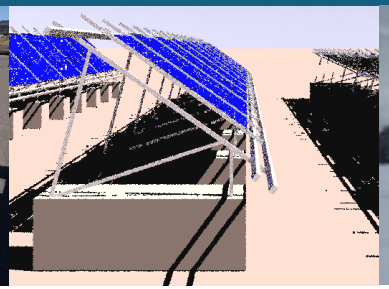
SAND2023-03896C

PVPerformance MODELING COLLABORATIVE

Sandia National Laboratories

The 2023 Blind Photovoltaic Modeling Intercomparisons



Marios Theristis, Kevin Anderson, Joshua S. Stein

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Many thanks to the 2021 participants

32 participants from 12 countries and 26 organizations with 29 submissions

PROGRESS IN PHOTOVOLTAICS

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

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QPV QualifyingPhotoVoltaics

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K2

Objectives of the 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

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 groups: 1) open invitation for anyone to participate, 2) software companies by invitation only
- Additional simulation exercise by IEA PVPS Task 13 Activity 2.3 where best practices for bifacial tracking PV systems are currently being documented
- Call for participants will be announced through the PVPMC emailing list in May; invitations will be sent to software companies separately
- FAQ section will be updated on the PVPMC website as questions arise
- Results will be collected and handled by Sandia ensuring **anonymity** and an **unbiased** analysis
- Participants will have knowledge of their "participation number"; software names will be published

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https://pvpmc.sandia.gov/

PVPMC and IEA Task 13 Scenarios

Generously shared by: Gantner instruments

S1: 72.36 kW_{dc} (1.2 DC/AC) **(or 14 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

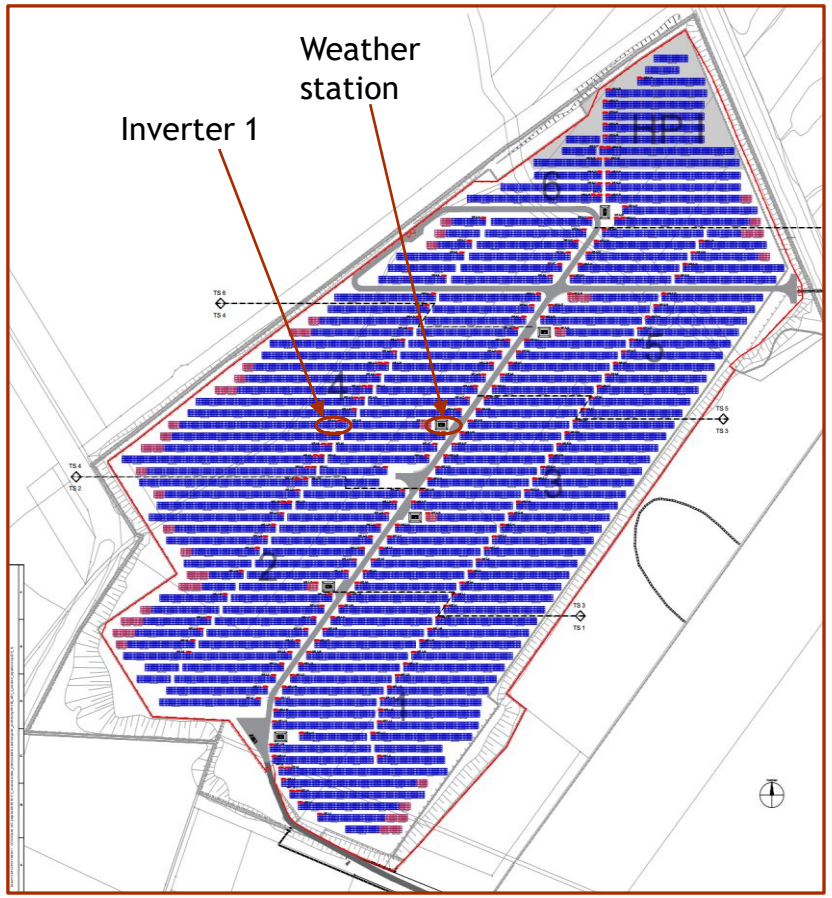
S2: 72.36 kW_{dc} (1.2 DC/AC) **(or 14 MW)** of monofacial, fixed-tilt, half-cut monocrystalline Trina Solar in Germany over 1-year at **hourly** avg resolution

PHASE 1

S3: 3.9 kW_{dc} of monofacial, fixed-tilt, LG n-PERT in Albuquerque, NM over 1-year at **1-min** resolution

S4: 3.9 kW_{dc} of monofacial, fixed-tilt, LG n-PERT in Albuquerque, NM over 1-year at **hourly** avg resolution

PHASE 2

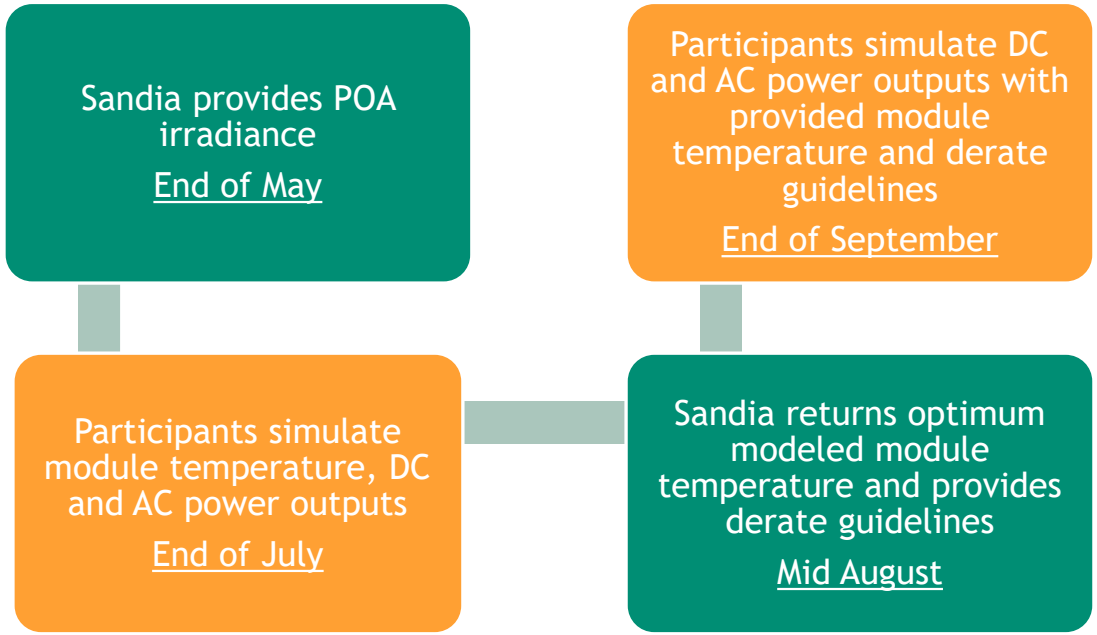


IEA Task 13 bifacial SAT simulation exercise

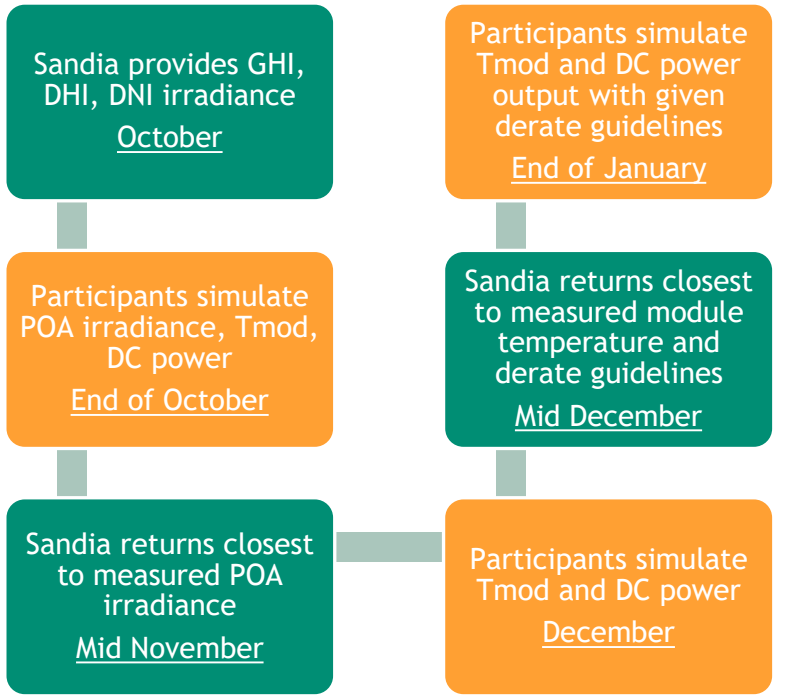
Runs with Phase 1

Blind PVPMC intercomparison iterative process

PHASE 1 (S1, S2): May – September 2023



PHASE 2 (S3, S4): October – January 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

Why participate?

- When an approach is tested against known datasets → bias
- These blind intercomparisons provide an opportunity for PV modelers to test their models and ability
- Participate in an international collaborative and see how your modeling skills or models compare to others
- Results are shared with the participants much earlier than any other dissemination efforts
- Participate in a large collaborative journal article
- Self-learning exercise; iterative process will allow modelers to understand at which step(s) the error/uncertainty is being introduced
- Get your company logo and name advertised for free!

IEA PVPS Task 13 Modeling Comparison

- IEA PVPS Task 13 Activity 2.3 is documenting best practices for bifacial tracking PV systems
- PV performance modeling comparison
  - Goal: Compare how different modeling tools represent a set of design variations for bifacial PV tracked systems.
  - Seven scenarios are defined that explore variations in GCR, height, albedo, configuration (1P vs. 2P), and ground slope.
  - Participants will simulate front and rear irradiance, module temperature and DC power for a 8760 TMY dataset.
- Simulation instructions will be released by end of May 2023. **Modeling will be performed during the Summer-Autumn of 2023.**
- Participants will email modeling results to Sandia National Laboratories where they will be anonymized and issued a participant number. Only anonymized data will be available to the rest of the analysis team.
- Summary of results will be included in an IEA PVPS Task 13 report and participants will have the option to be included in the acknowledgements.

IEA PVPS Task 13 Modeling Exercise

Simulation number	Scenario name	GCR	Albedo	Height	Configuration	Ground surface
1	Ref-A	0.4	0.2	1.5 m	1-Up portrait	Horizontal
2	A1	**0.25**	0.2	1.5 m	1-Up portrait	Horizontal
3	A2	0.4	**0.5**	1.5 m	1-Up portrait	Horizontal
4	A3	0.4	0.2	**3.5 m**	1-Up portrait	Horizontal
5	A5	0.4	0.2	1.5 m	1-Up portrait	**10% grade* down to the East**
6	A6	0.4	0.2	1.5 m	1-Up portrait	**10% grade* down to the SW**
7	Ref-B	0.4	0.2	3.5 m	**2-Up portrait**	Horizontal

Scenarios

•10% grade = slope angle of 5.71 deg from horizontal (*atan(0.1)*)

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Well-documented PVPMC validation datasets can be downloaded at: https://datahub.duramat.org/project/about/pvpmc

Any feedback is welcomed!

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Sandia National Laboratories

IEA PVPS

SOLAR ENERGY TECHNOLOGIES OFFICE U.S. Department Of Energy

Solar Energy Technologies Office Award Number 38267

Many thanks to our data sponsor (Juergen Sutterlueti)

Gantner instruments

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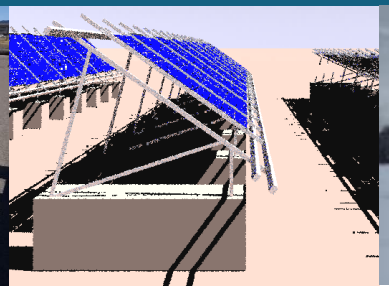
Sandia National Laboratories

IV curve fitting competition

Clifford Hansen

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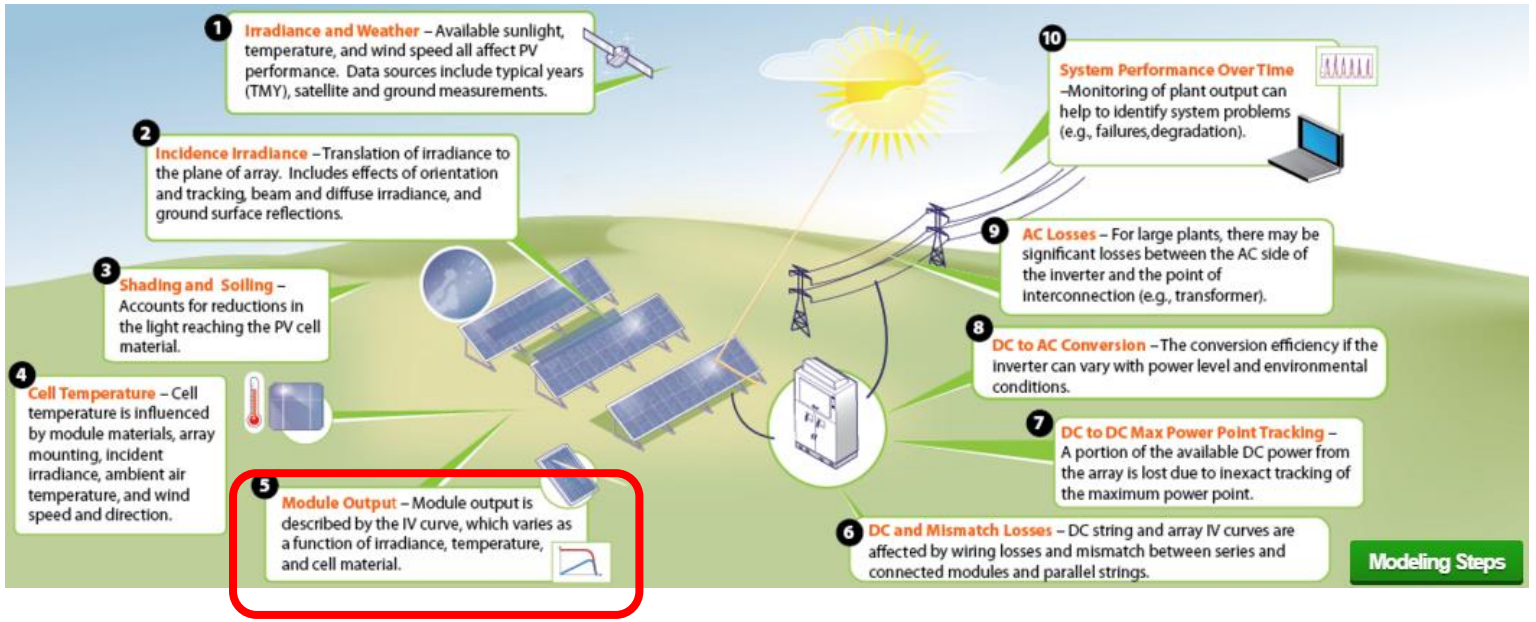
SAND2023-

IV curve fitting competition

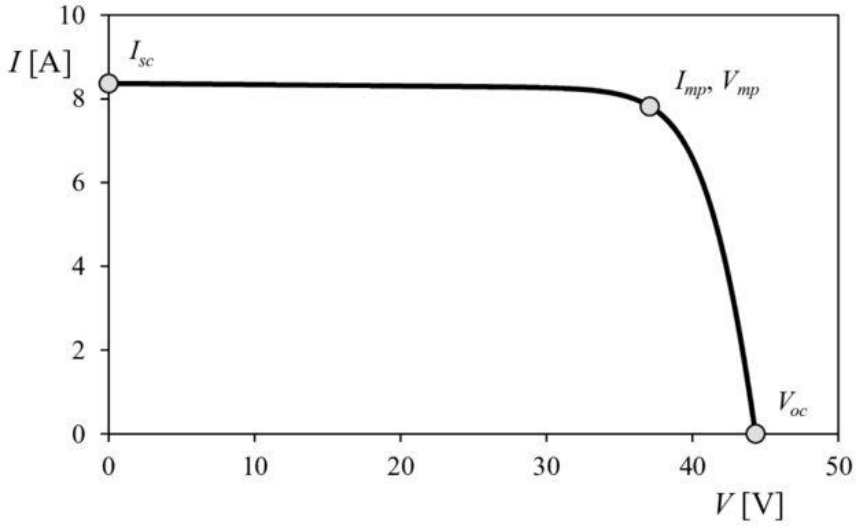


CEC, Pvsyst, other models contain IV curve models

IV curve models require parameters for the single diode equation

$$I = I_L - I_O\left(\exp\left(\left(\frac{V + IR_S}{nN_S V_{th}}\right) - 1\right)\right) - \frac{V + IR_S}{R_{SH}}$$

How do I fit this equation to IV curve data?



Fitting the Single Diode Equation

Also termed "parameter extraction"

Hundreds of papers on this topic

Comparison among methods is practically impossible

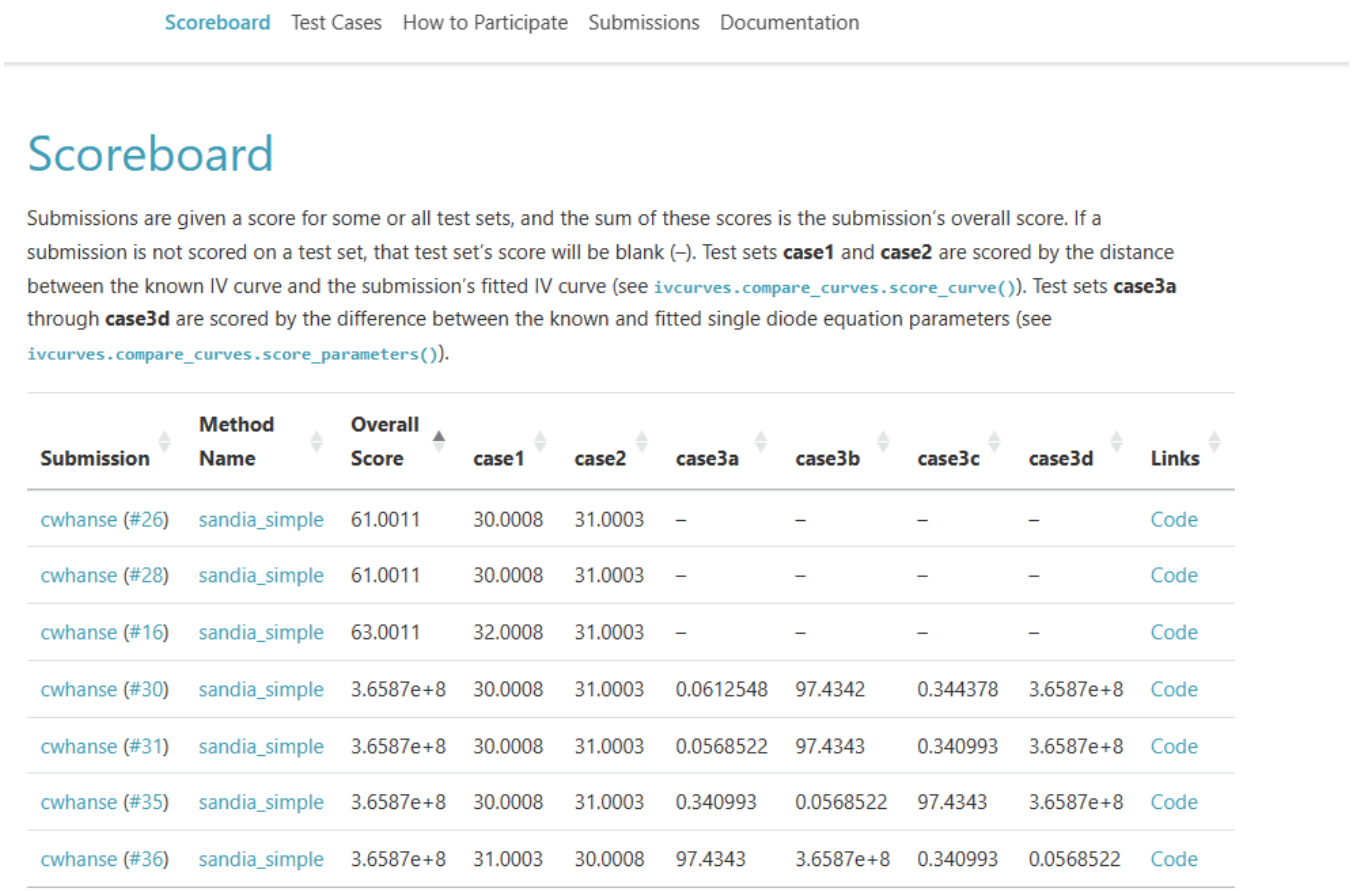
- No consistent metrics, validation sets or even validation processes.

We propose a set of benchmark tests and metrics

Automated scoring and a competition platform

https://cwhanse.github.io/ivcurves/

https://github.com/cwhanse/ivcurves



Scoreboard Test Cases How to Participate Submissions Documentation

Scoreboard

Submissions are given a score for some or all test sets, and the sum of these scores is the submission's overall score. If a submission is not scored on a test set, that test set's score will be blank (–). Test sets **case1** and **case2** are scored by the distance between the known IV curve and the submission's fitted IV curve (see `ivcurves.compare_curves.score_curve()`). Test sets **case3a** through **case3d** are scored by the difference between the known and fitted single diode equation parameters (see `ivcurves.compare_curves.score_parameters()`).

Submission	Method Name	Overall Score	case1	case2	case3a	case3b	case3c	case3d	Links
cwhanse (#26)	sandia_simple	61.0011	30.0008	31.0003	–	–	–	–	Code
cwhanse (#28)	sandia_simple	61.0011	30.0008	31.0003	–	–	–	–	Code
cwhanse (#16)	sandia_simple	63.0011	32.0008	31.0003	–	–	–	–	Code
cwhanse (#30)	sandia_simple	3.6587e+8	30.0008	31.0003	0.0612548	97.4342	0.344378	3.6587e+8	Code
cwhanse (#31)	sandia_simple	3.6587e+8	30.0008	31.0003	0.0568522	97.4343	0.340993	3.6587e+8	Code
cwhanse (#35)	sandia_simple	3.6587e+8	30.0008	31.0003	0.340993	0.0568522	97.4343	3.6587e+8	Code
cwhanse (#36)	sandia_simple	3.6587e+8	31.0003	30.0008	97.4343	3.6587e+8	0.340993	0.0568522	Code

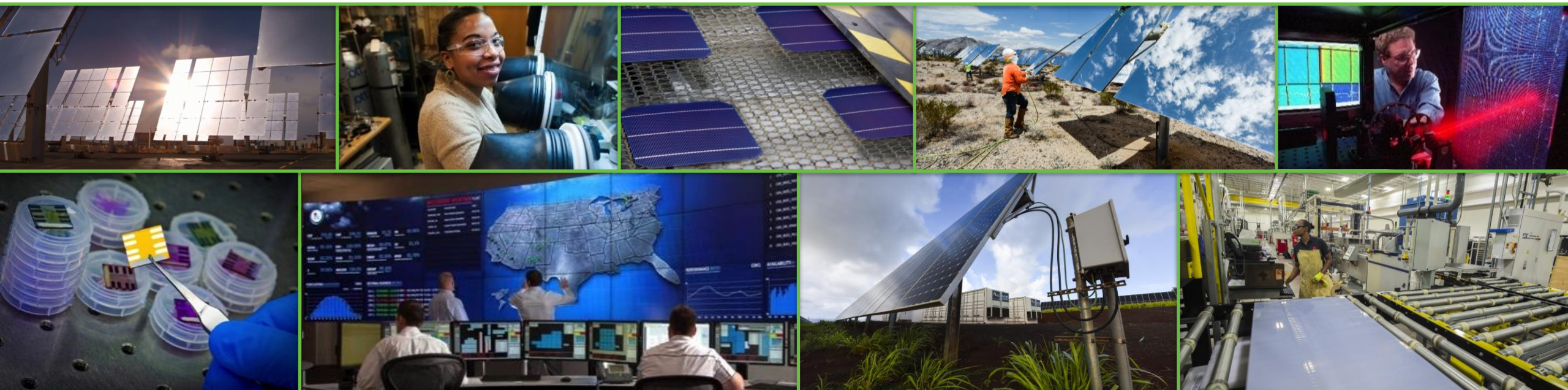
U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

Performance Data for Solar Photovoltaic Systems: Acquisition, Access, and Sharing

PVPMC 2023

Tassos Golnas, May 2023



Performance Data for Solar PV Systems - RFI

- Limited access to high-quality information about real-world PV system performances
- SETO issued a Request For Information (RFI) to understand the value and barriers to accessing these datasets (Oct 2022):

1. **Data Owner Perspective**
   - *Cost and value of data*
2. **Data User Perspective**
   - *Access, availability, and value of data*
3. **System Developer/Owner Perspective**
   - *Value-add Ancillary Datasets*

https://www.energy.gov/eere/solar/articles/request-information-performance-data-solar-photovoltaic-systems-acquisition

Diversity in RFI Respondents

- Received and reviewed responses from:

Utilities

Independent System Operators

Industry

University Researchers

National Labs

Insurance Companies

Key RFI Findings about PV Performance Data

Data Owners:
Cost and value of data

- Cost of sharing < Value of sharing
- Interest in data anonymization options

Data Users:
Access, availability, and value of data

- Interested in FAIR and Orange Button compliance
- Useful data: irradiance, weather, DC and AC generation, historical datasets (5-10+ years)

System Developers/Owners:
Value-add ancillary datasets

- Cell temperature, precise location of inverters, unique identifiers, system & component failure data, maintenance information, aerial imagery

QUESTIONS