI data and simulating the expected production for a variety of potential PV plant configurations, including varied slopes, azimuths, and panel types, using GPL's detailed PV power generation model. A new DG-PV model was developed that best fit this dataset, while also removing any model inputs often not readily available for a distributed generation system. This final DG-PV model was able to eliminate all inputs other than capacity, location, and a few weather-related parameters with only a minimal loss in accuracy when compared to the fully-defined PV power plant model. The DG-PV model was set up for forecasting over 20,000 installed DG-PV assets at service transformer level in the SDG&E's distribution grid. It currently produces both intra-hour (5 minute resolution, 1-3 hours ahead) and hourly (1 hour resolution, 1-120 hours ahead) forecasts of PV generation.

Scientific innovation and relevance

Traditional PV generation forecasts operate on a single point forecast and require a fully defined system to be able to produce accurate forecasts. This is not feasible for distributed PV sites as there is often no information on the actual setup of the site nor any measured power output at the site. Likewise, traditional models may not be applicable to providing forecasts for large numbers of installed sites as they are more computationally intensive than the developed DG-PV model. Being able to model the outputs of DG-PV at high electrical resolution allows distribution management systems to account for the effects of DG-PV at service transformer, circuit, substation, or even system level. Because metering is not available for all distributed PV systems, an alternative means of validating distributed PV forecast was developed. This was done by clustering sites based on similarities in geography and annual GHI profiles and comparing the accuracy of GPL's GHI forecasts in these regions to measured GHI data from local ground stations.

Results and conclusions

The developed distributed PV generation forecast model is capable of forecasting the generation of thousands of distributed generation systems with minimal information on each system at less than 2% increase in error, on average, when compared to full PV power plant models. The forecast can be readily incorporated into utilities' distribution management systems. With increasing penetration of distributed PV into utility grid, high resolution DG-PV forecasts enable more efficient management of the grid assets The developed DG-PV forecast allows SDG&E to fully define the effects of its distributed PV assets on its distribution grid and is readily expandable to incorporate any newly added DG-PV assets. The developed forecast solution is currently being deployed with the utility's advanced DMS.