PVPerformance MODELING COLLABORATIVE

Sandia National Laboratories

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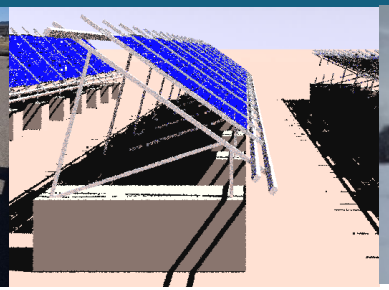
2023 PVPMC blind modeling comparison



PRESENTED BY

Marios Theristis

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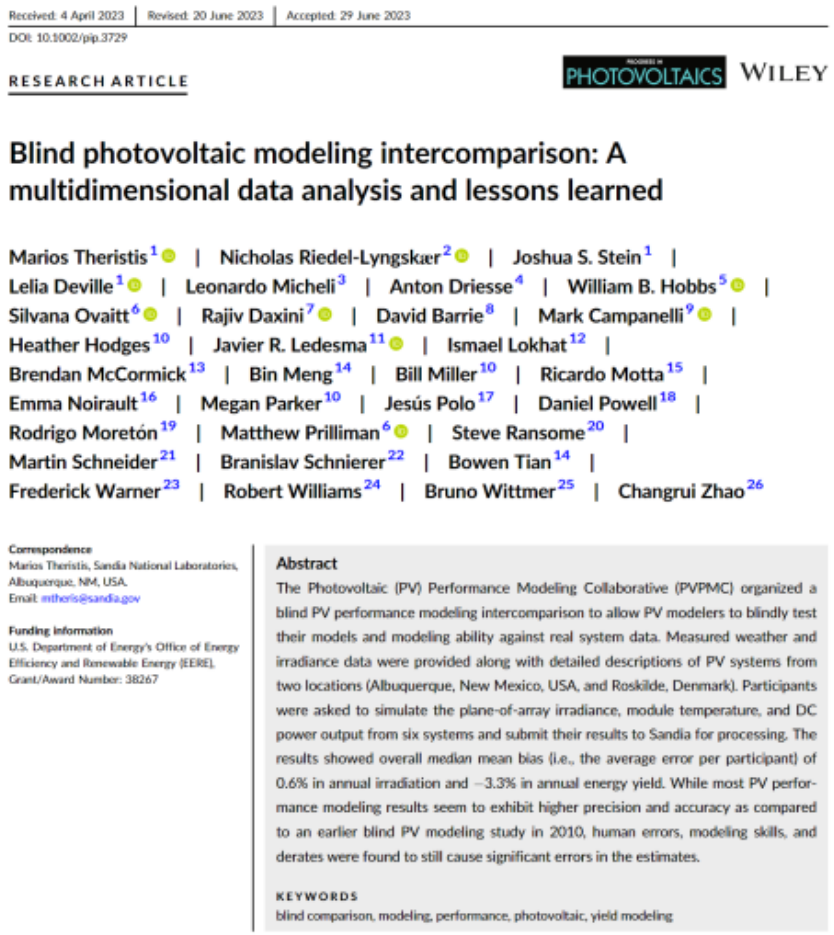
Many thanks to the 2021 participants

32 participants from 12 countries and 26 organizations with 29 submissions



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RESEARCH ARTICLE

PROGRESS IN PHOTOVOLTAICS WILEY

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

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Abstract

The Photovoltaic (PV) Performance Modeling Collaborative (PVPMC) 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

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

PVPerformance MODELING COLLABORATIVE

https://pvpmc.sandia.gov/

Simulation scenarios

Generously shared by: Gantner instruments

S1: Single inverter (80.4 kWdc) 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

Generously shared by: Gantner instruments

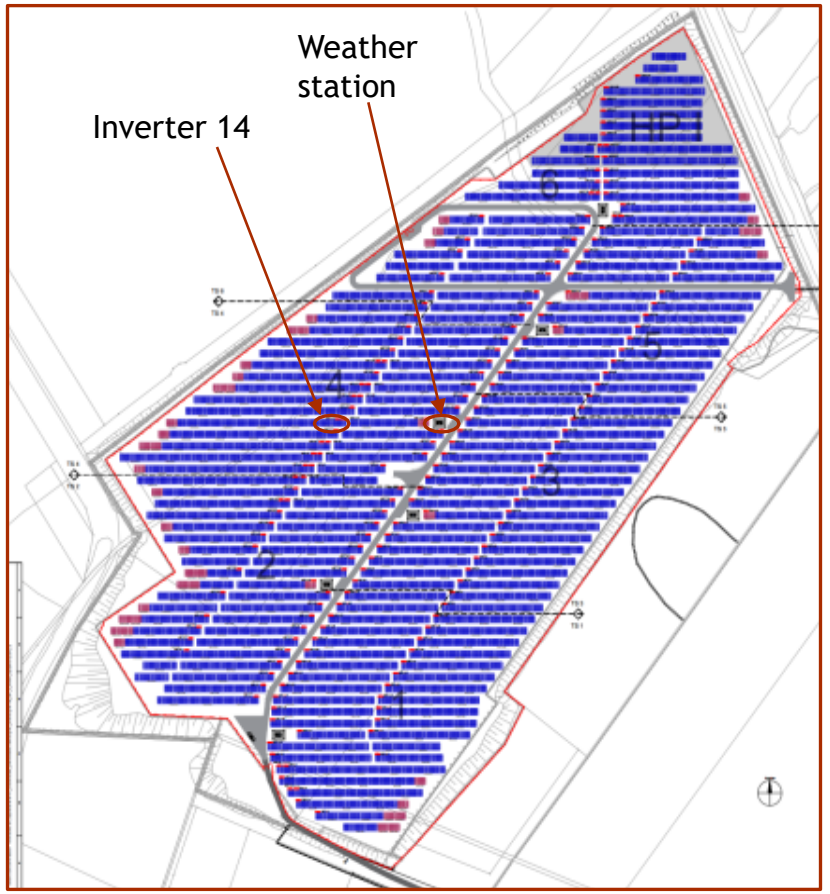
S2: Single inverter (80.4 kWdc) and whole power plant **(14.5 MW)** of monofacial, fixed-tilt, half-cut monocrystalline Trina Solar in Germany over 1-year at **hourly** avg resolution

PHASE 1

S3: 15.4 kW_{dc} of monofacial, fixed-tilt, LG n-PERT in Albuquerque, NM over 1-year at **1-min** resolution

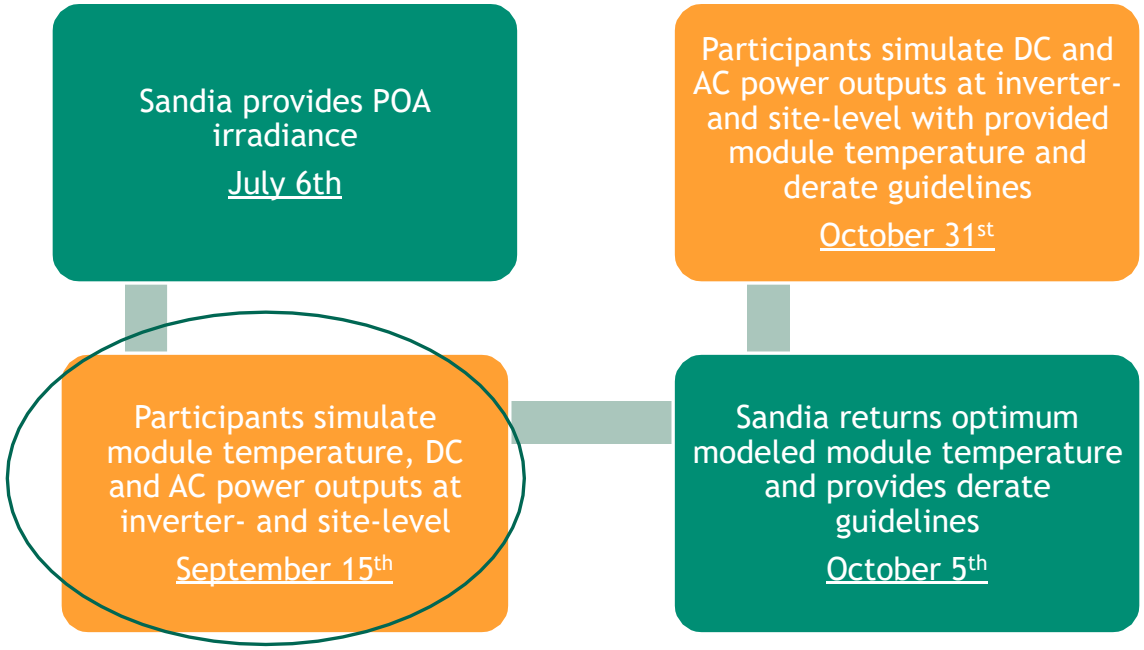
S4: 15.4 kW_{dc} of monofacial, fixed-tilt, LG n-PERT in Albuquerque, NM over 1-year at **hourly** avg resolution

PHASE 2

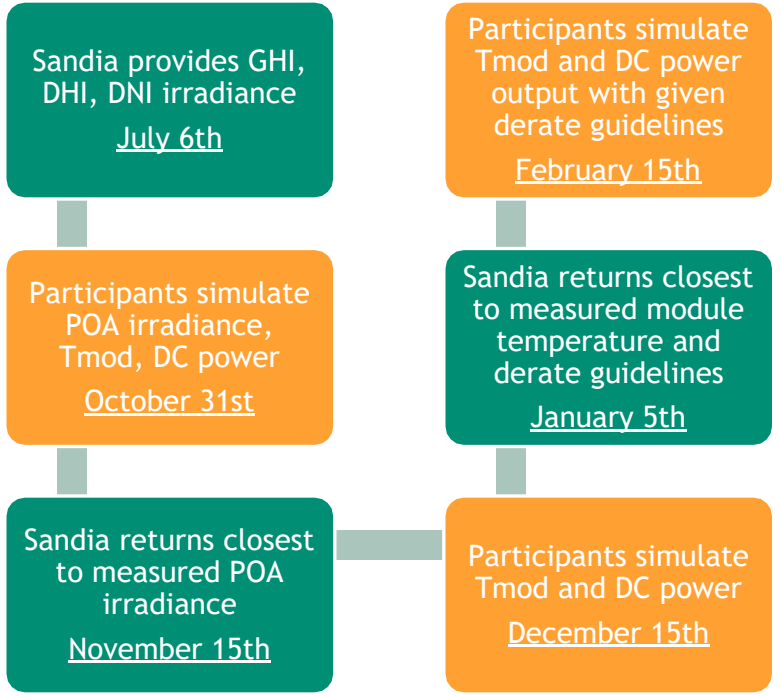


Blind PVPMC intercomparison iterative process

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

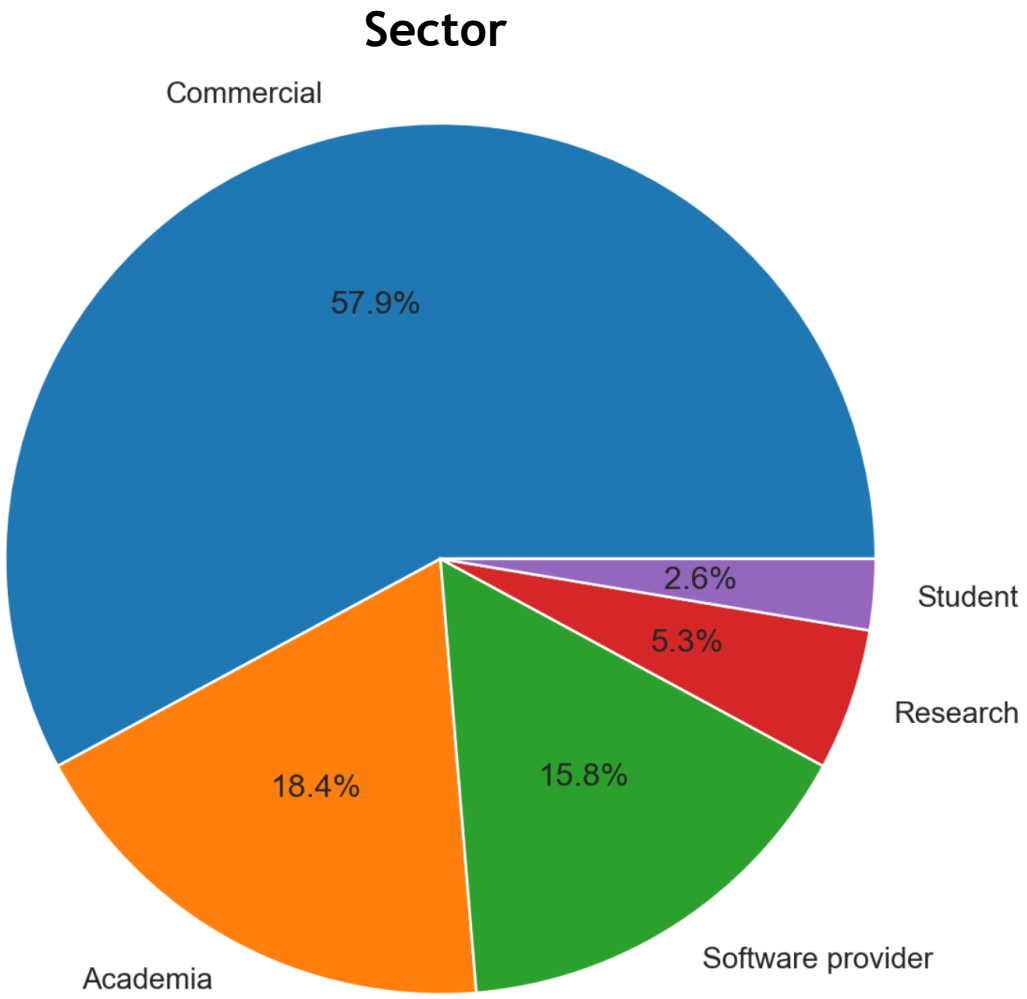
Participation so far

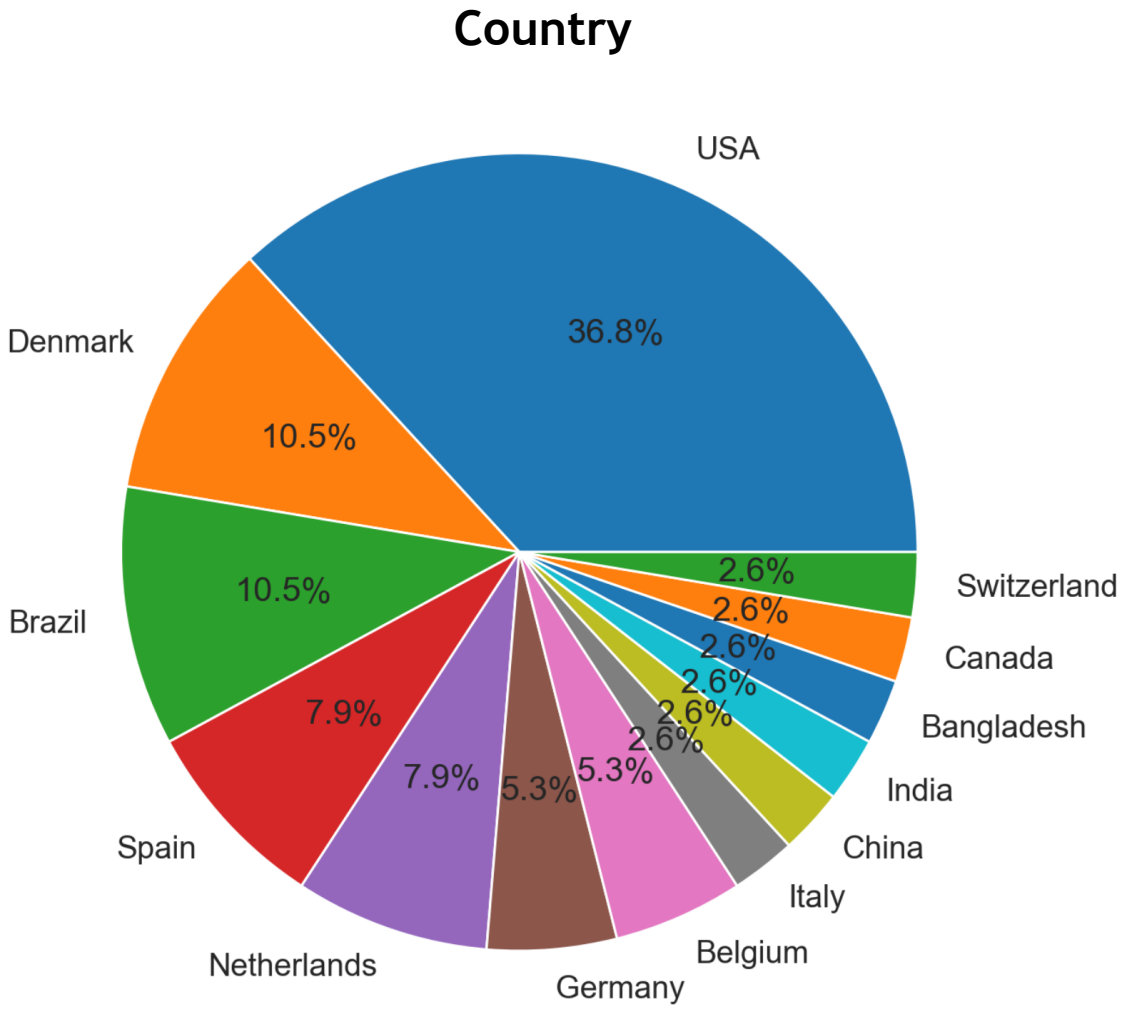
Juergen Sutterlueti, Joshua S. Stein, Kevin Anderson, Lelia Deville, Chloe Black, Youri Blom, Mark Campanelli, Alejandro Gonzalez Carballo, Gregorio Olivares Casero, Arijit Chakroborty, Anton Driesse, A S M Jahid Hasan,
Will Hobbs, Adam Rasmus Jensen, Sha Li,
Javier Lopez Lorente, Ivan Diaz Martinez,
Eduardo Mello Martins, Leonardo Micheli, Ricardo Motta, Marie-Joe Najm, Maitheli Nikam, Jeff Organ, Suveer Panditrao, Matthew Prilliman, Kurt Rhee, Rafael Pereira Santos, Martin Schneider, 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

Participation statistics

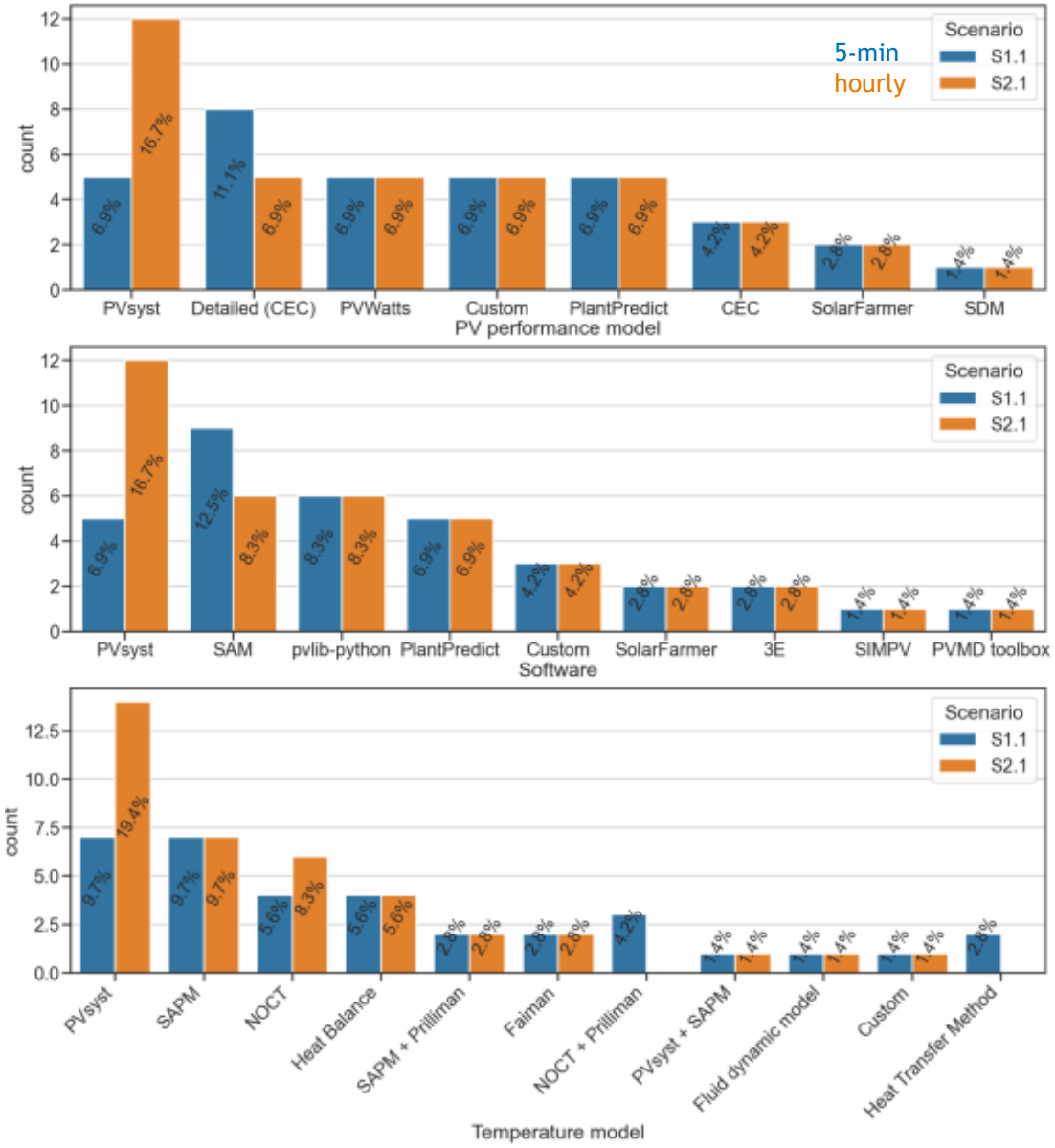




36 participants from 14 countries and 31 organizations with 37 submissions

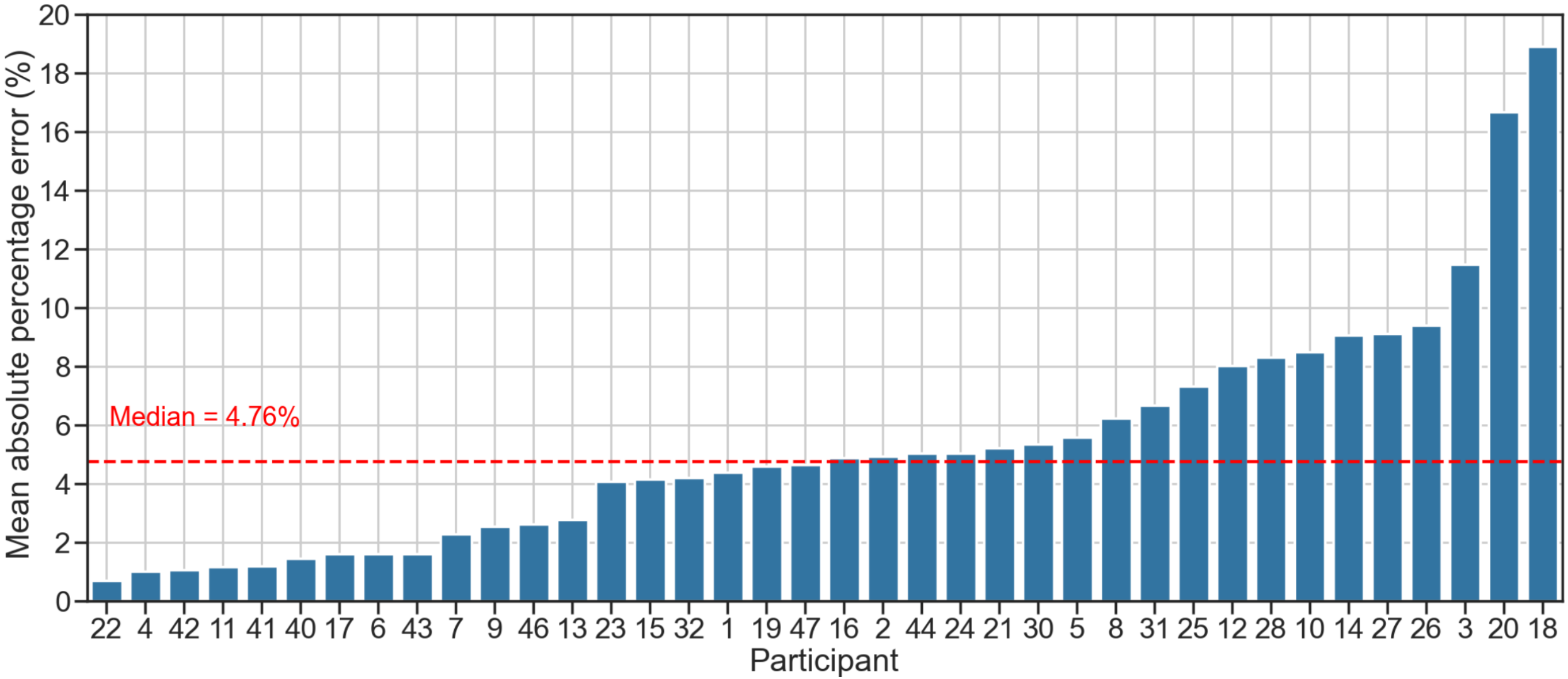
Modeling statistics

- Good representation from PVsyst, SAM, PlantPredict and… pvlib-python
- ~ 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**]

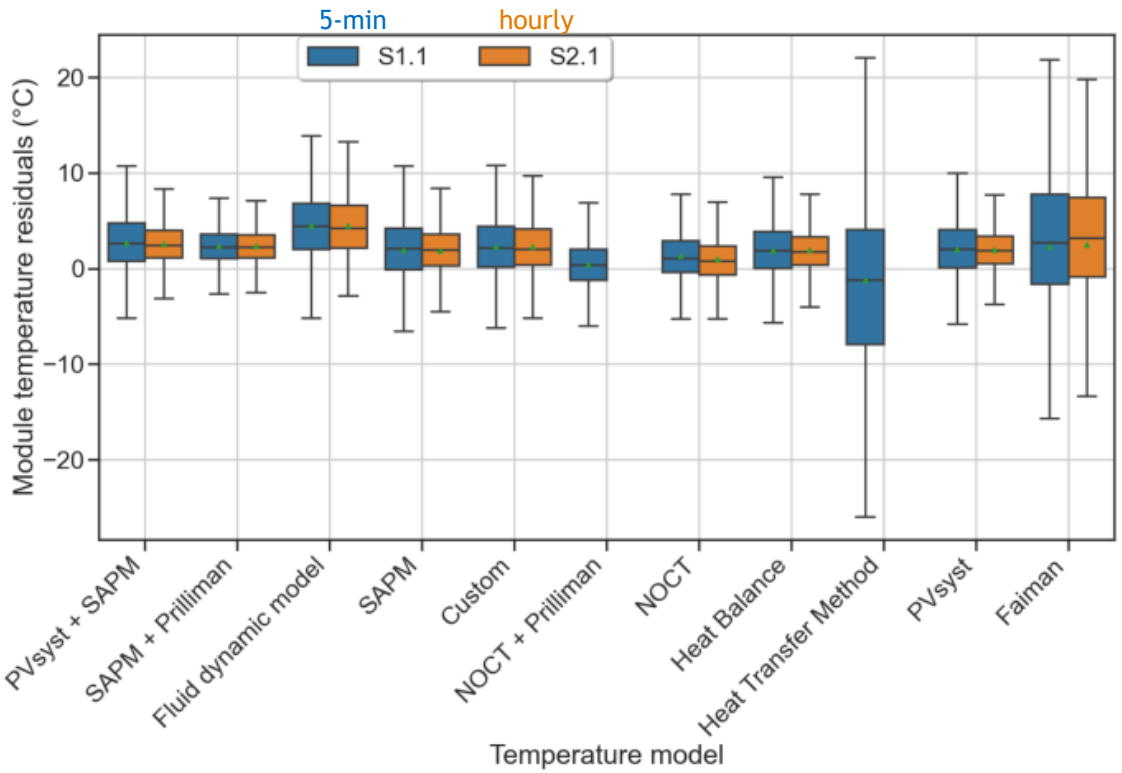
“Ranking” the participants using MAPE and annualized energy



* Ranking is very sensitive to the filtering criteria

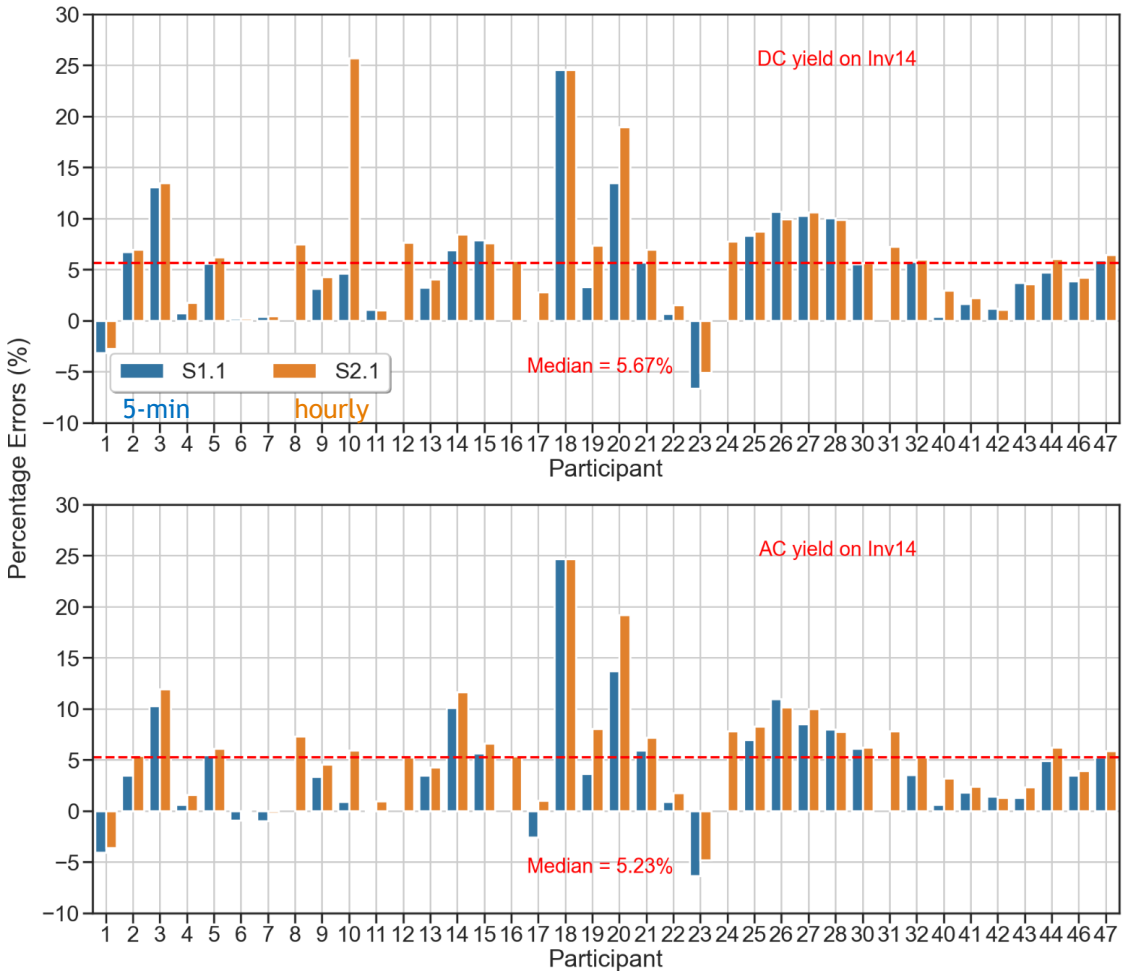
Temperature modeling

- 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 1st time SAM user
- Transient NOCT seems to exhibit improved performance

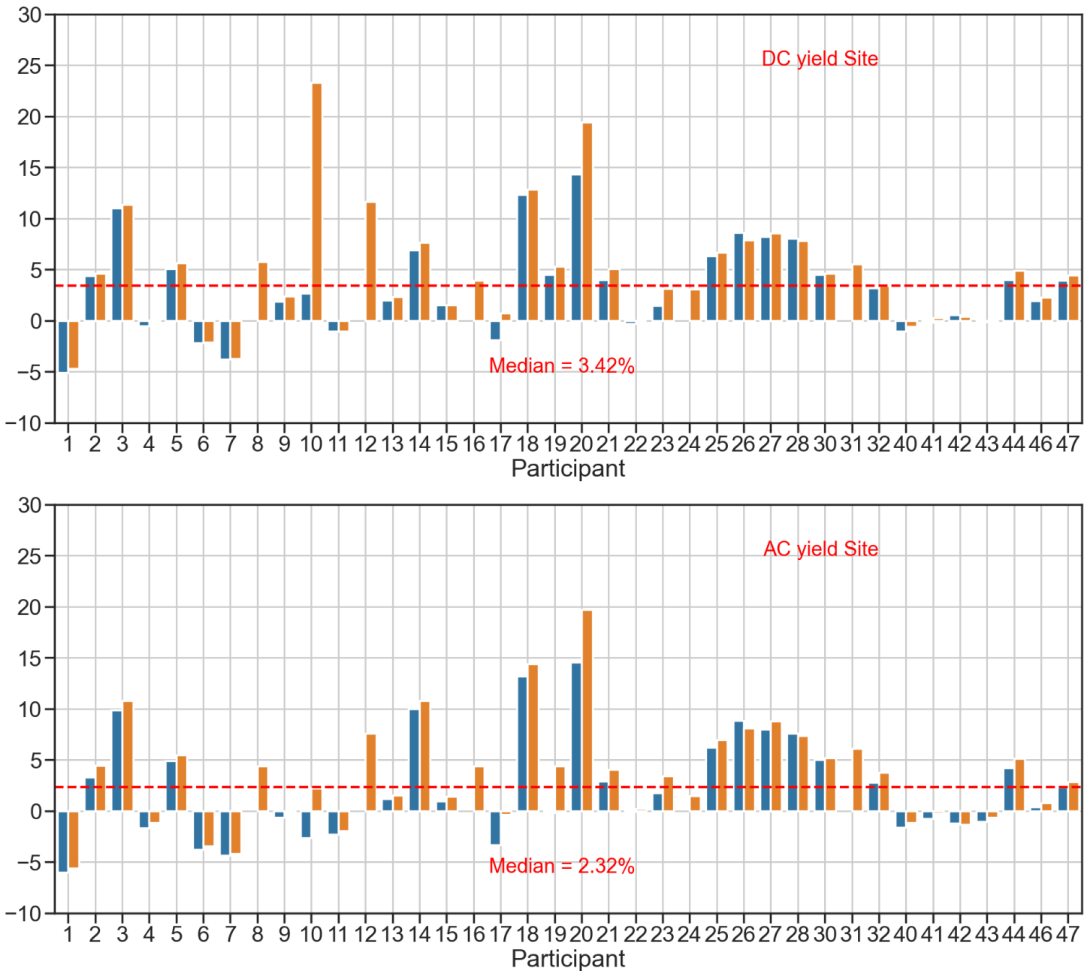


Bias in annual energy yield estimations on inverter- and site level

1 Inverter



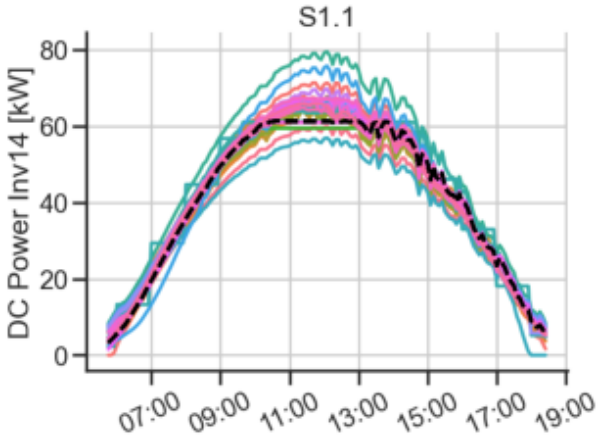
Site cumulative (i.e., 200 inverters)

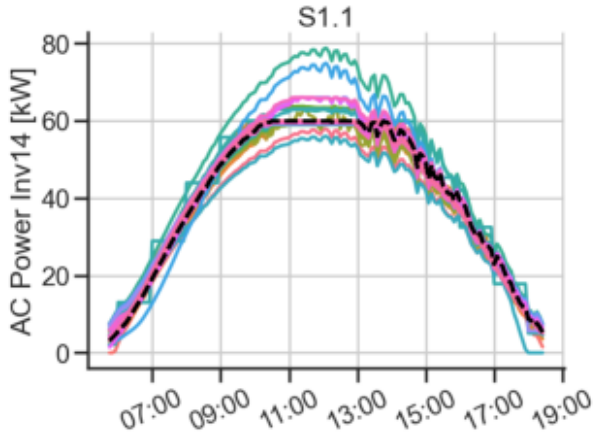


Power on inverter and site-levels: Diurnal

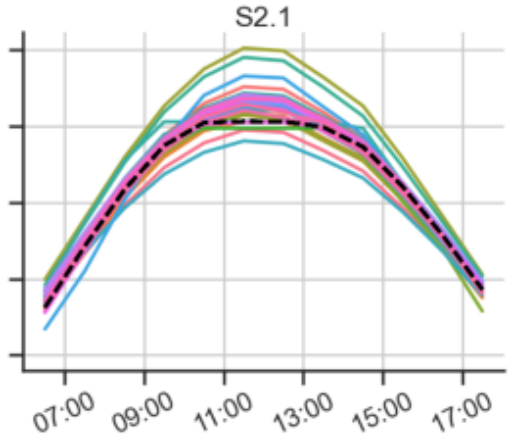
1 Inverter

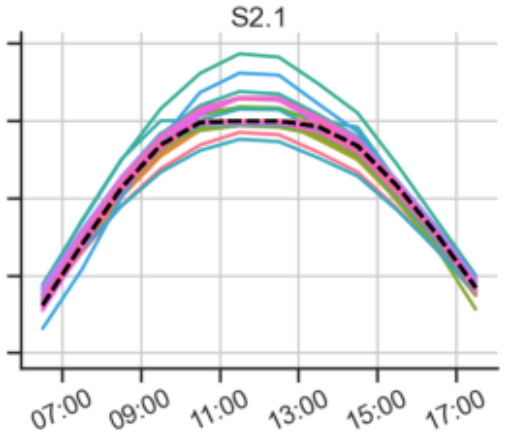
5-min





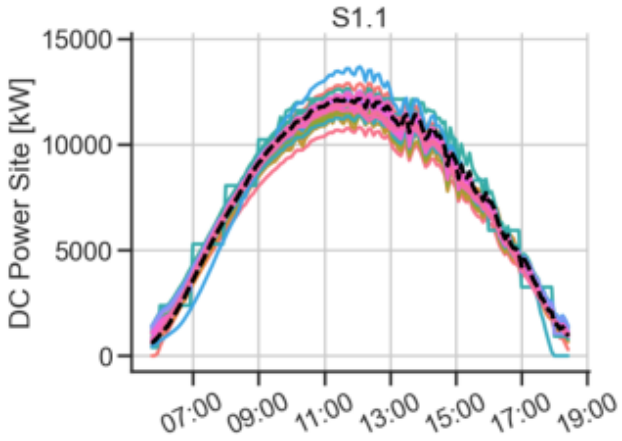
Hourly

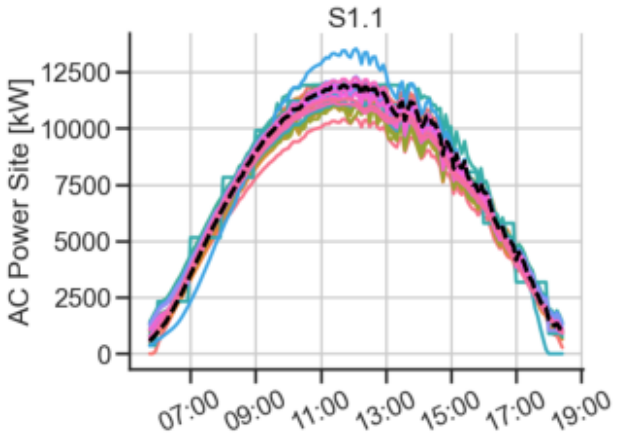




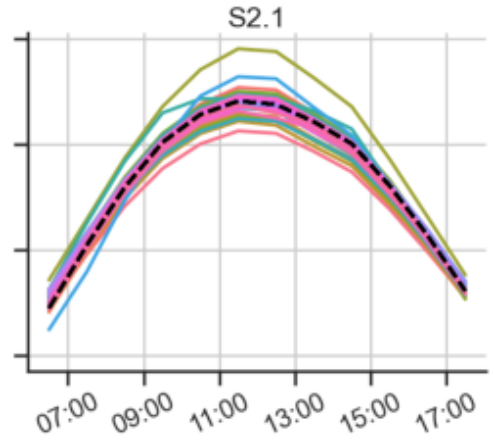
Site cumulative (i.e., 200 inverters)

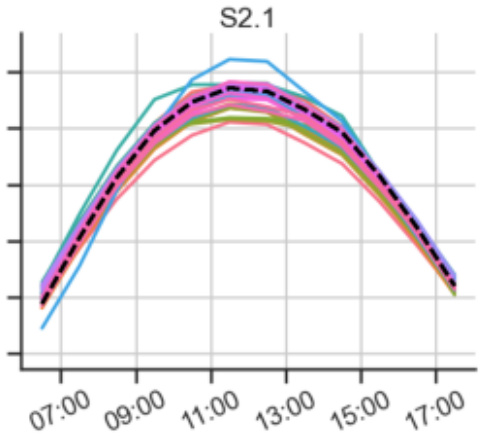
5-min





Hourly





Try our PVPMC datasets

Well-documented PVPMC validation datasets can be downloaded at:

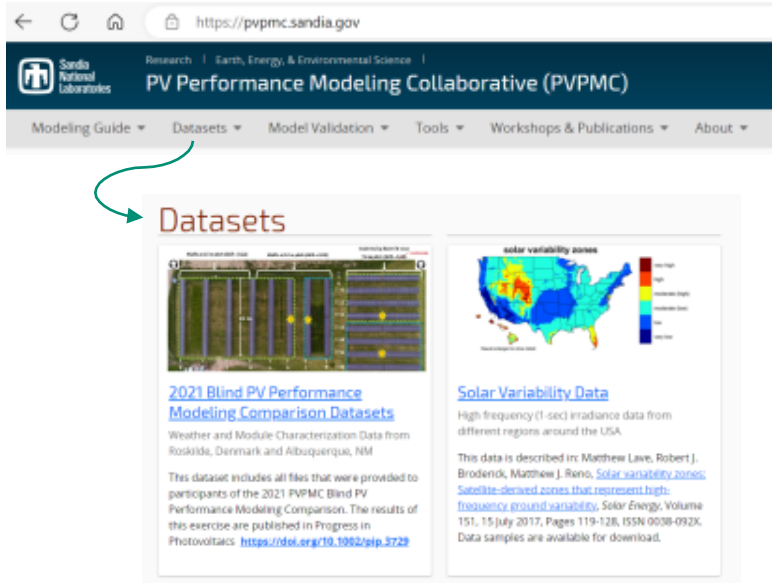
https://pvpmc.sandia.gov

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

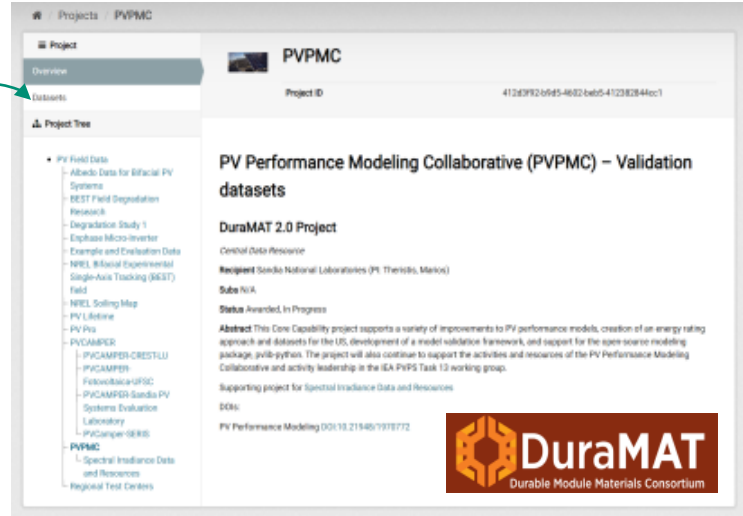
2021 blind PVPMC datasets:

https://doi.org/10.21948/1970772

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



Click here!



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)

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

Thank you!

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SOLAR ENERGY TECHNOLOGIES OFFICE
U.S. Department Of Energy

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Gantner instruments

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