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Improved PV System Modeling with ML-Based Power Model: Case Study of a Commercial Building

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Introduction

Accurately modeling PV system production requires three critical sets of inputs:

1) High quality weather data
2) A software model that properly simulates PV production
3) An accurate characterization of the PV system

Today, modeling PV production of a specific PV system or fleet of systems is a regular occurrence with readily available satellite-derived resource data and vetted software models.

Obtaining correct PV systems specifications, which are complex and unique to each system, is challenging. This typically means collecting detailed system specifications including:

- PV module ratings
- Inverter ratings
- Azimuths
- Tilts
- Solar obstructions
- Fixed/tracking mode
- Module temperature response

Some common problems include inaccurate reporting, a lack of time or expertise to detail shading and system losses, and general differences between real-world conditions and the project design.

By employing Machine Learning, we have developed an advanced power model, that with the use of historical measured PV production data, infers the system specification to produce the most accurate power simulation.

Case Study

The case study was performed for REI San Diego Store. The building had 111 kW AC system installed, that consist of 594 Sharp 216W modules and 1 Satcon AE-100-60-PV-D inverter unit. The PV array orientation was determined as South East at 167° (using phone as compass) with a tilt ~15°. The trees to the South-East present possible shading issues when sun is low on the horizon.

We obtained actual PV power measurements from a site with 15-minute resolution, which spanned from March through November 2018 and we used it to evaluate SolarAnywhere® power output.

With a reported specs we observed high MAPE of 22.6%.

Figure 1: REI San Diego location with shading trees indicated with an arrow and PV modules affected by those trees marked with a rectangle.

Results

We ran the ML-based method to optimize the PV power model using measured data and the location of the system (i.e., latitude and longitude). We simulated hourly PV production using this optimized power model and compared it with the reported system specs.

By using Machine Learning Power Model we were able to reduce the MAPE of power simulations to 14.0%, a reduction in error by about 1/3.

This was accomplished with the following changes to site specification:

- **Solar obstructions and system degradation** – the engine recommend reducing general system derate to 80%. The original spec had a general derate of 75.1%.
- **Azimuth** – the actual azimuth of the system appears to be 178°. The reported azimuth 167° (-13°) most likely doesn't take into account magnetic declination (currently 11.47° E ± 0.33° changing by 0.09° W per year).
- **Tilt** – given the seasonal difference in output from this system, the tilt is probably less than the reported 15°, inference engine recommended using 8°.

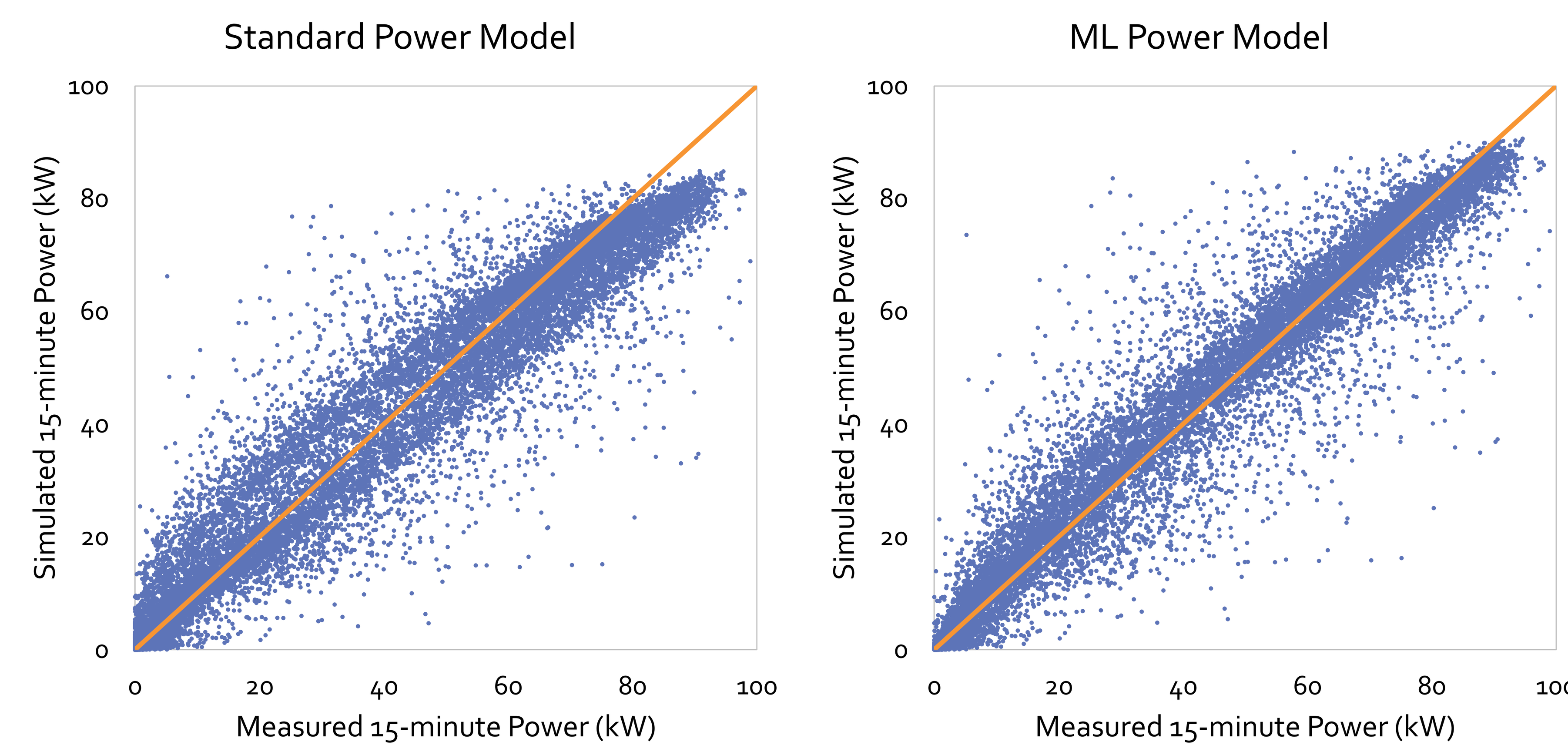

Figure 2: Improved accuracy of the SolarAnywhere simulated output, with the scatter plot marked "ML Power Model" showing better accuracy than scatter using "Standard Power Model".

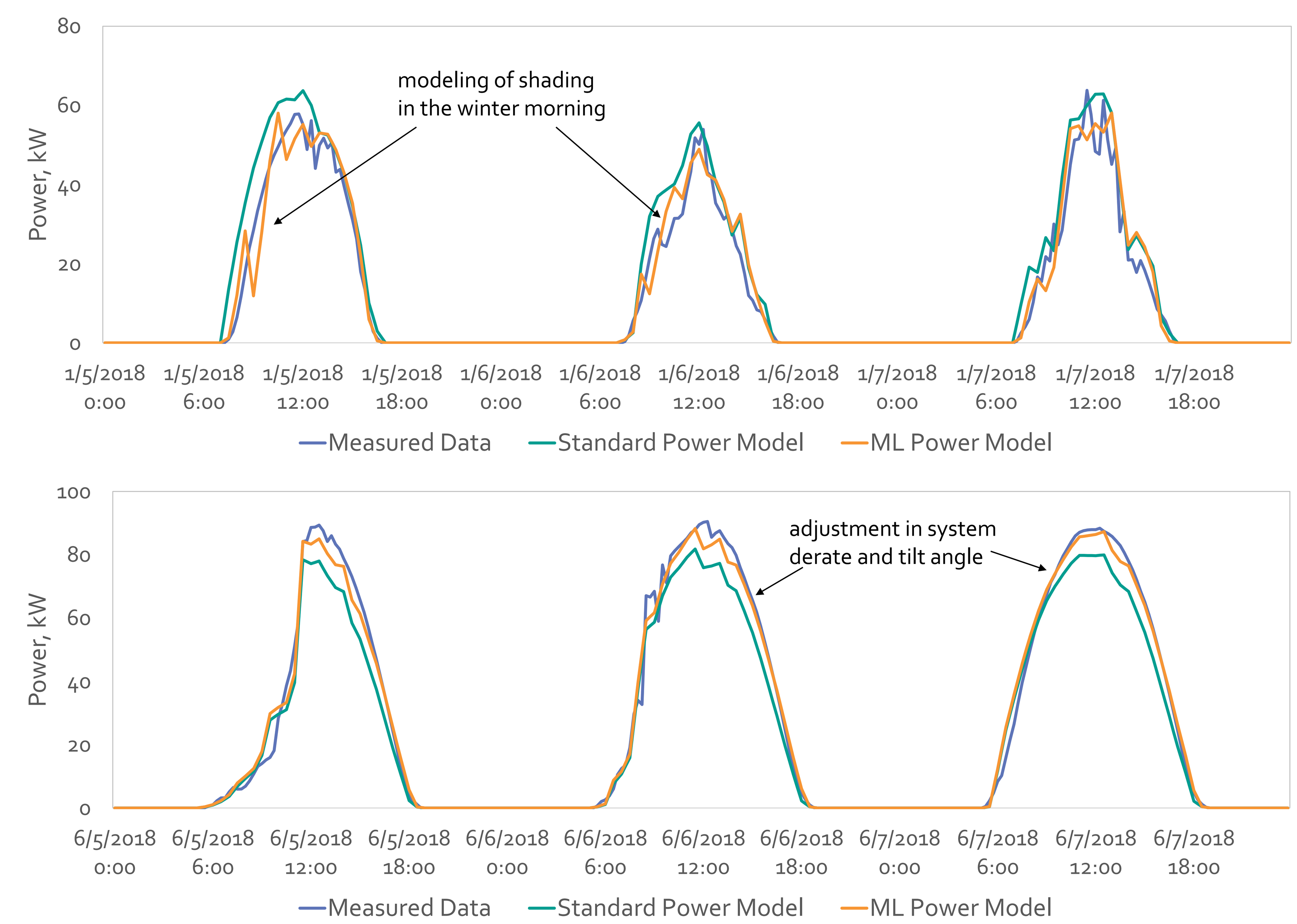

Figure 3: Differences in Power between Standard and Ml Power Model in relation to Measured Data for sample days in January and June.

What does this mean for you?

Clean Power Research has demonstrated how the Machine Learning Power Model can more accurately simulate historical and future PV production for operational systems using measured power data and SolarAnywhere historical irradiance data for training. The approach is scalable to fleets of any size and requires only the measured power data and location for each system. System specifications are not required.

Applications benefitting from the Machine Learning Power Model include: (1) More accurate utility scale solar power forecasting to inform operational and energy trading decisions, (2) Improved forecasts of system or fleet performance relative to performance guarantees and more efficient deployment of O&M resources.

For questions or to discuss your application for the ML power model, please contact Patrick Keelin, Lead Product Manager SolarAnywhere®, at pkeelin@cleanpower.com