A Comparison of PXX Estimation Methods Using Typical-year and Time-series Solar Resource Data

Evan Westphal • Luminate, LLC

Introduction

Probability-of-exceedance (PXX) energy estimates such as P50 and P90 are key inputs when evaluating the bankability and financial risk of a PV project. These metrics are impacted by how solar resource variability is represented. A common industry approach when modeling PV systems is to use a typical-year resource file to define a central energy estimate and then apply interannual variability (IAV) derived from historical time-series satellite data to estimate PXX values. The results of this straightforward approach can vary from the uncertainty results of other more detailed methods such as modeling multiple years directly from historical resource data, or bootstrapping methods that create a larger resource dataset than the current limit of approximately 25 years available through bankable satellite sources.

In this study, we compare approaches to resource and IAV modeling and the impact of those approaches on PXX values and energy generation at the inverter level. We additionally investigate how varying climates and project clipping due to overbuild may impact PXX distributions.

Methods

Approach:

We applied three different PXX estimation methods to four site locations in the Southwest and four site locations in the Northeast to explore the differences in uncertainty results of the methods. We also modulated the DC:AC ratio of a site location in Utah to investigate the impact of project overbuild. PVsyst® 8.0.20 software and SolarAnywhere® 4.0 resource data from 2000-2025 were used for the analysis.

PXX Estimation Methods:

Common Industry Method: Model P50 energy to the inverter using the SolarAnywhere® TGY for the site and then apply IAV uncertainty based on SolarAnywhere® time-series resource data to estimate P50 and P90.

Time-series Method: Model the site using all 26 individual years of SolarAnywhere® time-series data and compute P50 and P90 empirically.

Bootstrapping Method: Use the 26 energy models from the time-series data to bootstrap all possible four-month seasonal combinations and then compute P50 and P90 empirically from the bootstrapped data set.

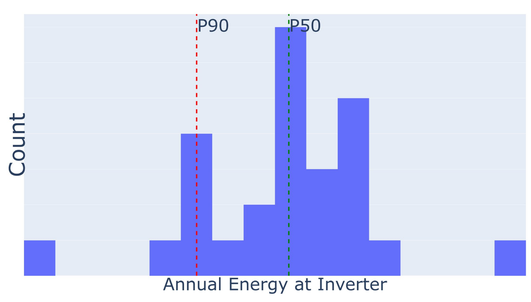

Figure 1: Example Time-Series Method

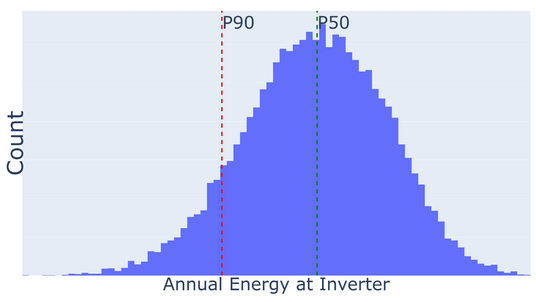

Figure 2: Example Bootstrapping Method

Base PVsyst® System Description:

- Single axis tracking, 35% GCR backtracking, 60-degree tracking limit
- 10 MW AC capacity, 1.2 DC:AC Ratio
- Modeled site locations in AZ, CA, NM, UT, IL, NY, OH, PA

Figure 3: Modeled site locations

Results and Discussion

PXX Methods Comparison

To compare the P50 and P90 results of the different PXX estimation methods, the Common Industry Method is treated as the baseline case, with deltas of the Time-series Method and Bootstrapping Method PXX values plotted against this baseline. Figure 4 shows these P50 and P90 deltas for project sites in Arizona, California, New Mexico and Utah.

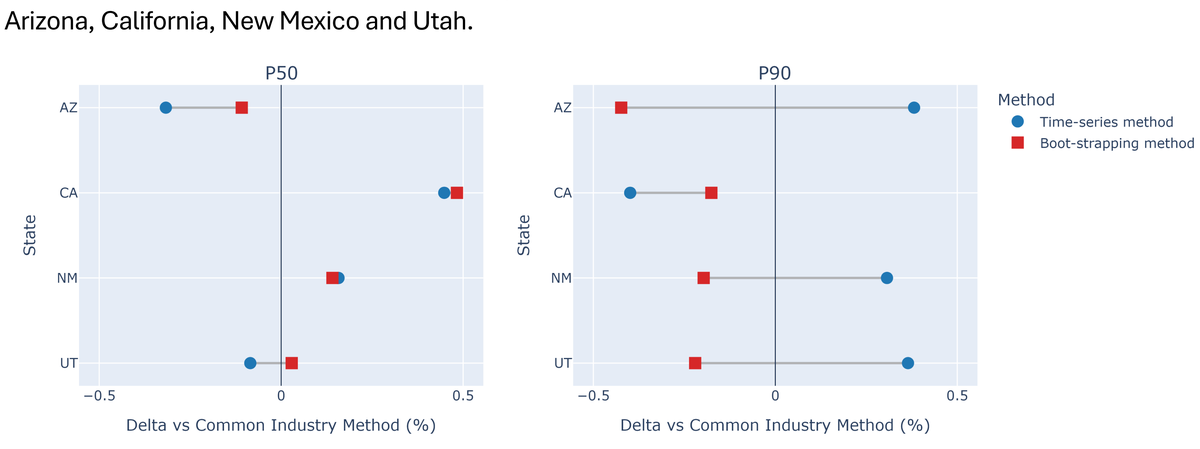

Figure 4: PXX Methods Comparison, Southwest States

The PXX estimation methods are within 0.5% of each other and are overall well-aligned around the central P50 estimate. There is more variability in the P90 values, with the Bootstrapping method having a conservative estimate likely due to the combination of worse-case seasonal years. The Common Industry method seems to be a reasonable middle-ground approach based on these data points. This is further illustrated in Figure 5 that plots the downside spread of the P50:P90 deltas.

Results and Discussion (cont.)

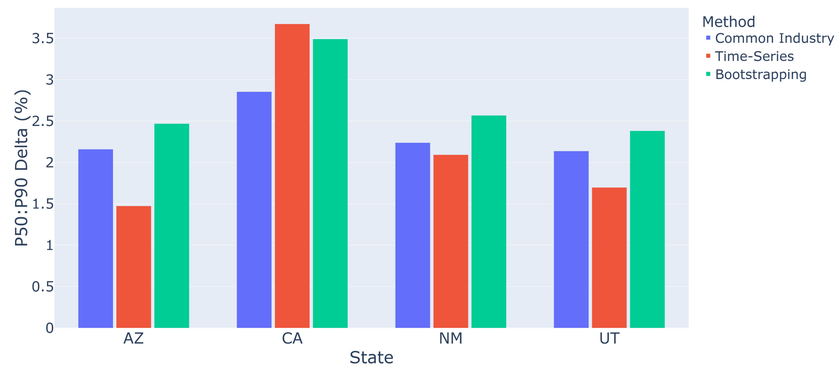

Figure 5: P50:P90 Deltas, Southwest States

The results in Figures 4 and 5 are for project sites in hot, sunny climates in the Southwestern United States. Figures 6 and 7 show the same PXX methods comparison for project sites in Illinois, New York, Ohio, and Pennsylvania. They show that the Common Industry method is still a reasonable central estimate for P50, however the P90 value may be an overestimate. This likely reflects the higher cloud cover and greater resource variability in this region that are not captured in the Common Industry approach.

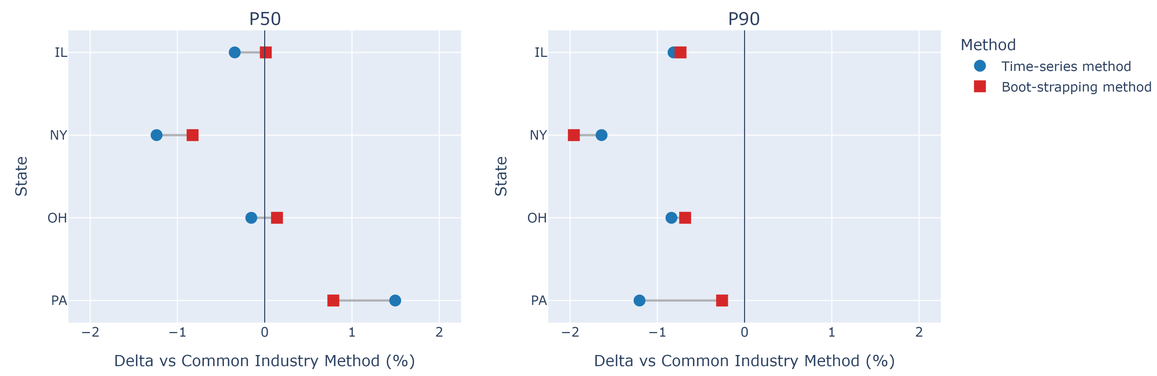

Figure 6: PXX Methods Comparison, Northeast States

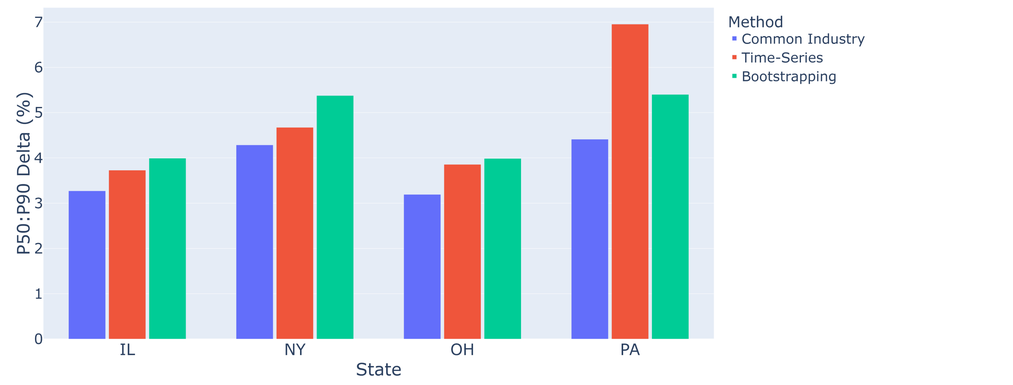

Figure 7: P50:P90 Deltas, Northeast States

Project Overbuild Analysis

Figure 8 compares the PXX method results of varying the DC:AC ratio for the project site in Utah. It shows that at a high DC:AC ratio, the P90 varies slightly more between methods and that the Common Industry Method is a possible underestimate. This may suggest that high clipping acts as a buffer against resource variability, therefore increasing the P90 value.

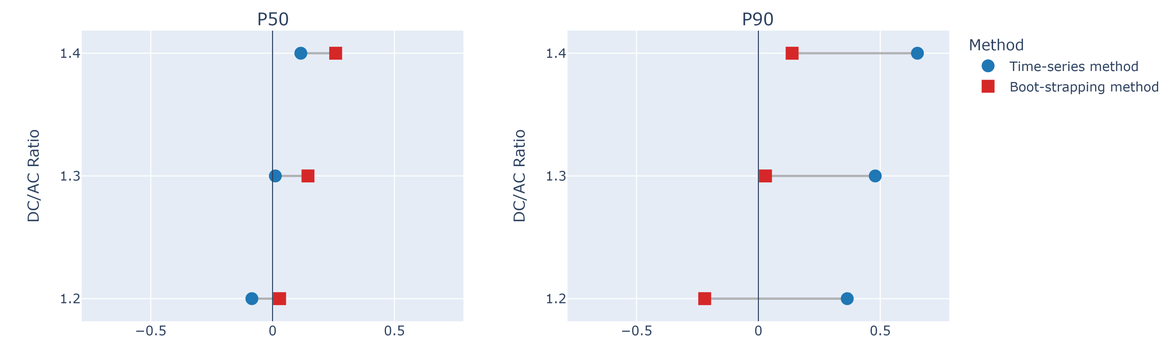

Figure 8: PXX Methods Comparison for Varying DC:AC Ratios, Utah

Conclusions

In this study, we compared three PXX estimation approaches (Common Industry, Time-series, and Bootstrapping methods) using PVsyst® and SolarAnywhere® data across multiple site locations and scenarios, including both Southwest and Northeast climates and a Utah DC:AC ratio sensitivity. Across the cases evaluated, the methods were generally well-aligned around the central P50 estimate, and the Common Industry Method remained a reasonable approach for estimating P50.

For the P90 results, the method choice had a larger impact. Based on the scenarios in this study, the Common Industry Method may overestimate P90 in cloudier climates (such as the Northeast) and may underestimate P90 in high DC:AC ratio scenarios, where clipping appears to buffer against resource variability. Overall, the results suggest the Common Industry Method is a reasonable middle-ground approach for P50, but further analysis may be warranted when estimating P90 values and downside risk.