



System
Advisor
Model

Modeling PV Uncertainty in SAM

Matt Prilliman
National Renewable Energy Laboratory
July 30, 2024



Webinars

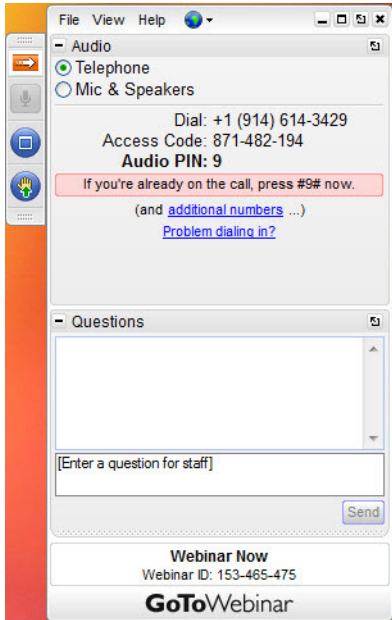
- **Modeling PV Uncertainty in SAM - July 30**
- Modeling Financial Incentives in SAM – August 13
- Modeling Hybrid Power Systems in SAM – August 27

*All webinars start at 1 PM MDT

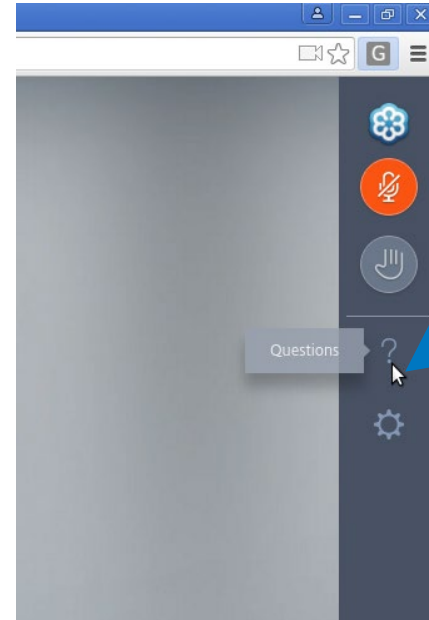
Register for free at: <https://sam.nrel.gov/events.html>

Find webinar recordings at <https://sam.nrel.gov/>

GoTo Webinar



Desktop application



Instant Join Viewer

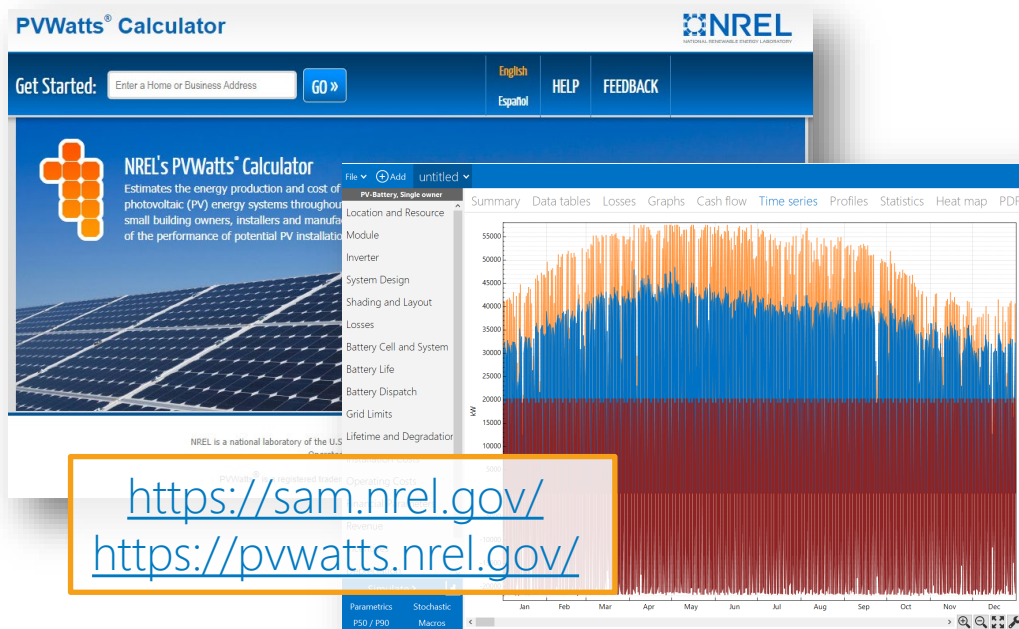
We will either type an answer to your question or answer it at the end of the presentation.

Agenda

1. Introduction to SAM
2. PV uncertainty modeling in SAM
3. Live demo
4. Q&A

System Advisor Model (SAM) & PVWatts

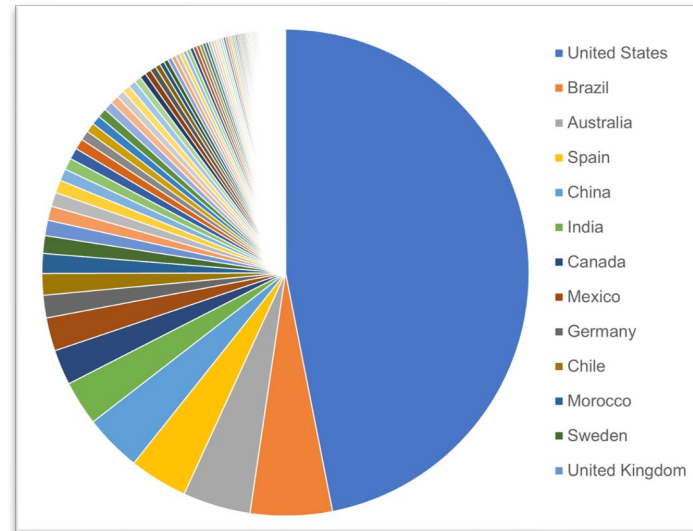
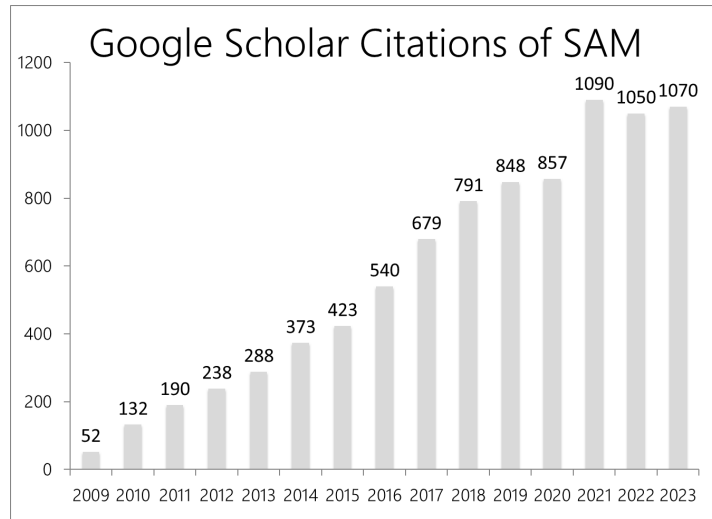
Free software that enable detailed performance and financial analysis for renewable energy systems



- ✓ 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

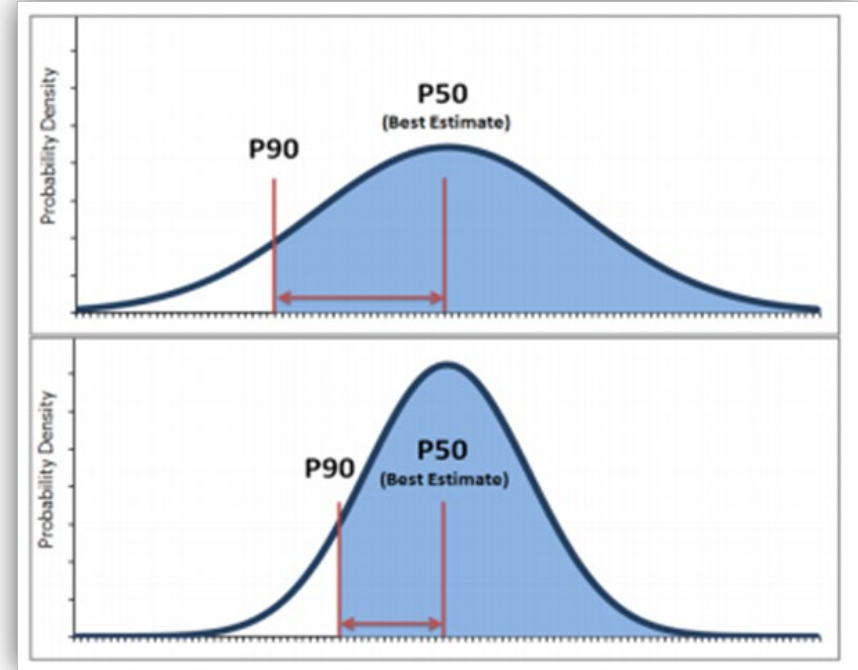


Acknowledgements and Availability

- SAM capability developed in conjunction with Sandia National Laboratories
- Funded by DOE Solar Energy Technologies Office (SETO)
- Developed in 2021 – 2023
- Available from SAM version 2022.11.21 onward

PV Uncertainty

- **P90:** 10th percentile of distribution of future annual energy
 - Plant expected to exceed P90 kWh annual yield 90% of time
- **PXX:** (100 – XX) percentile of distribution of future annual energy



Prilliman, M.; Hansen, C.; Keith, J.; Janzou, S.; Theristis, M.; Scheiner, A.; Ozakyol, E. (2023) Quantifying Uncertainty in PV Energy Estimates Final Report. National Renewable Energy Laboratory. 18 pp. NREL/TP-7A40-84993. ([PDF 541 KB](#))

Hansen, C. (2024) Uncertainty in P90 of Energy Yield. PVPMC Workshop, Salt Lake City, UT. ([PDF](#)).

PV Uncertainty

- Detailed PV, PVWatts:
account for weather
variability + model and
parameter uncertainty
- Other SAM technologies:
only calculate P90, P50
based on weather
variability
- Uncertainty due to:
 - Weather variability
 - Future weather
 - Model and parameter
uncertainty
 - Modeler skill

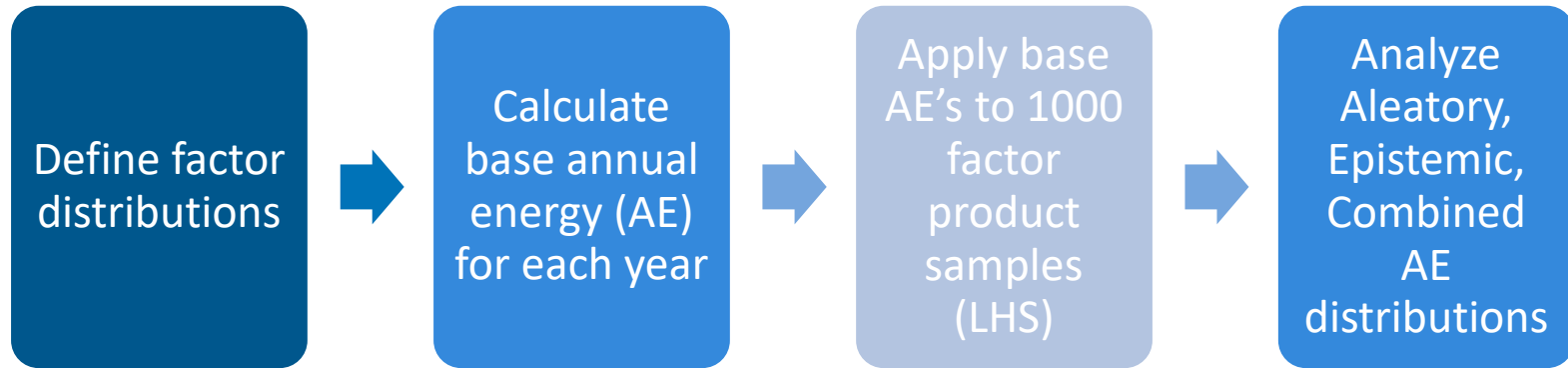
PV Uncertainty

- **Aleatory:** uncertainty that cannot be reduced with improved measurements or models
 - Ex: future weather cannot be fully known
- **Epistemic:** uncertainty that can be reduced with more accuracy, larger sample sizes in measurements; improved models
 - Ex: temperature coefficients known more precisely with better measurements

Prilliman, M.; Hansen, C.; Keith, J.; Janzou, S.; Theristis, M.; Scheiner, A.; Ozakyol, E. (2023) Quantifying Uncertainty in PV Energy Estimates Final Report. National Renewable Energy Laboratory. 18 pp. NREL/TP-7A40-84993. ([PDF 541 KB](#))

Hansen, C. (2024) Uncertainty in P90 of Energy Yield. PVPMC Workshop, Salt Lake City, UT. ([PDF](#)).

PV Uncertainty



- N weather years x 1000 factor product samples
- Up to 12 epistemic factor categories

PV Uncertainty

- Define uncertainty factor distributions
- New: turn on/off epistemic factor categories
- Upcoming: revised default values

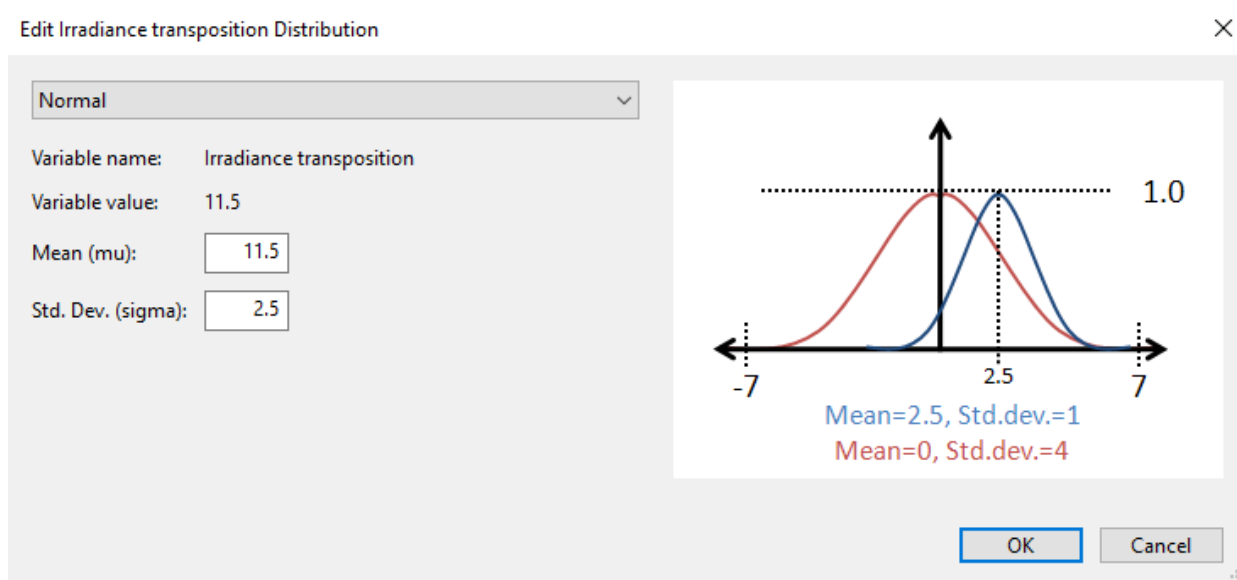
[Run uncertainty simulations >](#)

Probability Distributions of Mean Annual Energy Gain or Loss

<input checked="" type="checkbox"/> Irradiance transposition	Normal, Mean (μ)=11.5, Std. Dev. (σ)=2.5	Edit...
<input checked="" type="checkbox"/> Horizon shading	Triangular, A=-1, B=0, C=0	Edit...
<input checked="" type="checkbox"/> Row shading	Triangular, A=-5, B=-1, C=0	Edit...
<input checked="" type="checkbox"/> Single module rating at STC	Normal, Mean (μ)=0, Std. Dev. (σ)=2	Edit...
<input checked="" type="checkbox"/> Inverter availability	Triangular, A=-5.7, B=-2.7, C=0	Edit...
<input checked="" type="checkbox"/> Spectral response	Normal, Mean (μ)=-1, Std. Dev. (σ)=0.5	Edit...
<input checked="" type="checkbox"/> Cell temperature	Normal, Mean (μ)=-2.4, Std. Dev. (σ)=1	Edit...
<input checked="" type="checkbox"/> Mismatch loss	Triangular, A=-1.8, B=-0.8, C=0	Edit...
<input checked="" type="checkbox"/> DC wiring	Triangular, A=-2.5, B=-1.5, C=-1	Edit...
<input checked="" type="checkbox"/> Transformer	Triangular, A=-2, B=-1, C=-0.5	Edit...
<input checked="" type="checkbox"/> Soiling	Triangular, A=-1.5, B=-0.5, C=0	Edit...

PV Uncertainty

- Choose distribution type for each factor
- Example diagrams for each type



PV Uncertainty

- Download all available weather years from NSRDB (separate from base case simulation)
- Or select weather files from folder
- Minimum 10 years of weather data
- Select PXX to model

Interannual Variability

Weather file folder: C:\Users\mprillim\SAM Downloaded Weather Files\golden_co_uncertainty

Choose folder...

[Download from NSRDB...](#)

Update P value

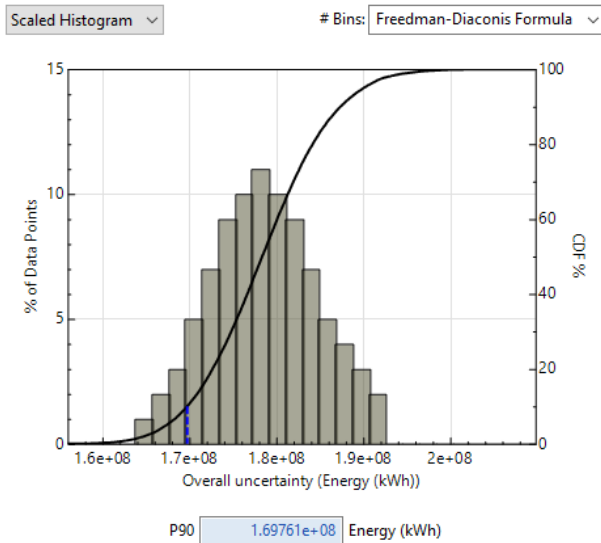
Custom Px:

90

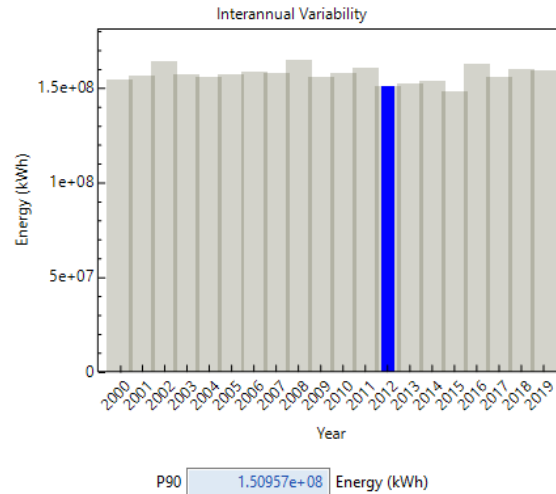
Change P-value

Uncertainty Results

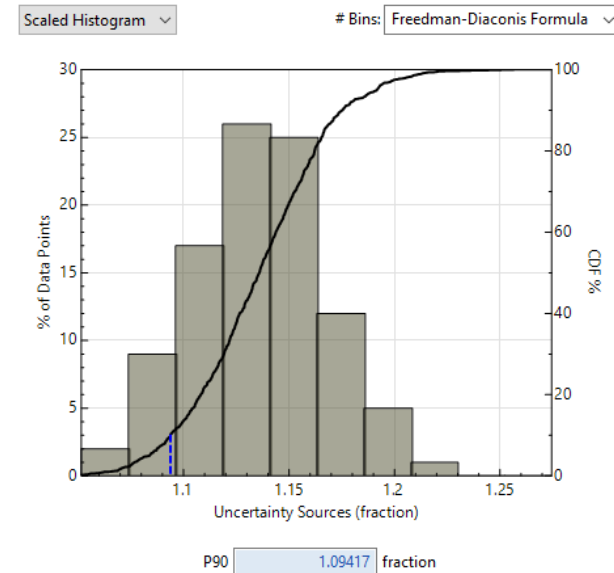
Combined



Aleatory



Epistemic



Live Demo

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.

Contact: Matt Prilliman
Matthew.Prilliman@nrel.gov

<https://sam.nrel.gov/>

SAM support email:
Sam.support@nrel.gov