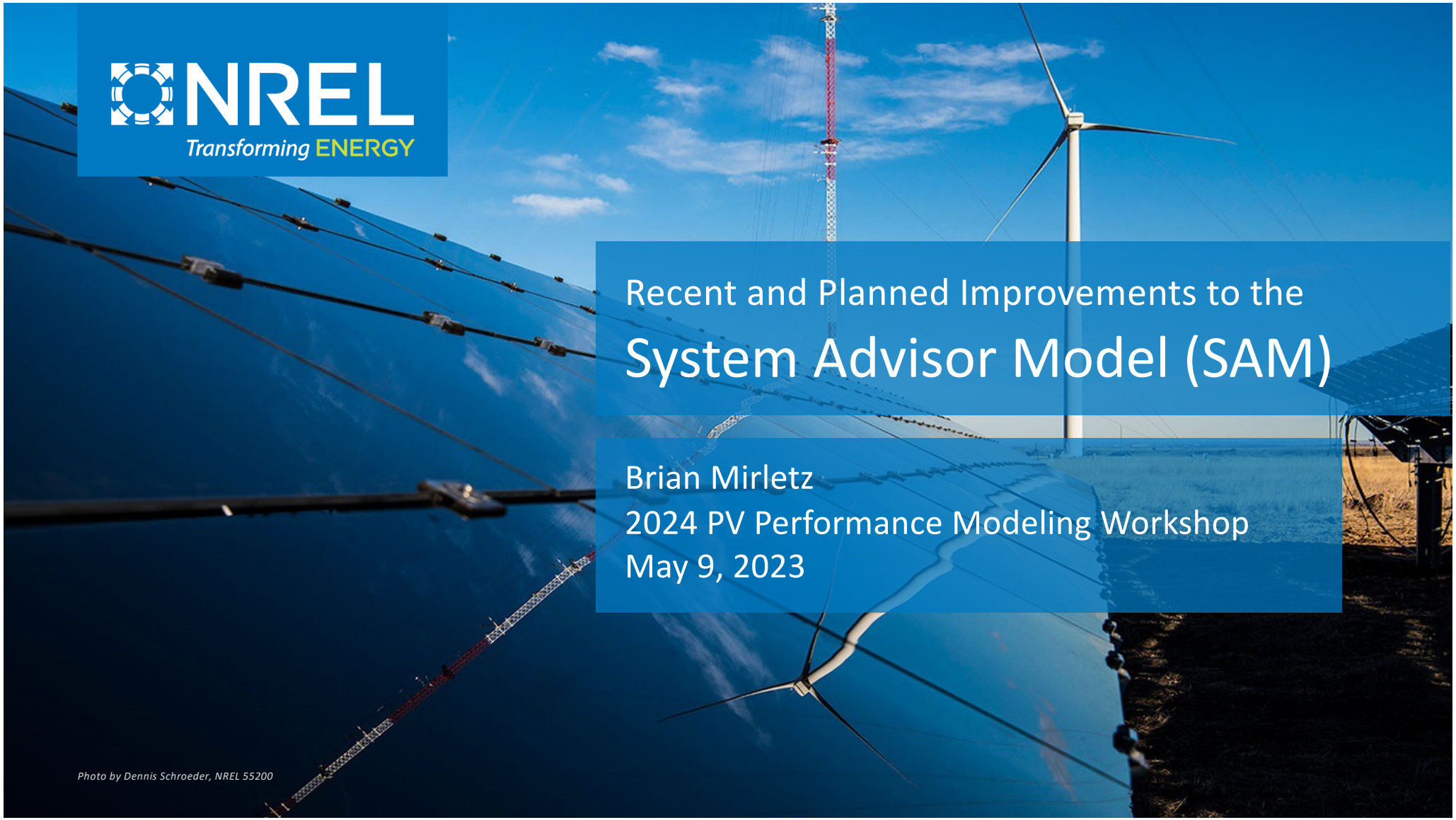


Recent and Planned Improvements to the

System Advisor Model (SAM)

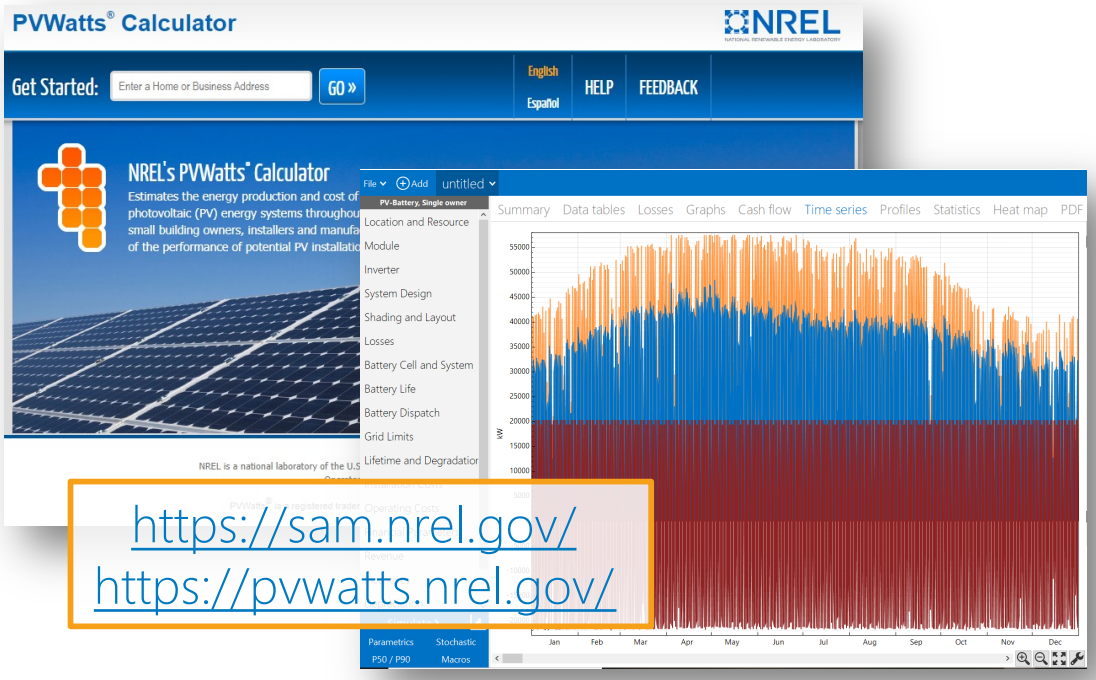
Brian Mirletz

2024 PV Performance Modeling Workshop

May 9, 2023

System Advisor Model (SAM) & PVWatts

Free software that enable detailed performance and financial analysis for renewable energy systems



https://sam.nrel.gov/
https://pvwatts.nrel.gov/

- ✓ Desktop application
- ✓ PVWatts web tool & API
- ✓ Software development kit
- ✓ PySAM Python package
- ✓ Open source code
- ✓ Extensive documentation
- ✓ User support

SAM Users

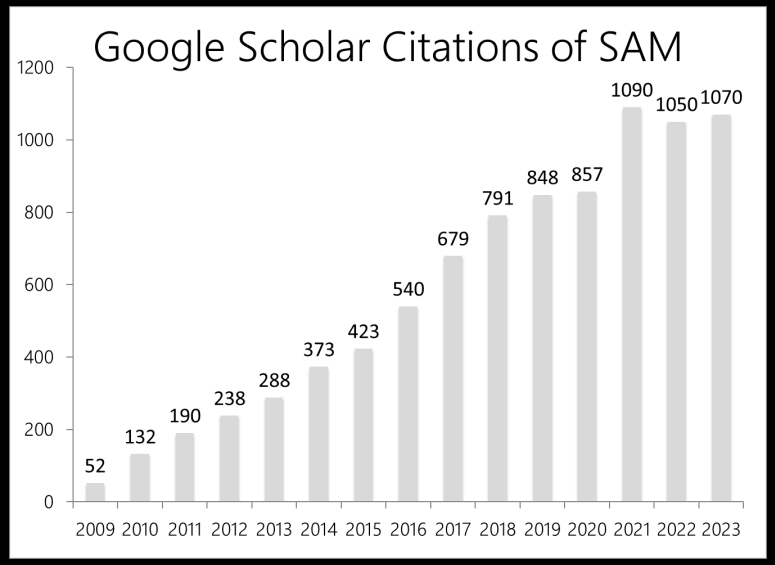
SAM is started **once every 1.4 minutes**

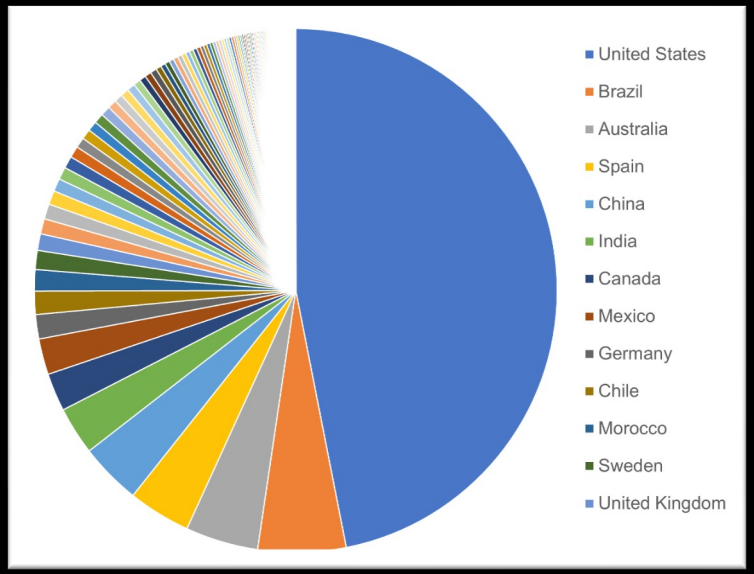
PVWatts receives over **17.5 million hits per month**

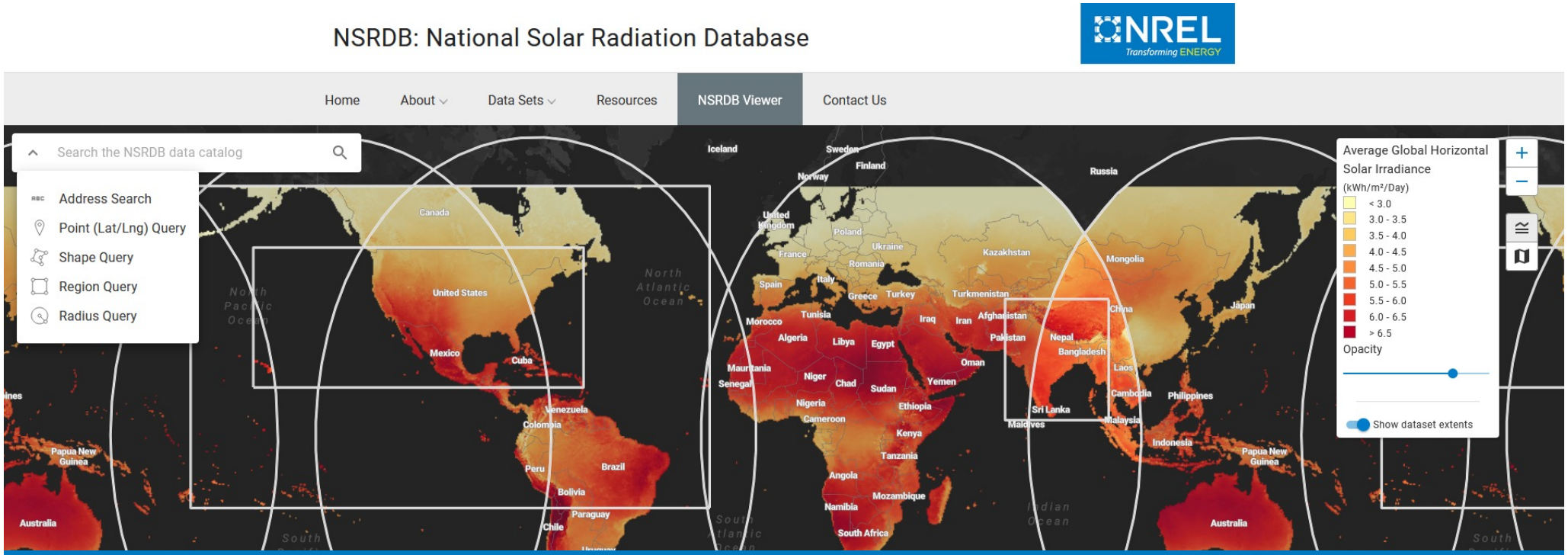
Over **200,000** users in 190+ countries

120+ webinars with **over 280,000 views**

Users include Sunrun, Enphase, AEP, Southern Company, EPRI, & more





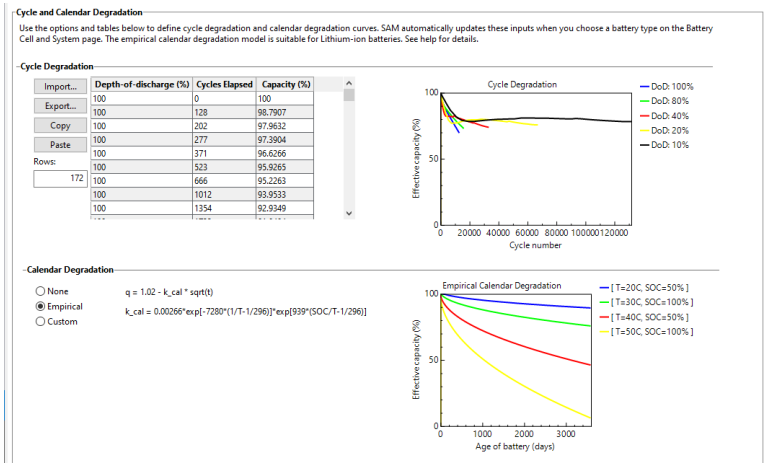


Integrated new NSRDB METEOSAT dataset for Europe and Africa

- SAM's weather file download automatically accesses new APIs
- PVWatts update coming soon

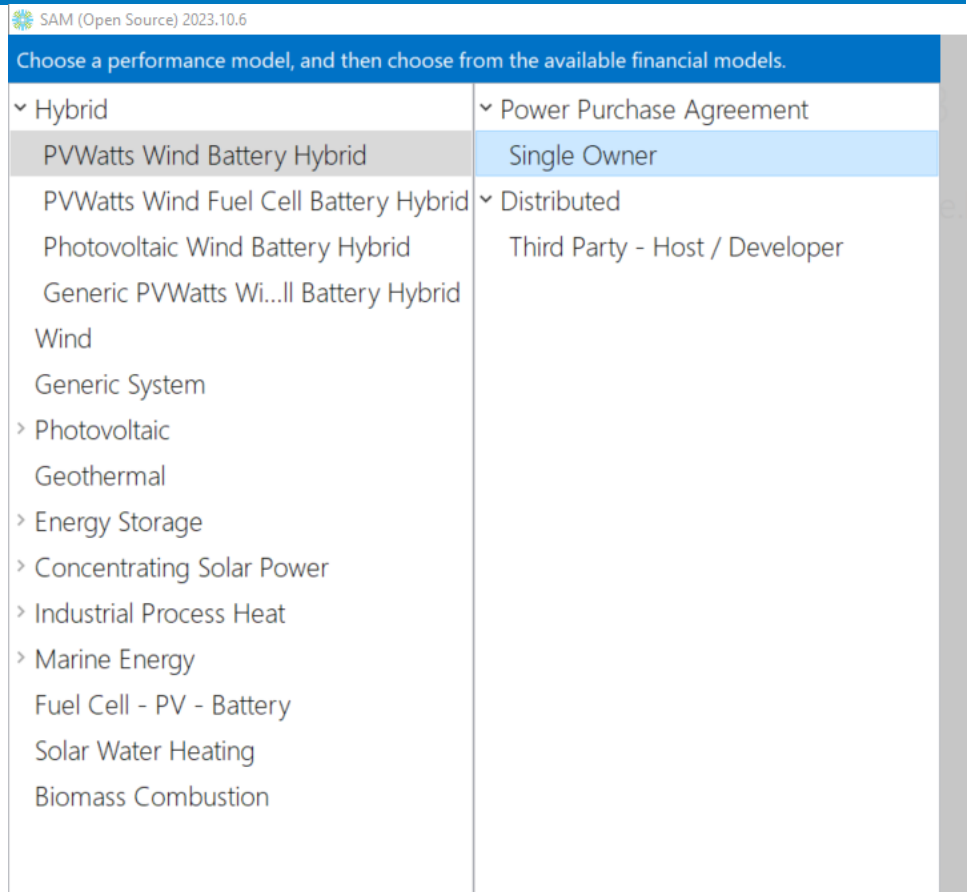
Noteworthy Older Features

- ✓ Subhourly timesteps
- ✓ AC or DC coupled PV plus battery models
- ✓ 11 different financial models (both front of meter and behind the meter)
- ✓ PySAM Python Wrapper
  - ✓ Access underlying compute modules (technology and/or financial)



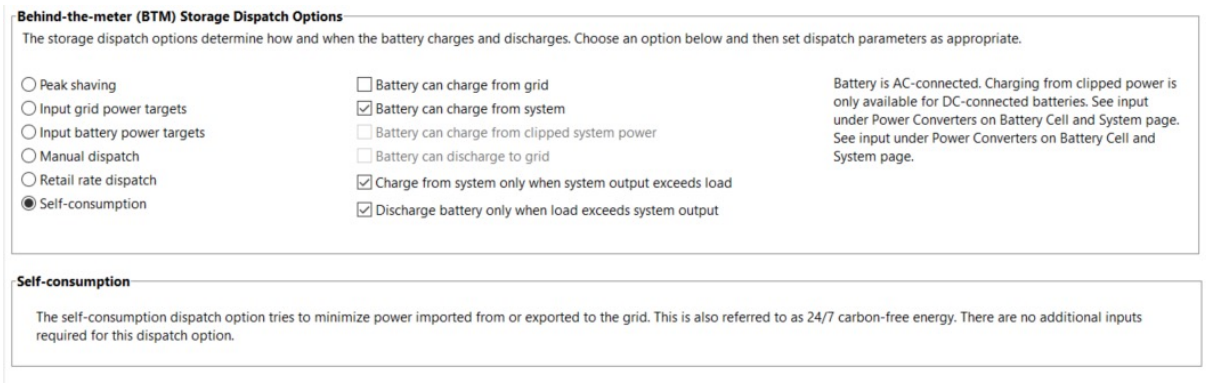
Hybrid Simulations (PV+Wind+Battery)

- Includes the following technology configurations:
  - Wind + PVWatts + Battery
  - Wind + PVWatts + Fuel Cell + Battery
  - Wind + Detailed PV + Battery
  - Generic System + Wind + PVWatts + Fuel Cell + Battery



Features co-funded by Southern Company and DOE SETO

Dispatch for Self Consumption



Features co-funded by Southern Company and DOE SETO

Southern Company

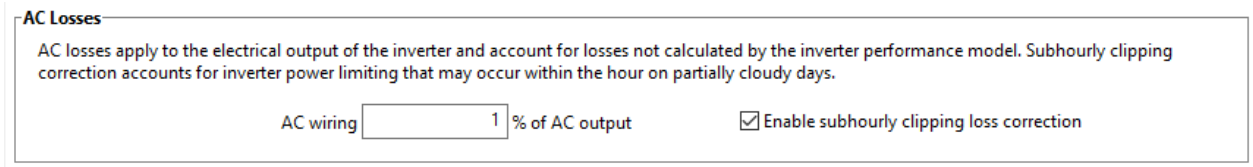
- Self consumption is a new dispatch method for behind-the-meter systems, also called 24/7 carbon-free energy.
- Can be used for generation co-located with load or a PPA with transmission.
- Enables additional outputs with the number of steps when the electric load is fully met by the system.

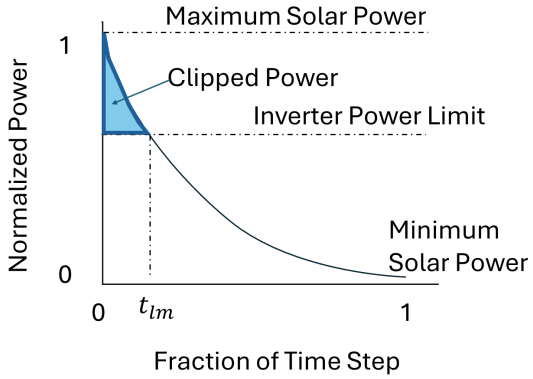
Lifetime Hourly Data | Single Values

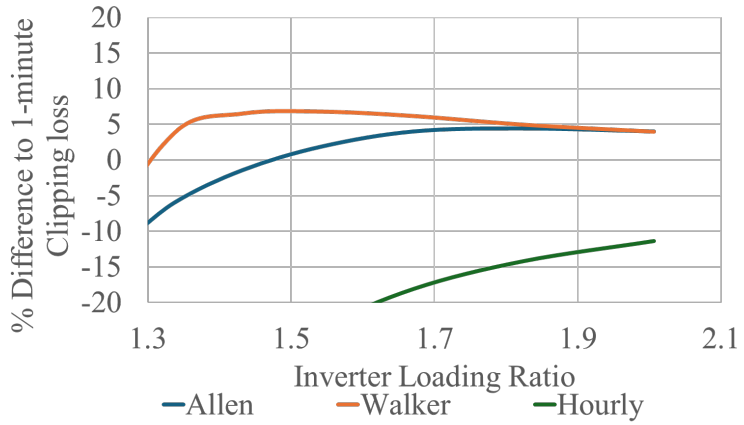
Battery Number of timesteps electric load met by system (lifetime)	123179
Battery Number of timesteps electric load met by system (year 1)	5051
Battery Percent of timesteps electric load met by system (lifetime)	56.2461
Battery Percent of timesteps electric load met by system (year 1)	57.6598

Sub-hourly Clipping Correction

- ✓ 2023.12.17 includes method from Allen, Hobbs, and Bolen 2022
- ✓ Walker method available in the SDK/PySAM







Features co-funded by Southern Company and DOE SETO

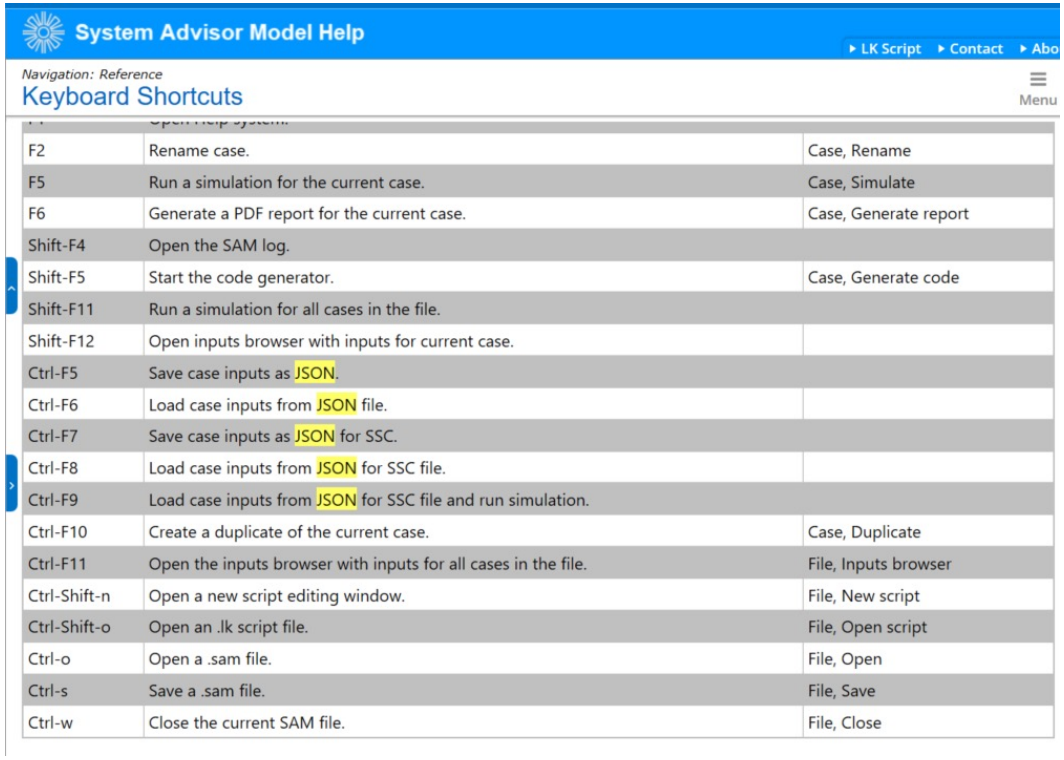
Allen, J. O., Hobbs, W. B., and Bolen, M., "Classification Method to Predict the Effect of Short-Term Inverter Saturation on PV Performance Modeling", PVPMC Workshop 2022, Salt Lake City, UT.

Walker, Andy, and Jal Desai. *Distribution Function Instead of Steady-State Assumption in Time-Series Simulation*. No. NREL/PO-7A40-83733. National Renewable Energy Lab.(NREL), Golden, CO (United States), 2022.

Prilliman, Matthew; Keith, Janine; Hobbs, William. "Subhourly Clipping Correction Model Comparison" PVPMC Workshop 2024, Salt Lake City, UT.

Improved PySAM & JSON integration

- ✓ New keyboard shortcuts now support loading a case from JSON in addition to saving to JSON
- ✓ Useful for loading cases generated in PySAM or the SDK for a more detailed analysis or debugging



F2	Rename case.	Case, Rename
F5	Run a simulation for the current case.	Case, Simulate
F6	Generate a PDF report for the current case.	Case, Generate report
Shift-F4	Open the SAM log.	
Shift-F5	Start the code generator.	Case, Generate code
Shift-F11	Run a simulation for all cases in the file.	
Shift-F12	Open inputs browser with inputs for current case.	
Ctrl-F5	Save case inputs as JSON.	
Ctrl-F6	Load case inputs from JSON file.	
Ctrl-F7	Save case inputs as JSON for SSC.	
Ctrl-F8	Load case inputs from JSON for SSC file.	
Ctrl-F9	Load case inputs from JSON for SSC file and run simulation.	
Ctrl-F10	Create a duplicate of the current case.	Case, Duplicate
Ctrl-F11	Open the inputs browser with inputs for all cases in the file.	File, Inputs browser
Ctrl-Shift-n	Open a new script editing window.	File, New script
Ctrl-Shift-o	Open an .lk script file.	File, Open script
Ctrl-o	Open a .sam file.	File, Open
Ctrl-s	Save a .sam file.	File, Save
Ctrl-w	Close the current SAM file.	File, Close

SDK/PySAM only features

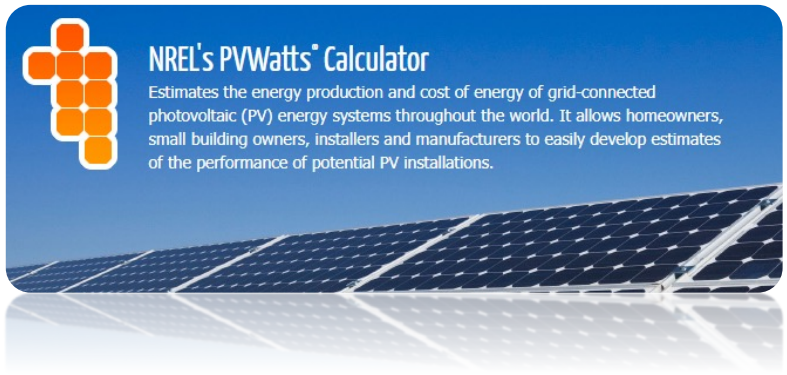
- ✓ Detailed PV and PVWatts support sub-annual simulations
- ✓ User-specified timeseries for measured module temperature input
- ✓ New: Custom tracker angles

More information: https://sam.nrel.gov/software-development-kit-sdk.html

https://nrel-pysam.readthedocs.io/en/main/

Upcoming

- ✓ Speed improvements to PVWattsV8 API
- ✓ Continued improvements to the new hybrids capabilities
- ✓ Simplified battery financial modeling including virtual power plants
- ✓ Improved PV, battery, load visualizations
- ✓ Continued updates to marine energy and geothermal models
- ✓ Improved wind wake modeling
- ✓ Industrial process heat financial updates

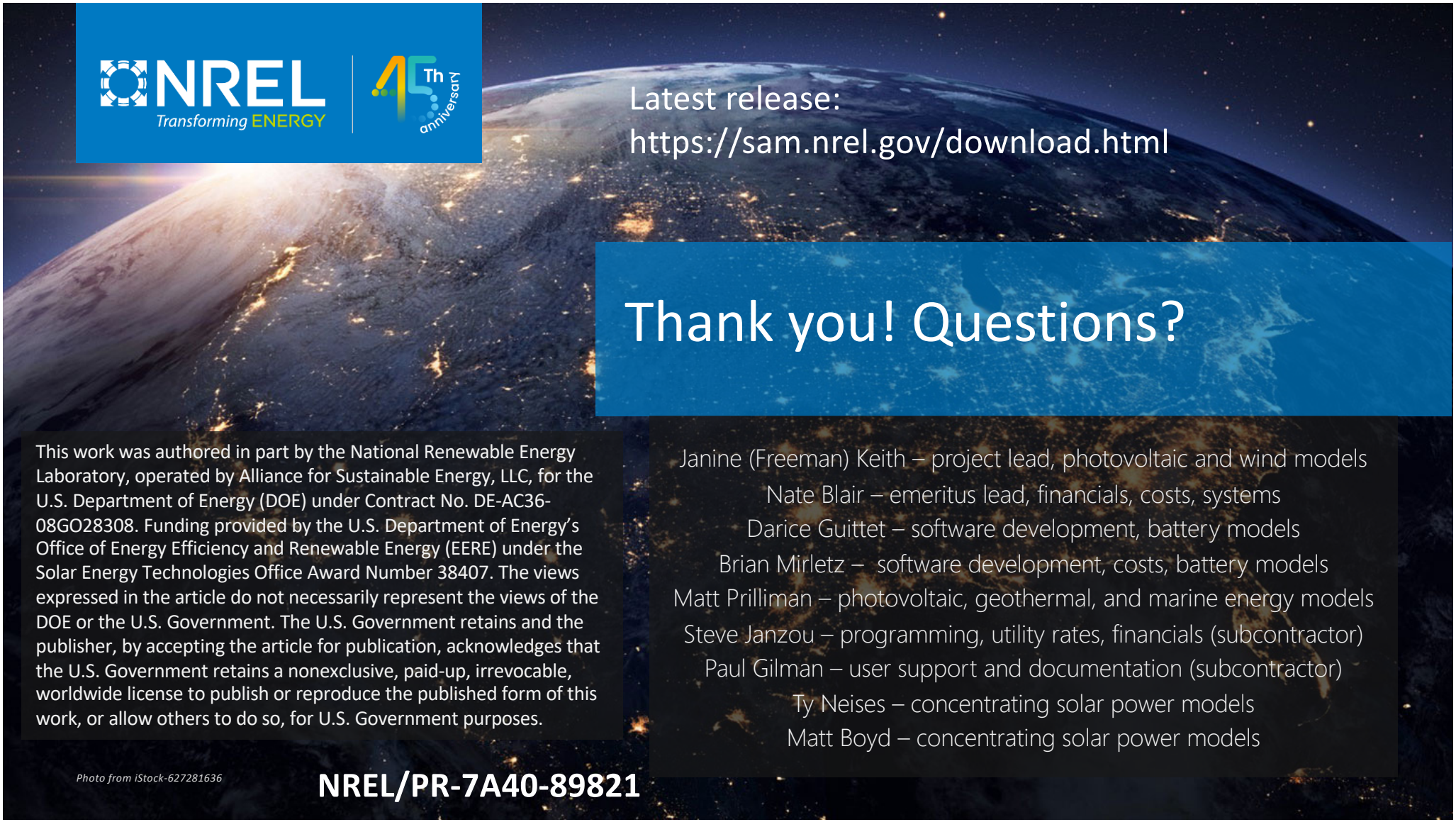


pvlib to PySAM demo

- ✓ Coming up at 2:30 pm
- ✓ Combines PV generation from pvlib's model chain with SAM's singleowner financial model
- ✓ Link to example: https://github.com/NREL/pysam/blob/main/Examples/PVPMC_pvlib_PySAM_example/pvlib_pysam_example.ipynb







Latest release:
https://sam.nrel.gov/download.html

Thank you! Questions?

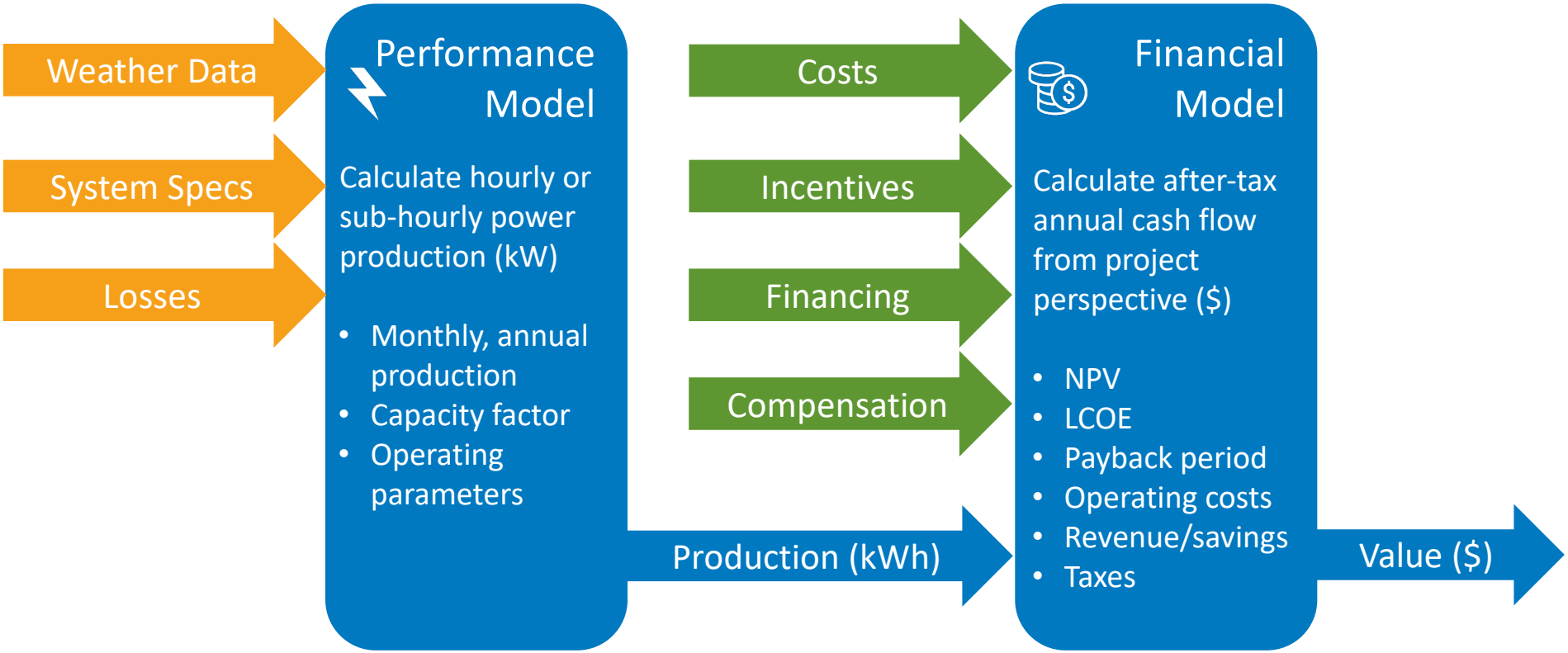
This work was authored in part by the National Renewable Energy Laboratory, operated by Alliance for Sustainable Energy, LLC, for the U.S. Department of Energy (DOE) under Contract No. DE-AC36-08GO28308. Funding provided by the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy (EERE) under the Solar Energy Technologies Office Award Number 38407. The views expressed in the article do not necessarily represent the views of the DOE or the U.S. Government. The U.S. Government retains and the publisher, by accepting the article for publication, acknowledges that the U.S. Government retains a nonexclusive, paid-up, irrevocable, worldwide license to publish or reproduce the published form of this work, or allow others to do so, for U.S. Government purposes.

Janine (Freeman) Keith – project lead, photovoltaic and wind models
Nate Blair – emeritus lead, financials, costs, systems
Darice Guittet – software development, battery models
Brian Mirletz – software development, costs, battery models
Matt Prilliman – photovoltaic, geothermal, and marine energy models
Steve Janzou – programming, utility rates, financials (subcontractor)
Paul Gilman – user support and documentation (subcontractor)
Ty Neises – concentrating solar power models
Matt Boyd – concentrating solar power models

Photo from iStock-627281636

NREL/PR-7A40-89821

Model Structure







Technologies

- Photovoltaic
- Energy storage
  - Electric battery
  - Electric thermal
  - Pumped thermal
- Concentrating solar power
- Industrial process heat
- Marine energy
- Wind power
- Fuel cell
- Geothermal power
- Solar water heating
- Biomass combustion
- Generic system

Financial Models

- Power purchase agreements
  - Single owner
  - Partnership flips
  - Sale leaseback
- Residential
- Commercial
- Third party ownership
- Merchant plant
- Community solar
- Simple LCOE calculator

How can you access SAM models?

- Desktop Application
- Advanced Analysis Features
  - Parametric
  - Stochastic
  - P50/P90
- Built-in Scripting Language
- Macros
- Software Development Kit (SDK)
  - Python (PySAM package)
  - C/C++
  - Matlab
  - PHP
  - C#
  - Java
  - VBA
  - iOS / Android
- Web Services API (PVWatts Only)
- Open-source SAM code