# 2025 PV Performance Modeling Collaborative Workshop (V10)

**Mon, May 12 5:00-6:30 PM Happy Hour**

| Site: | Hotel Albuquerque, 800 Rio Grande Blvd NW, Albuquerque, New Mexico USA | | |
|---|---|---|---|
| **Day 1** | | **Tuesday, May 13, 2025** | |
| 8:00 | 1:00 | Breakfast and Registration | |
| 9:00 | 0:10 | Welcome from Sandia National Laboratories | Rob Leland | Sandia National Laboratories |
| 9:10 | 0:10 | Welcome from Groundwork Renewables | Ann Will | Groundwork Renewables |
| 9:20 | 0:10 | PVPMC Updates | Joshua Stein | Sandia National Laboratories |
| **Session 1** | | **Hybrid Systems and Grid Integration -** This session explores how PV systems can provide benefits to the grid by combining PV with other generation resources or providing ancillary services. | **Chair: Juergen Sutterlueti** | Gantner Instruments |
| 9:30 | 0:15 | PV Modeling for Grid Studies: How it's different | Janine Keith | National Renewable Energy Laboratory |
| 9:45 | 0:15 | Reevaluating PV and Wind Power Variability Across Temporal Domains: Implications for Grid Integration | Marc Perez | Clean Power Research |
| 10:00 | 0:15 | Dynamically Curtailing PV Plants to Provide Ancillary Services | Mohit Aggarwal | BrightNight |
| 10:15 | 0:15 | Technoeconomic Modeling of Solar Energy Generation and Storage Grid Penetration | Jennifer Braid | Sandia National Laboratories |
| 10:30 | 0:15 | Q&A | | |
| **10:45** | **0:45** | **Networking Break** | | |
| **Session 2** | | **PV Tracking on 3D Terrain -** More and more tracked PV systems are being installed on complex terrain. Existing models are being updated to account for terrain-specifc factors. | **Chair: Kevin Anderson** | Sandia National Laboratories |
| 11:30 | 0:15 | Evaluating Software for Terrain-Integrated Modelling of Single-Axis Trackers | John Moseley | Array Technologies |
| 11:45 | 0:15 | Maximizing Energy Gains in PV Tracking Systems: A Comparative Study of Advanced Backtracking Methods on Undulating Terrain | Amir Asgharzadeh Shishavan | NexTracker |
| 12:00 | 0:15 | Validation of terrain losses and energy yield optimization through backtracking tuning – Case study | Kerstin Lukrafka | Wood PLC |
| 12:15 | 0:15 | Q&A | | |
| **12:30** | **1:00** | **Lunch** | | |
| **Session 3** | | **Posters** | | |
| 13:30 | 0:45 | Poster Session 1 - PV Performance Posters | | |
| **Session 4** | | **Power Plant Underperformance -** Actual performance of PV systems can be lower than expected due to a wide variety of causes. This session will explore some of these reasons. | **Chair: Jim Crimmins** | GroundWork Renewables |
| 14:15 | 0:15 | Diagnosis of under-performing power plants using new SolarGEMINI | Clara Fernandez | DNV |
| 14:30 | 0:15 | Soiling losses: from modelling to PV systems simulation | Tomas Cebecauer | Solargis |
| 14:45 | 0:15 | Identifying PV Underperformance Trends with Aerial Thermography | Molly McGuire | RaptorMaps |
| 15:00 | 0:15 | Q&A | | |
| **15:15** | **0:45** | **Networking Break** | | |
| **Session 5** | | **Model Validation for Bankability -** How do you know the model you are using is valid? How should you compare different models?  This session will dive deeply into the nuances of model validation for solar PV. | **Chair: Janine Keith** | National Renewable Energy Laboratory |
| 16:00 | 0:10 | Introduction to the session | Janine Keith | National Renewable Energy Laboratory |
| 16:10 | 0:15 | Commercial Photovoltaic Modeling Software Review and Comparison | Lelia Deville | Sandia National Laboratories, University of Louisiana at Lafayette |
| 16:25 | 0:15 | Tailored Performance Models: Custom Recipes for Every Palate | Imre T. Horvath | PVcase |
| 16:40 | 0:15 | When random errors are actually systematic errors | Jeff Newmiller | DNV |
| 16:40 | 0:20 | Moderated Discussion | | |
| **17:00** | **1:30** | **Happy Hour** | | |
| 18:30 | | End of Day 1 | | |

| Day 2 | | Wednesday May 14, 2025 | | |
|---|---|---|---|---|
| | 6:30 AM | Fun Run - Meet at Entrance to Hotel | | |
| 8:00 | 1:00 | Breakfast | | |
| 9:00 | 0:10 | Introduction to the PV O&M and Analytics Collaborative (PVMAC) | Marios Theristis | Sandia National Laboratories |
| Session 6 | | **Reconciling Proforma and Expected Yield -** We will explore challenges in calculating expected energy, where methods vary widely due to limited proforma model availability and reliance on empirical approaches. We will discuss the impact of this variability and whether standardization could improve transparency and consistency. | **Chair: Marios Theristis** | Sandia National Laboratories |
| 9:10 | 0:10 | Harmonizing Calculations of Expected Yield | Joshua Stein | Sandia National Laboratories |
| 9:20 | 0:10 | iSight's approach to expected yield using pvlib and irradiance data validation | Ishtiza Azad | Southern Power Company |
| 9:30 | 0:10 | Differences between pre and post-construction performance modeling | Kurt Rhee | Proximal Energy |
| 9:40 | 0:10 | Expected vs. Measured: Yield assessment for utility scale PV assets in operation | Juergen Sutterlueti | Gantner Instruments |
| 9:50 | 0:20 | Moderated Discussion | | |
| 10:10 | 0:45 | Networking Break | | |
| Session 7 | | **Challenges for Estimating KPIs -** While KPI definitions exist in industry standards, they are subject to interpretation, especially when working with imperfect datasets. We will discuss sources of uncertainty, their impact on decision-making, and potential approaches to reduce risks. | **Chair: Rob van Haaren** | Proximal Energy |
| 10:55 | 0:05 | Intro to the Session | Rob van Haaren | Proximal Energy |
| 11:00 | 0:15 | Standardizing Availability Calculations for PV inverters | Abhishek Parikh | EDF Renewables |
| 11:15 | 0:15 | Assessing Tracker Availability in Utility-Scale Solar Power Plants | Gofran Chowdhury | 3E |
| 11:30 | 0:15 | O&M KPIs: uncertainty due to data loss and operational issues | Kevin Anderson | Sandia National Laboratories |
| 11:45 | 0:20 | Moderated Discussion | | |
| 12:05 | 1:00 | Lunch Break | | |
| Session 8 | | Posters | | |
| 13:05 | 0:45 | Poster Session 2 - PV Operations Posters | | |
| Session 9 | | **Solar Capacity Testing: Insights and Trends -** This session will explore the latest trends and insights in solar capacity testing, with a focus on key industry topics, including ASTM standards and IEC 61724-2 capacity testing. Our diverse panel—featuring experts from development, EPC, and consulting—will provide perspectives on current methodologies, challenges, and best practices. | **Chair: Jon Kalantar** | DNV |
| 13:50 | 0:10 | Current Capacity Testing Methods and Uncertainties | Jessica Forbess | Sunshine Analytics |
| 14:00 | 0:10 | Irradiance Measurements in Capacity Testing | Justin Robinson | GroundWork Renewables |
| 14:10 | 0:10 | Major Observed Issues in Capacity Tests by EPCs | Jaya Mallineni | SOLV Energy |
| 14:20 | 0:10 | Capacity Testing Insights from a Developer's Perspective | Andrew Nurse | Invenergy |
| 14:30 | 0:20 | Moderated Discussion | | |
| 14:50 | 0:45 | Networking Break | | |
| Session 10 | | **From Data to Insights: AI/ML for Predictive Fault and Underperformance Detection -** Discover how AI/ML Models are revolutionizing solar power plants by enabling predictive diagnostics and early detection of underperformance. This session will delve into real-world use cases, showcasing how data-driven models enhance the reliability and efficiency of photovoltaic systems. We aim to inspire the performance community to use this as a starting point to delve deeper into AI/ML-based analytics for solar power plants operations and maintenance. | **Chair: Jaya Mallineni** | **SOLV Energy** |
| 15:35 | 0:15 | Beware of the Black Box | Julien Deckx | 3E |
| 15:50 | 0:15 | The Inverter Classifier: A Boosting Model for Detecting Inverter Underperformance | Sandra Villamar | Power Factors |
| 16:05 | 0:15 | Boosting Physics-Based Models with AI/ML: Case Studies on Data Quality and Data Availability Challenges | Xuanji Yu | Univers |
| 16:20 | 0:15 | Leveraging AI/ML for proactive and early identification/classification of photovoltaic (PV) system faults and underperformance | Neeraj Desila | SmartHelio |
| 16:35 | 0:20 | Moderated Discussion | | |
| 16:55 | 0:05 | *Poster Award Ceremony* | | |
| 17:00 | | End of Day 2 | | |

| Day 3 | | Thursday May 15, 2025 | | |
|---|---|---|---|---|
| 8:00 | 1:00 | Breakfast | | |
| **Session 11** | | **Solar Resource -** Irradiance is the fuel that drives solar energy systems. Join this session to learn about the latest updates in data availability, methodology, uncertainty, and modeling. | **Chair: Clifford Hansen** | Sandia National Laboratories |
| 9:00 | 0:15 | Improving the National Solar Radiation Data Base using PSM v4 | Manajit Sengupta | National Renewable Energy Laboratory |
| 9:15 | 0:15 | Measuring the Sun: A Field Comparison of Different Radiometer Technologies | Adam Jensen | DTU |
| 9:30 | 0:15 | The influence of cloud cover on the reliability of satellite-based solar resource data | Yu Xie | National Renewable Energy Laboratory |
| 9:45 | 0:15 | Assessment of the transportability of the coefficients of a new solar radiation decomposition model | Brighton Mabasa | University of Johannesburg |
| 10:00 | 0:15 | Q&A | | |
| **10:15** | **0:45** | **Networking Break** | | |
| **Session 12** | | **Software Updates -** PV modeling software is always evolving and improving. This session will review the latest developments in the most advanced PV design and performance tools. | **Chair: Sophie Nguyen** | PVcase |
| 11:00 | 0:10 | Tools Update Session: SolarFarmer development highlights, insights and near-term plans | Javier Lopez Lorente | DNV |
| 11:10 | 0:10 | Updates and future developments in PVsyst | Michele Oliosi | PVsyst SA |
| 11:20 | 0:10 | Unified and validated ray-tracing framework applied from PV cell to PV plant | Arthur Poquet | TotalEnergies |
| 11:30 | 0:10 | Validation and results of the 3D energy yield calculation model for the RatedPower software | Félix Ignacio Pérez Cicala | RatedPower |
| 11:40 | 0:10 | PlantPredict Model Updates and Roadmap | Jason Spokes | Terabase |
| 11:50 | 0:15 | Q&A | | |
| 12:05 | 0:10 | Closing Remarks | Joshua Stein | Sandia National Laboratories |
| **12:15** | **1:00** | **Lunch** | | |

**Afternoon parallel sessions continue on next page**

PVcase — Gold Level Sponsor
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| Day 3, Continued | | Thursday May 15, 2025 | | |
|---|---|---|---|---|
| | | **Parallel Sessions A** | **Parallel Sessions B** | **Parallel Session C** |
| 13:15 | 0:45 | **PV Modeling Academy – Developing Curriculum for PV Performance Modeling (Clifford Hansen, Sandia) -** This session aims to gather feedback from industry on modeling expertise and topic areas that they wish new hires had encountered in school. | | |
| 14:00 | 0:05 | Transition break | | |
| 14:05 | 0:45 | **Updates on Revision to IEC 61724 (Josh Horst, Atonometrics) -** This working group session will provide an overview of the ongoing revisions to the IEC 61724 standard series for PV system performance monitoring, including IEC 61724-1 (instrumentation), IEC 61724-2 (short-term capacity testing), and IEC 61724-3 (long-term energy performance testing). Participants will have the opportunity to offer feedback, share experiences, and learn how to contribute to the revision process. | **How to Model Batteries (with PV, stand-alone, or hybrids) in SAM and PySAM (Brian Mirletz, NREL) -** This tutorial will be a deep dive into considerations for battery modeling and demonstrating how to model them in SAM, including battery chemistry, thermal modeling, degradation/lifetime, dispatch, interconnection limits and curtailment, and their associated impacts on project profits and battery lifetime. By the end of the tutorial attendees will know how to size and model both behind-the-meter and front-of-meter battery systems, including financial analysis and pairing with other PV models (including pvlib) via PySAM. | **Industry Modeling Software Office Hours**<br><br>**JMP**<br>**PlantPredict**<br>**PowerUQ**<br>**pvcaptest**<br>**Pvcase**<br>**pvlib-python**<br>**PVsyst SA**<br>**RatedPower**<br>**SolarFarmer**<br>**Solargis Evaluate** |
| 14:50 | 0:30 | Networking Break | | |
| 15:20 | 0:45 | **PlantPredict API / SDK Introduction and Demonstration (Jason Spokes, Terabase) -** Terabase will introduce attendees to the PlantPredict API (Application Programming Interface) and associated Python SDK (Software Development Kit). Basic API set up and interactions will be demonstrated, and industry use cases will be discussed. | **PVRADAR Python Package: Extension to pvlib for faster and easier modelling (Thore Müller, PVRADAR) -** The PVRADAR Python package enhances pvlib by automating data retrieval, model execution, and parameter optimization, enabling faster and more accurate PV performance modeling. This session will demonstrate its capabilities at the example of soiling modeling, including model creation, parameter fitting to field measurements, and benchmarking against pvlib's existing models. | |
| 16:05 | 0:05 | Transition break | | |
| 16:05 | 0:45 | **Modeling Streamed Sensor Data: How to Handle Curved Data (Clark Ledbetter, JMP) -**<br>In this presentation we will show how to explore and predict the entire curved response (Irradiance vs wavelength, I-V curves, Temp vs Time. Etc.) given various input factors (other system or environmental inputs)." | **Optimizing Repowering and Lifecycle Decisions with PV ICE and SAM (Heather Mirletz & Silvana Ovaitt, NREL) -** Should you repower or extend the life of your PV system? Are high-efficiency modules, durable modules, or recyclable modules the best option for your site and goals? Evaluating the trade-offs in design and lifecycle strategies can be complex. The PV in Circular Economy (PV ICE) tool is an open-source model designed to help developers, modelers, and decision-makers assess material flows, energy return on investment (EROI), and financial viability of PV systems. Now integrated with the System Advisor Model (SAM), PV ICE enables site-specific comparisons of lifecycle strategies—such as repowering benefits, module selection for reliability and recyclability, among others.<br>This interactive tutorial will provide hands-on experience with PV ICE using Google Collab, exploring scenario-based analyses on these topics. | |
| 16:50 | | **End of Workshop** | | |
| **Day 4** | | **Friday May 16, 2025** | | |
| 9:00 | 2:00 | **Groundwork PV Test Lab Tour -** Tour of the GroundWork PV Test Lab featuring a wide array of indoor PV test equipment and a walkthrough of the outdoor test yard.<br><br>**Address:** 5600A University Blvd. SE 87106 (Free Parking, Self-Organized Car Pooling, Uber) | | |
| 11:00 | | **End of Lab Tour** | | |

## Poster Session 1 - 13:00 -13:45 on Day 1 (May 13)

| Number | Session | Title | Name | Institution |
|---|---|---|---|---|
| 1 | 1 | How complex are satellite-based irradiation data? | Gofran Chowdhury | 3E |
| 2 | 1 | Performance Modeling Challenges with Terrain-following Single-Axis Trackers | Stephen John | Black & Veatch |
| 3 | 1 | Comparison of simplified scaled single inverter block modeling to detailed full-scale plant modeling for utility-scale solar plant optimization | Saurav Kadel | Black & Veatch |
| 4 | 1 | Accurate performance modeling of bifacial PV technologies under different operating conditions | Khadija El Ainaoui | Chouaib Doukkali University |
| 5 | 1 | Remote Assessment of Parking Areas for PV Canopies with Deep Image Segmentation and Minimum Bounding Rectangle Polygonization | Thomas Haley | Clean Power Research |
| 6 | 1 | More than a Year: Beyond the "Typical" for Reliable PV Performance Estimates | Javier Lopez-Lorente | DNV |
| 7 | 1 | Solar Position Algorithms | Adam R. Jensen | DTU |
| 8 | 1 | Sub-hourly solar performance modeling and comparison to field measurements | Christopher E. Valdivia | Enurgen Inc. |
| 9 | 1 | AI/ML Feature Selection and Modeling of Spectral Correction Factors from FARMS-NIT | Bryan Skarbek | First Solar |
| 10 | 1 | AI to predict solar spectra from basic meteorological parameters | Sevillano-Bendezú Miguel Ángel | Instituto de Micro y Nanotecnología (IMN-CNM, CSIC) |
| 11 | 1 | Mitigating Model Bias in Conjunction with Variability-Driven Financial Risks in Solar PV Projects | Mark Campanelli | Intelligent Measurement Systems LLC |
| 12 | 1 | Accounting for Snow Stow in Energy Modeling | Reilly Smith | Invenergy |
| 13 | 1 | Three Methods to Improve Inverter Performance Under Shading Conditions in Large-Scale Complex Terrain PV Systems | Hailin Bai | LONGi Green Energy Technology Co., Ltd |
| 14 | 1 | Simulation of Power Generation for Mountainous Photovoltaic Power Plants | Hailin Bai | LONGi Green Energy Technology Co., Ltd. |
| 15 | 1 | Quantifying and examining subhourly correction methodologies | Abby Hentges | Luminate LLC |
| 16 | 1 | Soiling inputs for the Kimber dust soiling model derived from soiling measurements | Nate Croft | Luminate LLC |
| 17 | 1 | A methodology to capture technology and market- specific shading behavior in common industry performance modeling tools | Kiran Balasubramanian | Maxeon Solar Technologies |
| 18 | 1 | Development of a 95-year Solar Dataset for Resource Adequacy Studies | Jaemo Yang | NREL |
| 19 | 1 | Comparing PAR Calculation Methods for Tracker and Vertical Agrivoltaic Arrays | Chong-Seok Choi | NREL |
| 20 | 1 | Impact of data temporal resolution on multijunction energy yield modeling | Rajiv Daxini | NREL |
| 21 | 1 | Solar Energy Non-Standard Probability Distributions Estimated via Monte Carlo Simulations | Halley Darling | OWC |
| 22 | 1 | PVRADAR Python Package: Extension to pvlib for faster and easier modelling | Thore Müller | PVRadar |
| 23 | 1 | Integrating SPICE and pvlib for Advanced Modeling of PV String Power Losses | Norman Jost | Sandia National Laboratories |
| 24 | 1 | Selecting horizon sample locations for utility-scale solar projects | Michael Locher | Silcon Ranch |
| 25 | 1 | Snow losses: from modelling to PV systems simulation | Branislav Schnierer | Solargis |
| 26 | 1 | Subhourly Clipping Model Comparisons | Kenneth Sauer | UL Solutions |

## Poster Session 2 - 13:05-13:50 on Day 2 (May 14)

| Number | Session | Title | Name | Institution |
|---|---|---|---|---|
| 27 | 2 | Severe Weather Risk Assessment - Preliminary Guidance for Proactive Procurement Strategies | Dominic Cartina | Apex Clean Energy |
| 28 | 2 | Maintenance-Free Measurement of Power Losses from Soiling | Josh Horst | Atonometrics |
| 29 | 2 | Analysis of hybrid PV+BESS energy dispatch profiles with various Solar PV orientations | Shail Bajpai | Black & Veatch |
| 30 | 2 | PV project performance testing from an EPC perspective | Jay Miller | Black & Veatch |
| 31 | 2 | Probabilistic Ramp Rate Forecasts of Aggregate Power of PV Fleets | Thomas Haley | Clean Power Research |
| 32 | 2 | A review of impacts of uncertainty in PV system capacity tests | Jeff Newmiller | DNV |
| 33 | 2 | Empirical Performance Loss Rates in Distributed Solar PV Installations | Dale Tutaj | DNV |
| 34 | 2 | A Comparison of PV Capacity Test Standards | Thomas Dodamead | EDF Renewables |
| 35 | 2 | Physics and machine learning: two digital twins for production modelling; two views of plant performance | Todd Miller | GreenPowerMonitor |
| 36 | 2 | Energy Performance Index (EPI) application for solar farms under energy curtailment and frequent reactive power injection into the grid | Rafael Avila | ICREA |
| 37 | 2 | Calculation of Expanded Uncertainty for a Capacity Test | David Auslender | McCarthy Building Companies, Inc. |
| 38 | 2 | The Fourth Edition of the Best Practices Handbook for Solar Resource Data for Solar Energy Application | Manajit Sengupta | NREL |
| 39 | 2 | Recent Update of International Standards on Radiometry | Aron Habte | NREL |
| 40 | 2 | Scaling the PV Fleet Performance Data Initiative | Martin Springer | NREL |
| 41 | 2 | Automated Detection of SCADA Tag Mismatches in Utility-Scale PV Systems Using Time-Series Cross-Correlation | Rob van Haaren | Proximal Energy |
| 42 | 2 | Three Methods for Deriving the Reporting Conditions and Expected Capacity of PV Power Plants | Adam Kankiewicz | Origis Energy |
| 43 | 2 | Effect of Intra-row Placement of Pyranometers on Capacity Tests for Non-Backtracking Systems | Chris Hart | SB Energy |
| 44 | 2 | PI Data-Driven Predictive Analytics for BESS Performance Monitoring | Drumil Joshi | Southern Power Company |
| 45 | 2 | Automated Fault Detection & Performance Monitoring for PV Systems Using Dash | Jason Chestnutt | Southern Power Company |
| 46 | 2 | Plant performance analysis with satellite resource data and public power data | Will Hobbs | Southern Company |
| 47 | 2 | Remote sensing for floating PV site prospection: automatic water body detection and layout generation | Emanuela Matrullo | TotalEnergies |
| 48 | 2 | Modeling soiling of photovoltaic systems with atmospheric reanalysis: Supporting Site Selection and Cleaning Strategy Optimization | Guillaume Masson | TotalEnergies |
| 49 | 2 | Intraday Solar and Power Forecasts for Market Participation Optimization | Nelson Salazar-Peña | Universidad de los Andes |
| 50 | 2 | Improved PV Cleaning Schedule Optimization with a Markov Decision Chain Approach | Carl Becker | University of Heidelberg |
| 51 | 2 | How Remote sensing helps solar power plants mitigate wind hazards | Michael Scripps | VAISALA |
| 52 | 2 | Advanced Hail Risk Modeling, Maps & Fighting-Jays Adjacent Hail Stow Case Study | Dennis Weaver | VDE Americas |
| 53 | 2 | Inverter availability analysis of operational solar project portfolio | Albert Chang | VDE Americas / Carnegie Mellon University |
| 54 | 2 | How to Assess Energy Yield and Degradation with Operational Power Curves | Innes MacMillan | Wood PLC |
| 55 | 2 | Challenges in Capacity Testing: A Case Study | David Smith | Wood PLC |