Photo by SunPower Corporation. NREL 23816.

Absorbing the Sun: Operational Practices and Balancing Reserves in Florida's Municipal Utilities

Florida's municipal utilities are integrating more solar PV generation as costs decline and cities pursue clean energy goals. These utilities also act as balancing authorities responsible for reliably dispatching generation resources to meet load, with peak system demands between 430 megawatts and 3.6 gigawatts. With smaller power system sizes compared to many other U.S. power systems, will these municipal utilities always need to keep most of their thermal generators online to balance out the variability and uncertainty in solar output? Not necessarily.

"Absorbing the Sun" employs detailed modeling to study the relationship between the photovoltaic (PV) share of generation and operating reserve needs in Florida's municipal utilities. The report identifies several approaches that can reduce the reserves required for small balancing authorities with high shares of PV generation.

What are balancing reserves?

Operating a power system is difficult because there is variability and uncertainty in both supply and demand, and the two must always be in balance to maintain stable electric grid frequency and voltages. Balancing reserves refer to both of the below types of real-time adjustments, which operate at different timescales.

Regulation reserves provide continuous, fast, and frequent balancing of supply and demand. Generating units and responsive loads provide this service by following the automatic generation control signals that are sent out in 4-second intervals by system operators.

Flexibility or ramping reserves ensure sufficient ramping capability is available to address balancing needs that present over longer time frames (typically 10-20 minutes). These types of reserves have been introduced in some regions specifically to address wind and solar forecast errors.

These balancing reserves are only a subset of grid reliability services. Other reliability services address additional system needs such as responding to unexpected generator or transmission outages, and voltage control.

How do operational practices affect balancing reserve needs?

The amount of balancing reserves that a balancing authority needs to hold depends on the expected size of the gaps between generator dispatch points and actual demand.

More frequent forecasts and dispatch, such as by increasing the frequency of dispatch from hourly to every 5-to-15-minutes, reduce balancing reserve needs by dispatching generators based on very recent measurements and forecasts. The report estimates significantly different reserve requirements for the same or similar balancing authorities depending on whether the highest frequency dispatch process is day-ahead, hour-ahead, or 5-minute-ahead.

Increasing the accuracy of forecasts also reduces reserve needs. The report leverages historical day-ahead load forecast errors for Florida balancing authorities to estimate reserve needs under day-ahead and hour-ahead operational practices. Normalized against load, balancing authorities with smaller load forecast errors need less reserves.

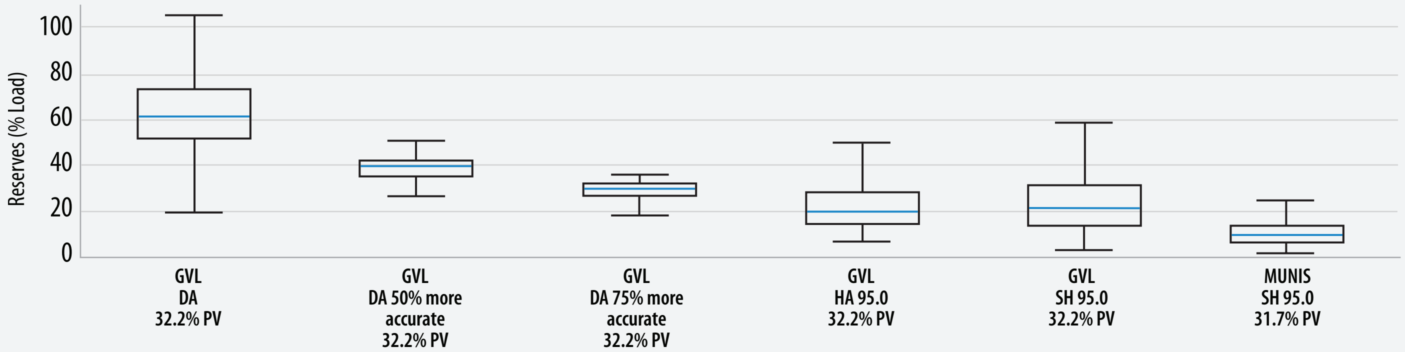

Figure1: Amount of reserve capacity, as a percentage of load in each timestep, needed to provide regulation and flexibility services in the up (more generation) direction for Gainesville Regional Utilities (GVL) when annual PV generation is 30% of annual load. Reserve requirements shrink as the modeled utility incorporates better solar forecasts (from day-ahead [DA] to DA 50% more accurate or DA 75% more accurate), increases its operating frequency (from GVL DA to GVL hour-ahead [HA] or GVL sub-hourly [SH]), and forms an operating reserve sharing group with other utilities (from GVL SH to MUNIS SH). Blue lines show the medians; whiskers extend to the full range of the data.

How does adding solar PV change balancing reserve needs?

Because PV generation is zero marginal cost, its variable output is generally dispatched first and, in many ways, shows up in the system as a negative load. Therefore, balancing authorities can also think about balancing reserves in relation to the gap between forecasted and actual net load, with net load defined as load minus PV generation.

Forecast versus actual solar generation is an uncertainty akin to load forecast uncertainty that must be balanced out by regulation and flexibility reserves. Better and more frequent solar forecasts reduce this uncertainty and the attendant balancing reserve needs.

Steep ramps in net-load profiles caused by the diurnal pattern of PV generation are also subject to uncertainty that can be mitigated by holding ramping reserves in proportion to, for example, hour-ahead solar forecast errors.

How can small balancing authorities moderate their balancing reserve needs as they integrate more solar generation?

At low PV shares, small balancing authorities, such as Gainesville Regional Utilities, might update load forecasts and generator dispatch plans as infrequently as once per day and might not use day-ahead solar forecasts based on weather forecasts. The leftmost box-and-whisker plot in Figure 1 shows that at a 30% PV share, those practices would lead to very high (median of 60% of load) reserve requirements.

Incorporating weather-forecast-based solar forecasts could significantly lower reserve requirements. For example, if solar forecasts were 75% more accurate than the low-data forecasts used in the report, median reserve needs would only be 30% of load (Figure 1, DA 75% more accurate).

Increasing operational frequency by adjusting generator dispatch in response to more frequently measured data and updated forecasts would further reduce reserve needs to a median level of about 20% of load (Figure 1, GVL HA and GVL SH).

Forming an operating reserve sharing group with other Florida municipal utilities would further reduce reserve needs by geographically averaging solar resource and load uncertainty. Analysis suggests median reserve needs of about 10% of load in this case (Figure 1, MUNIS SH).

Learn More

Download the report at https://www.nrel.gov/docs/fy21osti/79385.pdf.

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NREL/FS-6A40-81225 • December 2021