

# 2023 PVPMC blind modeling comparison



PRESENTED BY

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## 2 Many thanks to the 2021 participants

32 participants from 12 countries and 26 organizations with 29 submissions

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RESEARCH ARTICLE

PHOTOVOLTAICS WILEY

### Blind photovoltaic modeling intercomparison: A multidimensional data analysis and lessons learned

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#### Abstract

The Photovoltaic (PV) Performance Modeling Collaborative (PVMC) organized a blind PV performance modeling intercomparison to allow PV modelers to blindly test their models and modeling ability against real system data. Measured weather and irradiance data were provided along with detailed descriptions of PV systems from two locations (Albuquerque, New Mexico, USA, and Roskilde, Denmark). Participants were asked to simulate the plane-of-array irradiance, module temperature, and DC power output from six systems and submit their results to Sandia for processing. The results showed overall median mean bias (i.e., the average error per participant) of 0.6% in annual irradiation and -3.3% in annual energy yield. While most PV performance modeling results seem to exhibit higher precision and accuracy as compared to an earlier blind PV modeling study in 2010, human errors, modeling skills, and derates were found to still cause significant errors in the estimates.

#### KEYWORDS

blind comparison, modeling, performance, photovoltaic, yield modeling



### 3 Objectives of PVPMC's blind modeling comparisons



1. Quantify differences among modelers
2. Investigate whether some models are more accurate than others
3. See if performance modeling can be improved
4. Quantify validity of PV performance models
5. Find sources of uncertainty
6. Develop best practices to improve functionality and reproducibility



## The 2023 PVPMC blind modeling intercomparison



- What is different in this comparison: Two scenarios from a larger size plant and an iterative process for easier error propagation
- Two tracks: 1) open invitation for anyone to participate, 2) software companies by invitation only
- Call for participants was announced through the PVPMC emailing list in July; invitations to 20 software companies were sent separately
- FAQ section is updated on the PVPMC website as questions arise
- Results are collected and handled by Sandia ensuring **anonymity** and an **unbiased** analysis
- Participants have knowledge of their “participation number”; software names will be published

## Simulation scenarios

Generously shared by: **Gantner**  
instruments

**S1:** Single inverter (80.4 kW<sub>dc</sub>) and whole power plant (**14.5 MW**) of monofacial, fixed-tilt, half-cut monocrystalline Trina Solar in Germany over 1-year at **5-min** avg resolution

**S3:** 15.4 kW<sub>dc</sub> of monofacial, fixed-tilt, LG n-PERT in Albuquerque, NM over 1-year at **1-min** resolution

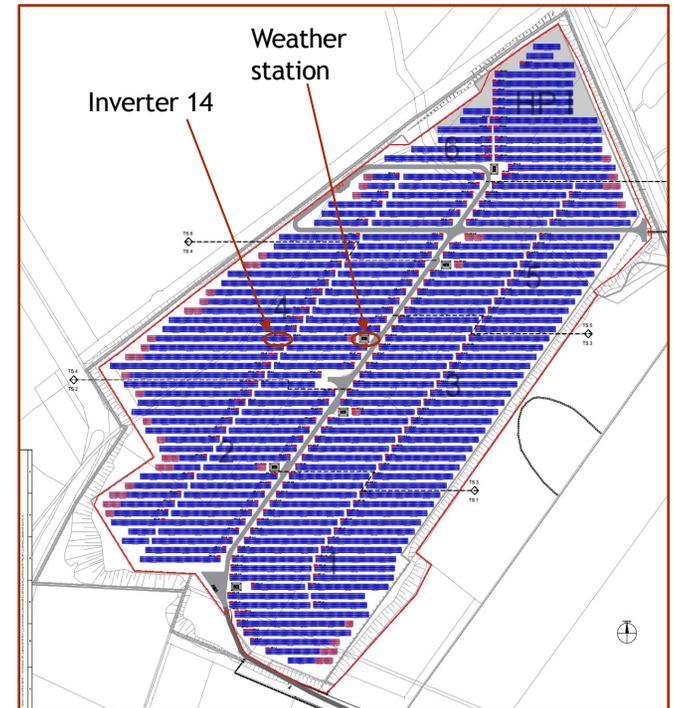
Generously shared by: **Gantner**  
instruments

**S2:** Single inverter (80.4 kW<sub>dc</sub>) and whole power plant (**14.5 MW**) of monofacial, fixed-tilt, half-cut monocrystalline Trina Solar in Germany over 1-year at **hourly** avg resolution

**S4:** 15.4 kW<sub>dc</sub> of monofacial, fixed-tilt, LG n-PERT in Albuquerque, NM over 1-year at **hourly** avg resolution

PHASE 1

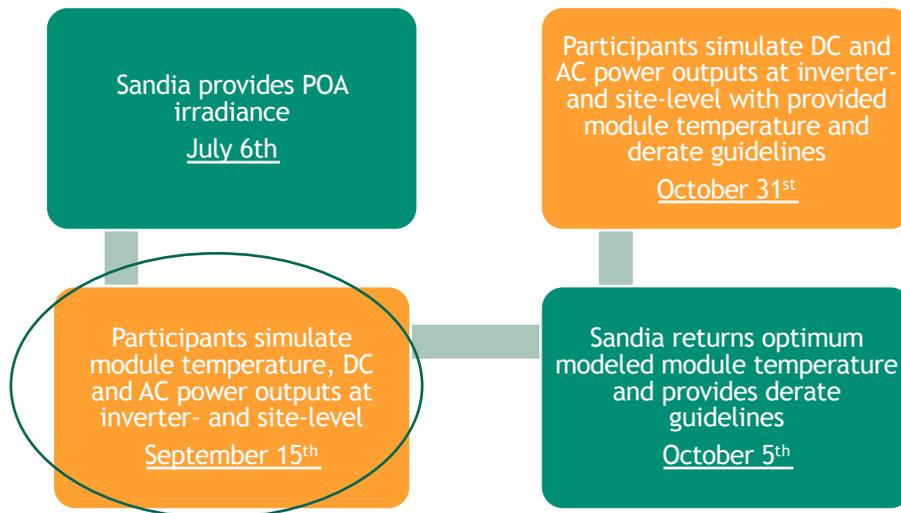
PHASE 2



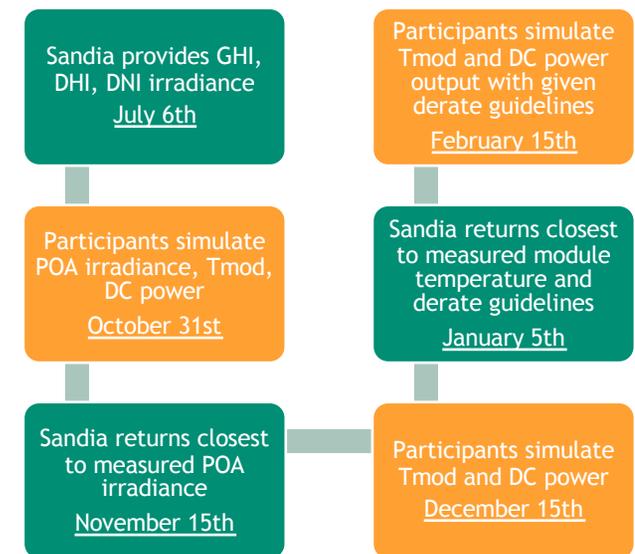
## Blind PVPMC intercomparison iterative process



### PHASE 1 (S1, S2): July - October 2023



### PHASE 2 (S3, S4): October 2023 - February 2024



Iterative process enables error propagation and a self-learning experience  
 Analysis of Phase 1 and 2 will be published in a manuscript with best practices  
 Software comparison will remain open until November 30<sup>th</sup> for Phase 1 and 2



## Participation so far



Juergen Sutterlueti, Joshua S. Stein, Kevin Anderson, Lelia Deville, Chloe Black, Youri Blom, Mark Campanelli, Alejandro Gonzalez Carballo, Gregorio Olivares Casero, Arijit Chakroborty, Felix Perez Cicala, Andrei Cunha, Anton Driesse, A S M Jahid Hasan, Will Hobbs, Adam Rasmus Jensen, Sha Li, Javier Lopez Lorente, Ivan Diaz Martinez, Eduardo Mello Martins, Leonardo Micheli, Ricardo Motta, Marie-Joe Najm, Upama Nakarmi, Maitheli Nikam, Jeff Organ, Suveer Panditrao, Matthew Prilliman, Kurt Rhee, Rafael Pereira Santos, Martin Schneider, Branislav Schnierer, Ioannis Sifnaios, David Smith, Alvaro Fernandez Solas, Navin Vanderwert, Robert Williams, Bruno Wittmer, Changrui Zhao

**Special thanks to  
Juergen Sutterlueti and Gantner Instruments!**

**Gantner**  
instruments

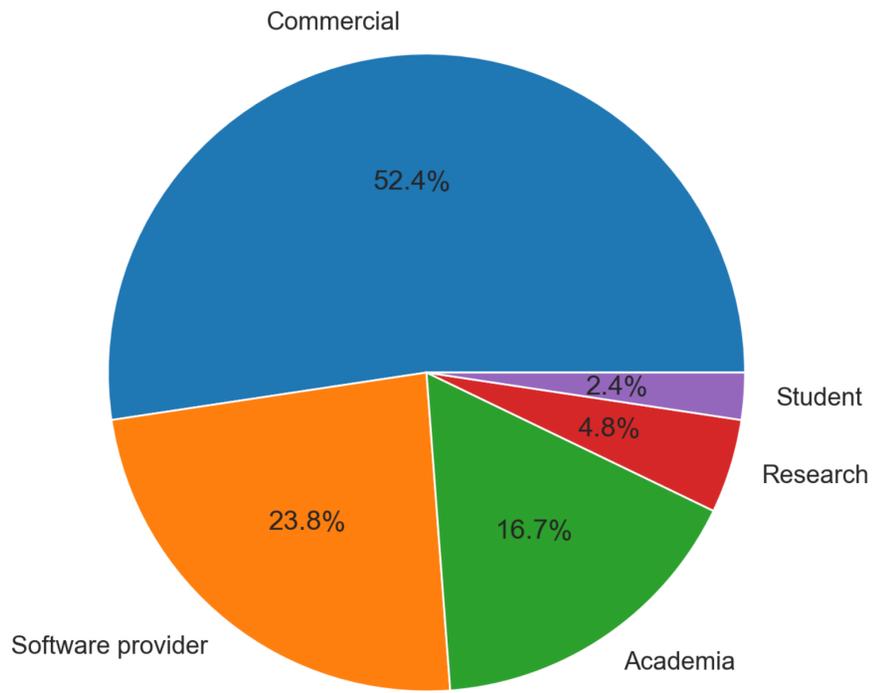
40 participants from 15 countries and 34 organizations with 76 submissions so far



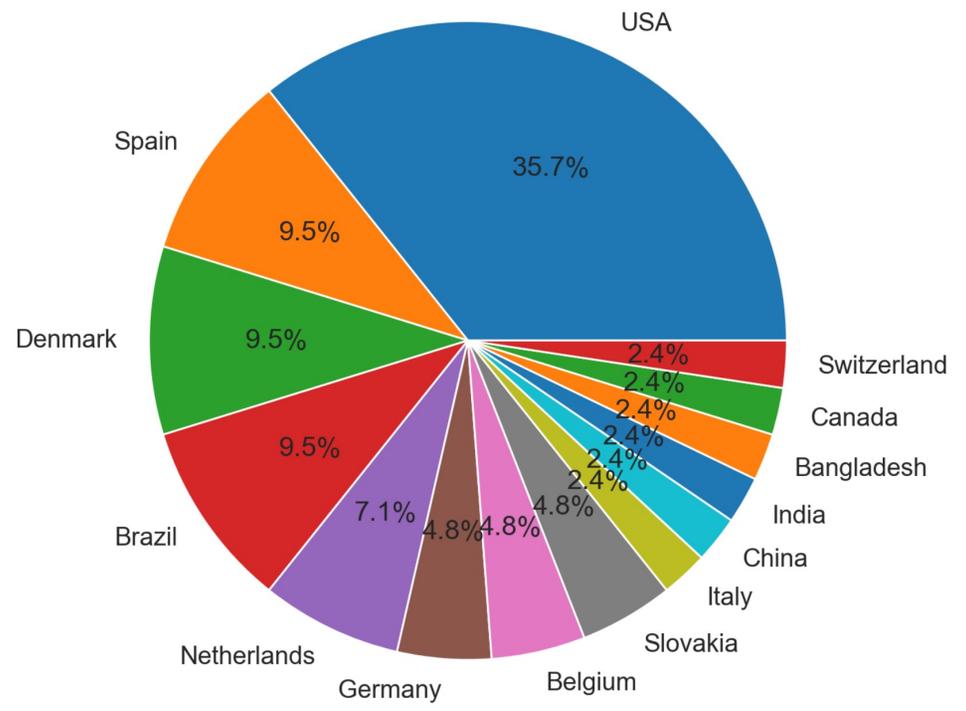
# Participation statistics



### Sector

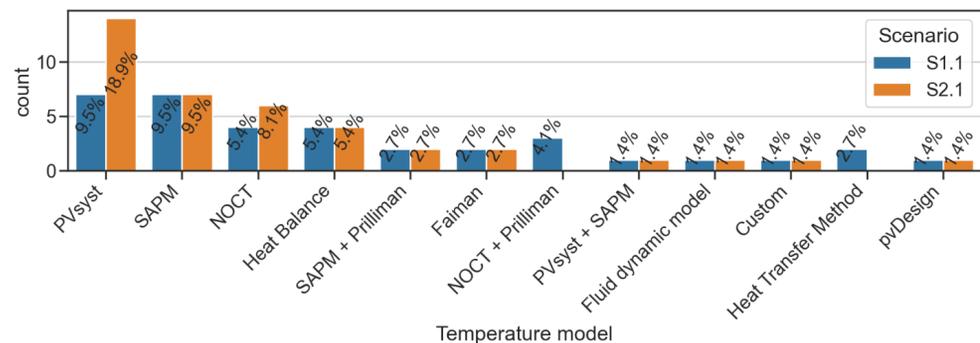
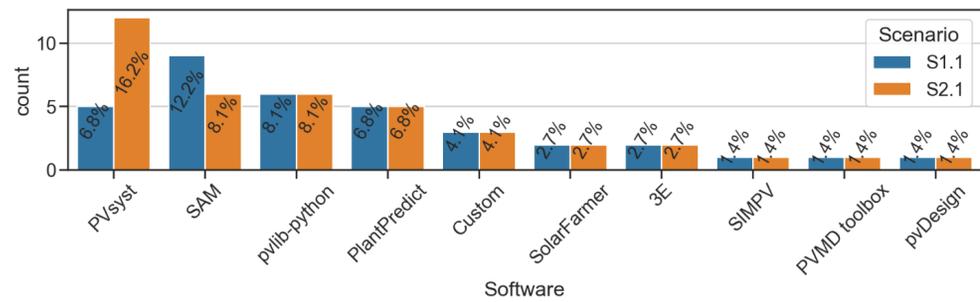
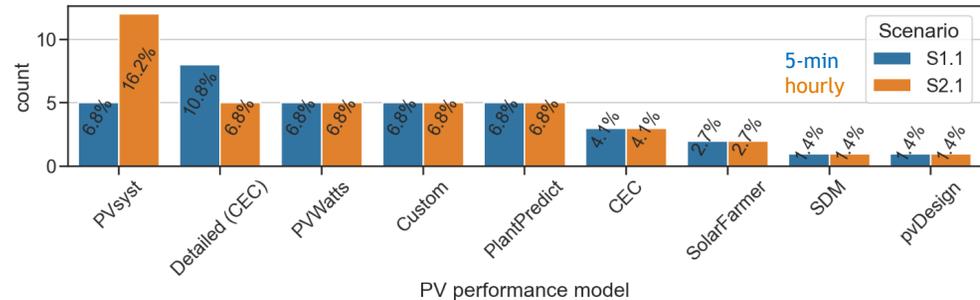


### Country



## Modeling statistics

- Good representation from PVsyst, SAM, PlantPredict and... pvlib-python
- New software that we have not seen before in this exercises
- ~ 50% are PVsyst and SAM users
- Most PVsyst users used SAM for sub-hourly simulations
- ~1/3 used the PVsyst model for Tcell estimation
- Transient models make appearance, especially in sub-hourly simulations

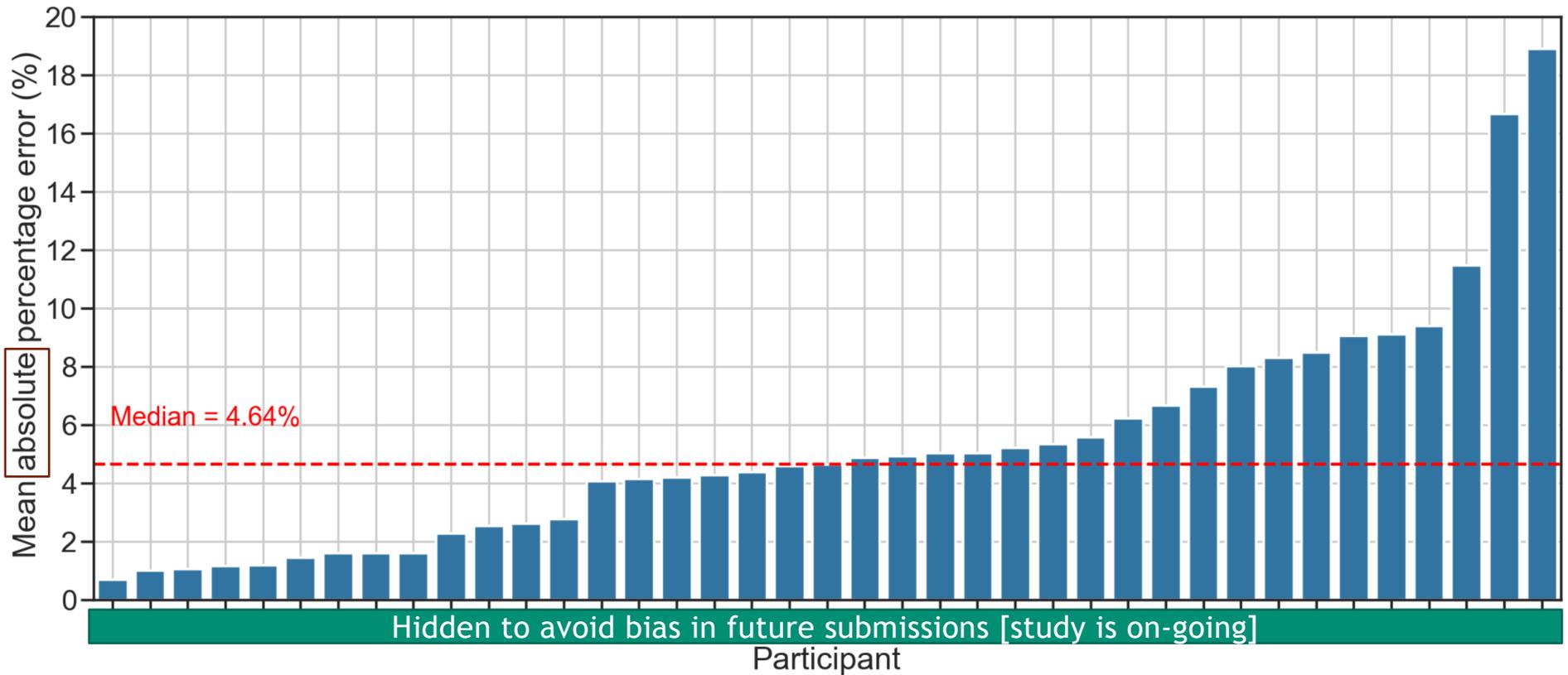




Preliminary results [not to cite]

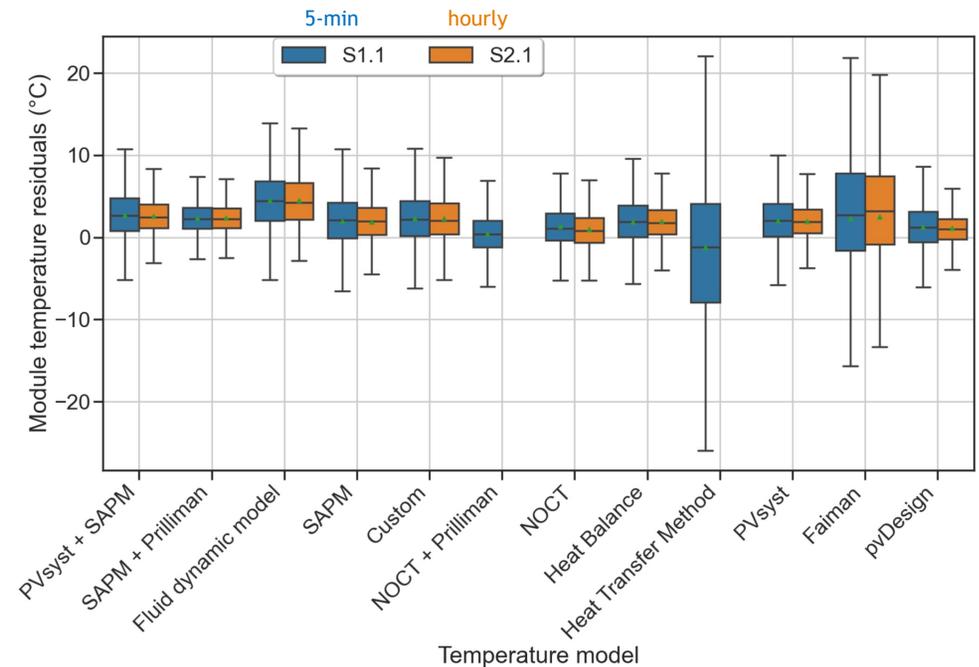


## “Ranking” the participants using MAPE and annualized energy



## Temperature modeling

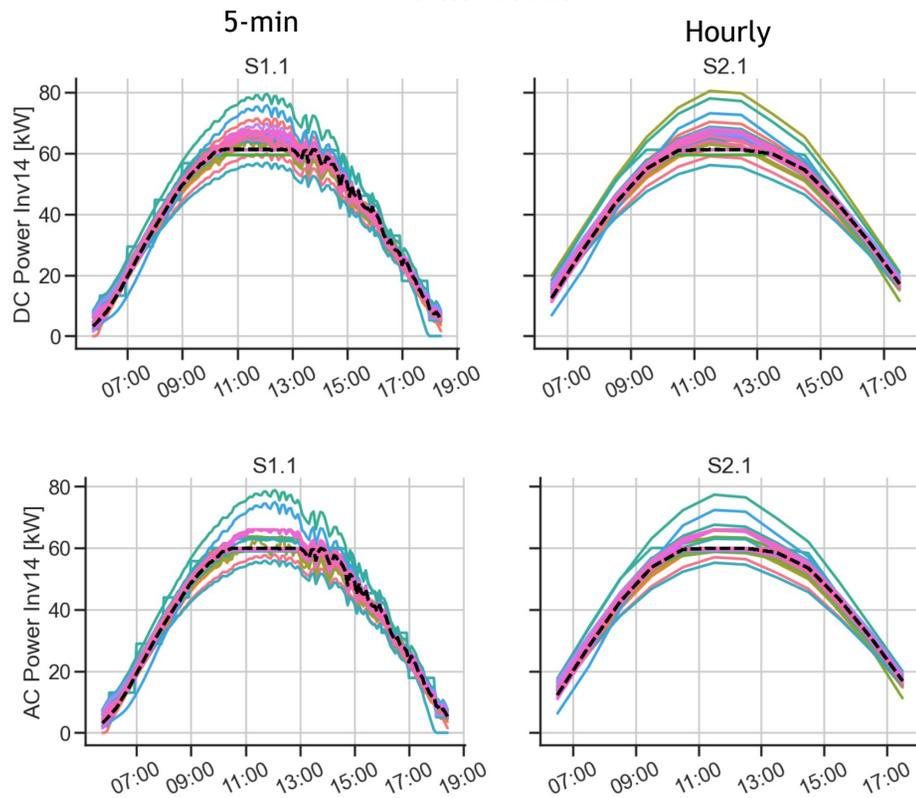
- Overall over-estimation of temperature
- Sub-hourly temperature estimation exhibits higher residuals
- Mean/Median values are lower than 3°C
- Extreme residuals in SAM's "Heat transfer method" by a 1<sup>st</sup> time SAM user
- Transient NOCT seems to exhibit improved performance



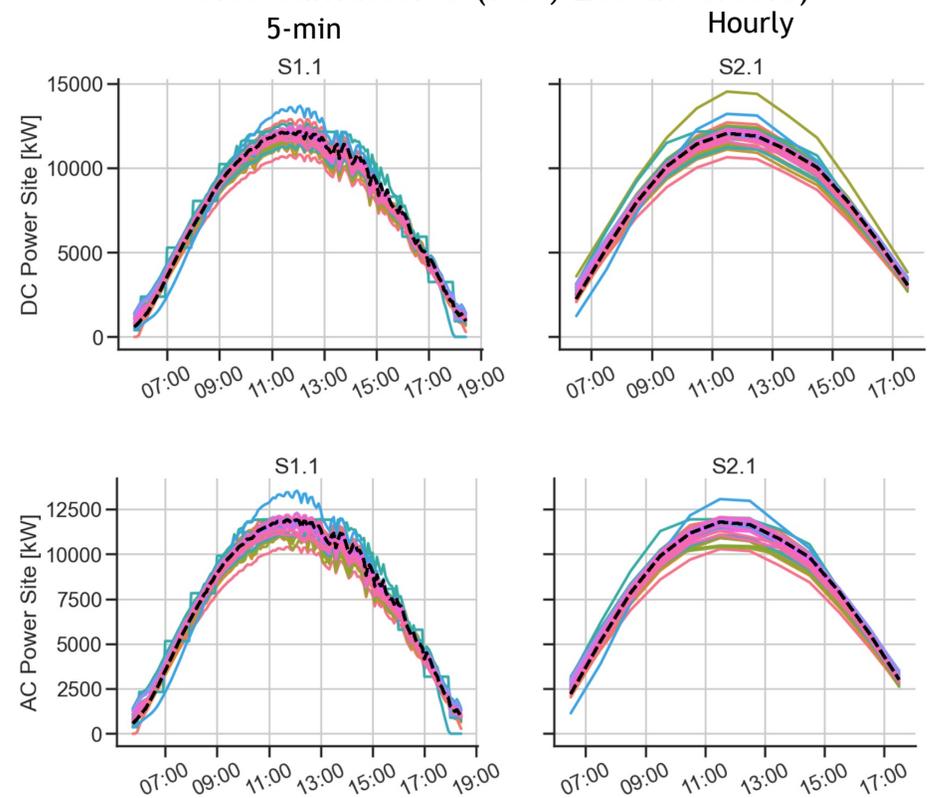
# Power on inverter and site-levels: Diurnal



## 1 Inverter



## Site cumulative (i.e., 200 inverters)



## Try our PVPMC datasets

Well-documented PVPMC validation datasets can be downloaded at:

<https://pvpmc.sandia.gov>

<https://datahub.duramat.org/project/about/pvpmc>

2021 blind PVPMC datasets:

<https://doi.org/10.21948/1970772>

<https://datahub.duramat.org/en/dataset/pv-performance-modeling-data>

https://pvpmc.sandia.gov

Sandia National Laboratories Research | Earth, Energy, & Environmental Science |

### PV Performance Modeling Collaborative (PVPMC)

Modeling Guide | Datasets | Model Validation | Tools | Workshops & Publications | About

#### Datasets

**2021 Blind PV Performance Modeling Comparison Datasets**

Weather and Module Characterization Data from Roskilde, Denmark and Albuquerque, NM

This dataset includes all files that were provided to participants of the 2021 PVPMC Blind PV Performance Modeling Comparison. The results of this exercise are published in Progress in Photovoltaics <https://doi.org/10.1002/plp.3729>

**Solar Variability Data**

High frequency (1-sec) irradiance data from different regions around the USA

This data is described in: Matthew Lave, Robert J. Broderick, Matthew J. Reno, [Solar variability zones: Satellite-derived zones that represent high-frequency ground variability](#), *Solar Energy*, Volume 151, 15 July 2017, Pages 119-128, ISSN 0038-092X. Data samples are available for download.

Click here!

Projects PVPMC

Project Overview

**PVPMC**

Project ID: 412d3f92-b9d5-4602-beb5-4123b2844cc1

**PV Performance Modeling Collaborative (PVPMC) – Validation datasets**

**DuraMAT 2.0 Project**

Central Data Resource

Recipient: Sandia National Laboratories (PI: Theritis, Marinos)

Subs: N/A

Status: Awarded, In Progress

**Abstract:** This Core Capability project supports a variety of improvements to PV performance models, creation of an energy rating approach and datasets for the US, development of a model validation framework, and support for the open-source modeling package, `pvlib-python`. The project will also continue to support the activities and resources of the PV Performance Modeling Collaborative and activity leadership in the IEA PVPS Task 12 working group.

Supporting project for Special Irradiance Data and Resources

DOI: <https://doi.org/10.21948/1970772>

**DuraMAT**  
Durable Module Materials Consortium

## Closing notes

- Pleased to see increased participation in the PVPMC's blind modeling comparisons
- There is still time if you are interested to participate
- If any software companies did not receive an invitation please reach out
- Results will be communicated in a manuscript and the next PVPMC workshop (Salt Lake City in May 2024)





Please join the PVPMC at <https://pvpmc.sandia.gov/>  
Contribute, and help increase confidence in PV system performance

Thank you!  
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Many thanks to our data sponsor (Juergen Sutterlueti)



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