Recent and Planned Improvements to the System Advisor Model (SAM)

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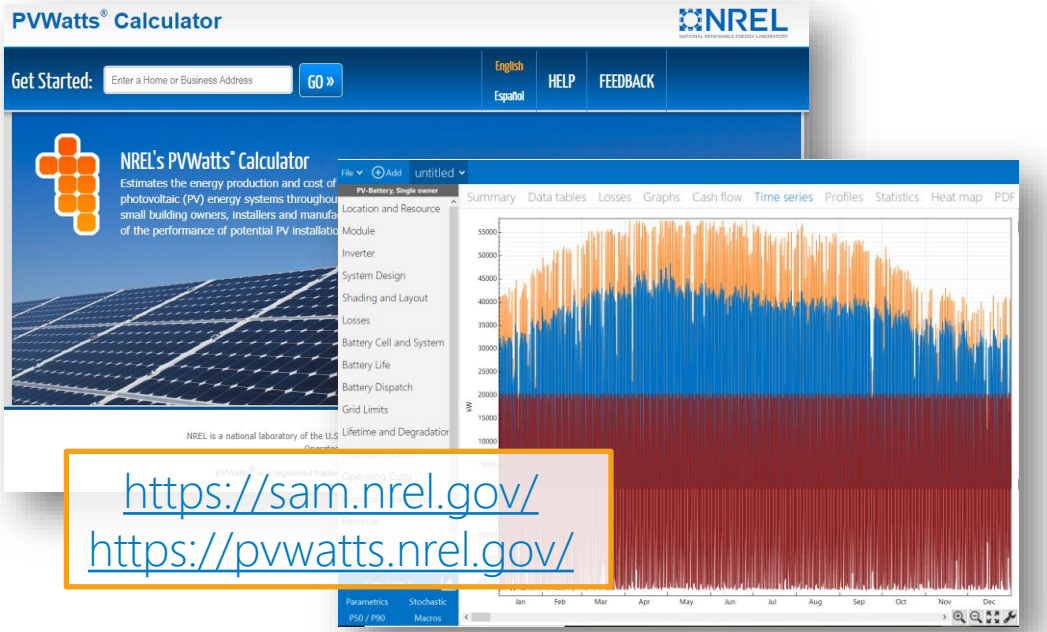
2022 PV Performance Modeling Workshop

August 23, 2022

Photo by Dennis Schroeder, NREL 55200

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

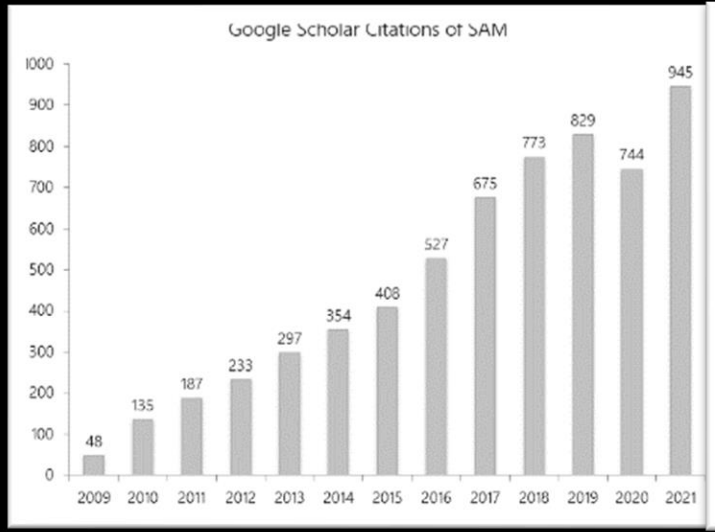
SAM is started **once every 2 minutes**

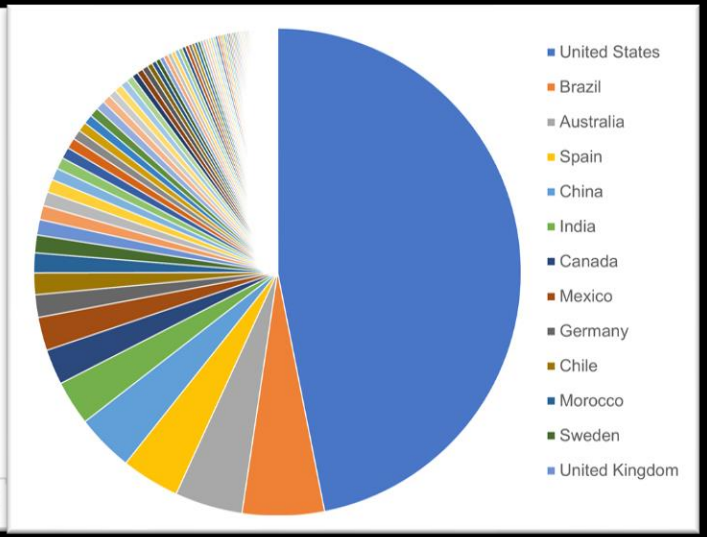
PVWatts receives over **17.5 million hits per month**

Over **150,000** users in 190+ countries

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

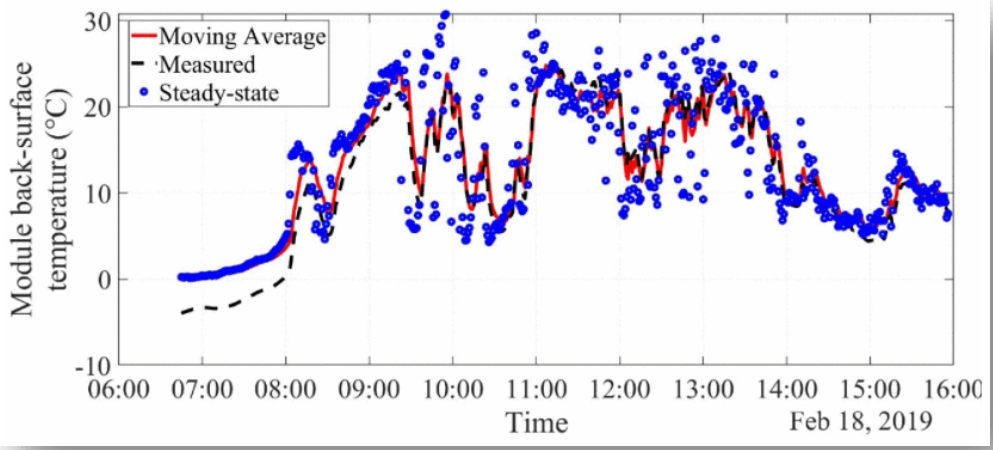
Users include Sunrun, Enphase, AEP, Southern Company, EPRI, & more





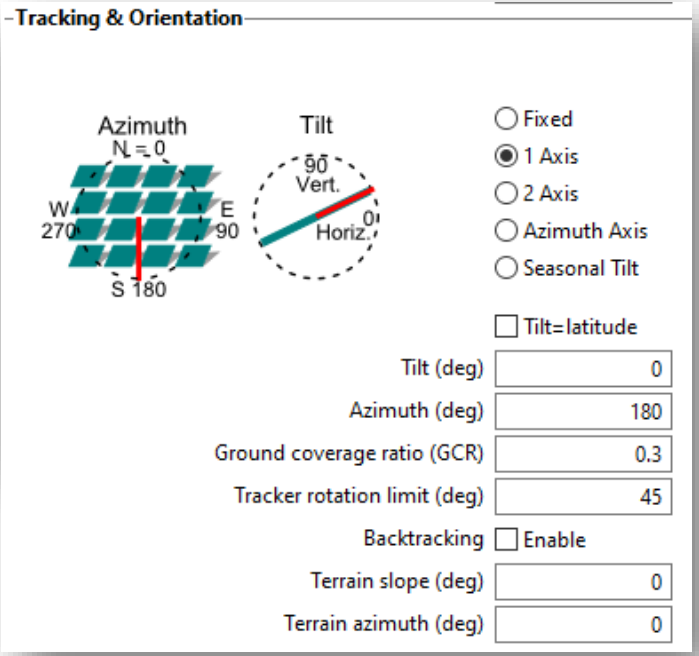
Detailed PV Model Improvements

Transient Module Thermal Model for subhourly simulations



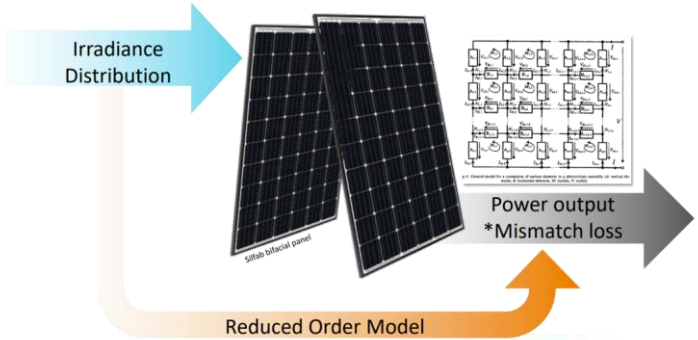
M. Prilliman, J. S. Stein, D. Riley and G. Tamizhmani, "Transient Weighted Moving-Average Model of Photovoltaic Module Back-Surface Temperature," in IEEE Journal of Photovoltaics, vol. 10, no. 4, pp. 1053-1060, July 2020, doi: 10.1109/JPHOTOV.2020.2992351.

Improved backtracking algorithm with simple terrain slope input



Upcoming: Bifacial Model Improvements

- Bifacial electrical mismatch
- Shading from racking structures
- Multi-albedo ground surface
- Edge effects



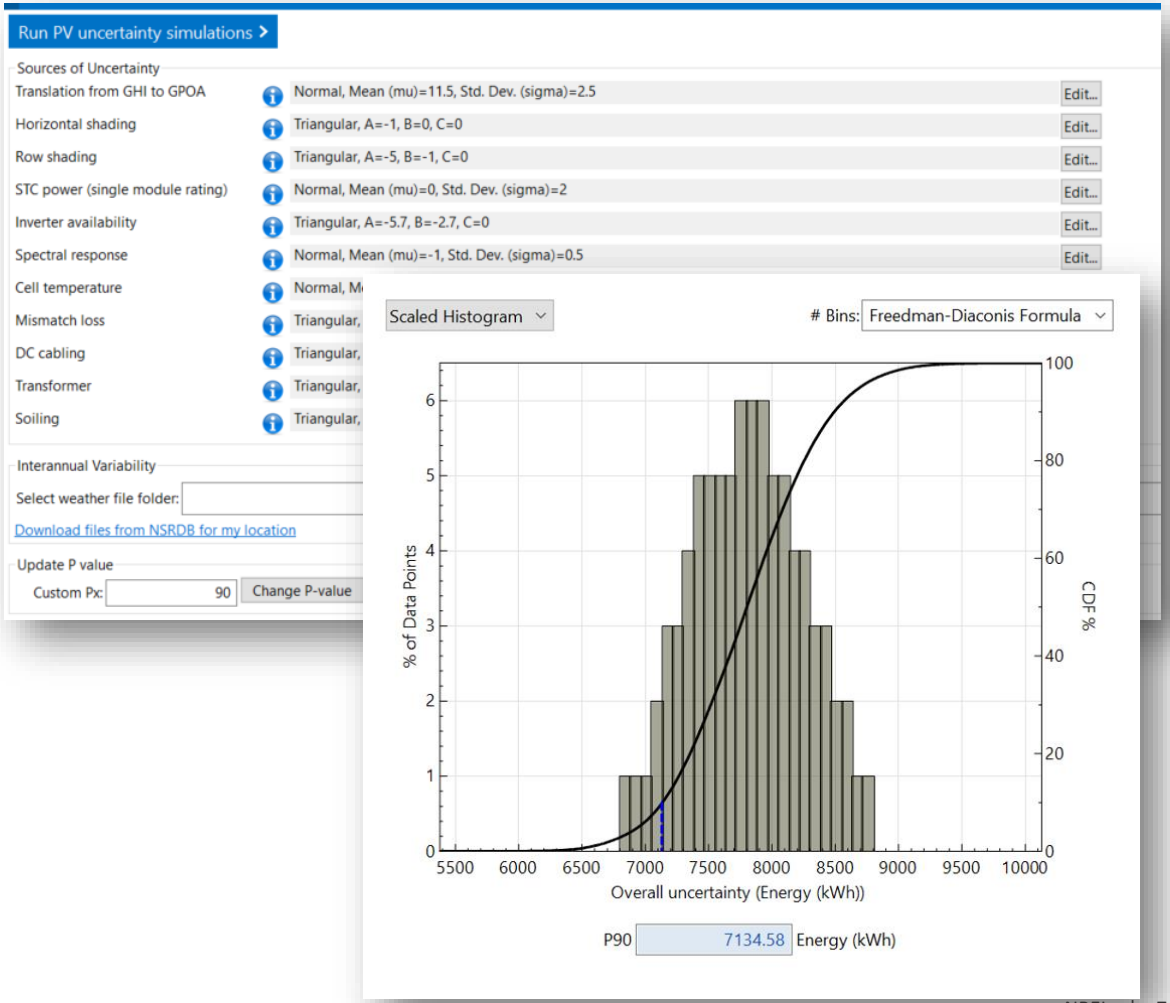
PVWattsV8

- *Available now in the SAM desktop application/PySAM*
- *Coming soon to the PVWatts API and website*

- Bifacials, snow, wind stow, monthly soiling
- Expanded global weather data availability
- Now uses same module, thermal, & inverter models as detailed PV model

Coming this fall: PV Uncertainty Model

Implemented functionality to combine specifying multiple weather years (interannual uncertainty) with annual uncertainty factors for calculation of joint probability of exceedance (P90 etc)



New Battery Technology Models

Standalone Electric Battery

Image credit: https://www.teslarati.com/tesla-powerwall-demand-after-australian-blackouts/

Standalone Electric Thermal Energy Storage

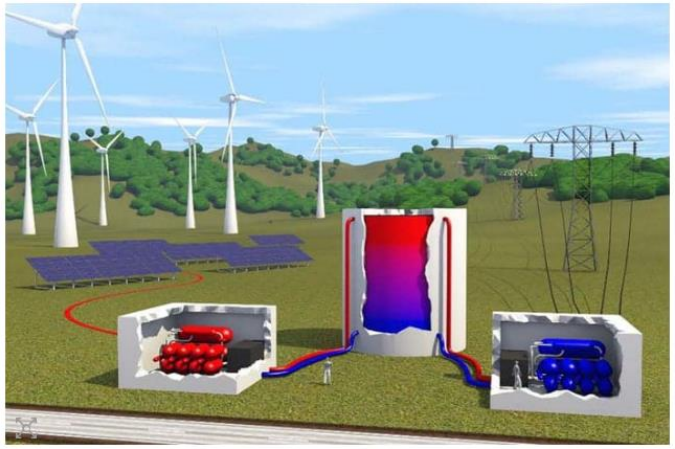
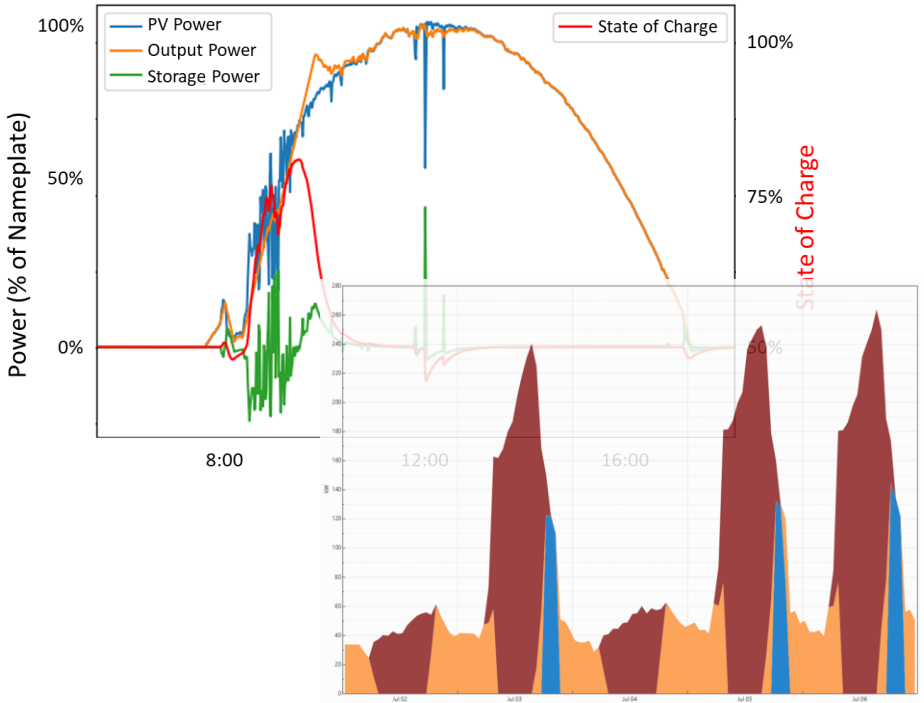


Image credit: https://physicsworld.com/a/how-to-store-electrical-energy-as-heat/

https://www.nrel.gov/docs/fy22osti/82989.pdf

New Battery Dispatch Algorithms

- Utility-scale PV smoothing dispatch algorithm
  - ***Thank you EPRI and Southern Company!***
- Behind-the-meter dispatch to respond to prices
  - Previously responded to energy peaks that might not always coincide with highest cost
- Optimal battery sizing and dispatch profile using NREL's REopt tool



Grid and Resiliency Capabilities

Image credit: https://www.constructionweekonline.com/projects-tenders/260365-gcc-egypt-jordan-ink-mou-to-work-on-interconnected-arab-power-grid

- Specify grid outages and use the battery to cover only critical loads
- Calculate resiliency metrics
- Specify interconnection limits and grid curtailment

More Battery Model Features

- **Levelized Cost of Storage** (LCOS)
- Improved **battery degradation modeling** for Li-ion NMC/graphite and LMO/LTO technologies
- Forthcoming report on **battery model validation**

Check out Brian Mirletz's poster for more battery info!

New Financial Models

- Community solar
- Merchant plant
  - Access to NREL's CAMBIUM dataset for market price proxies

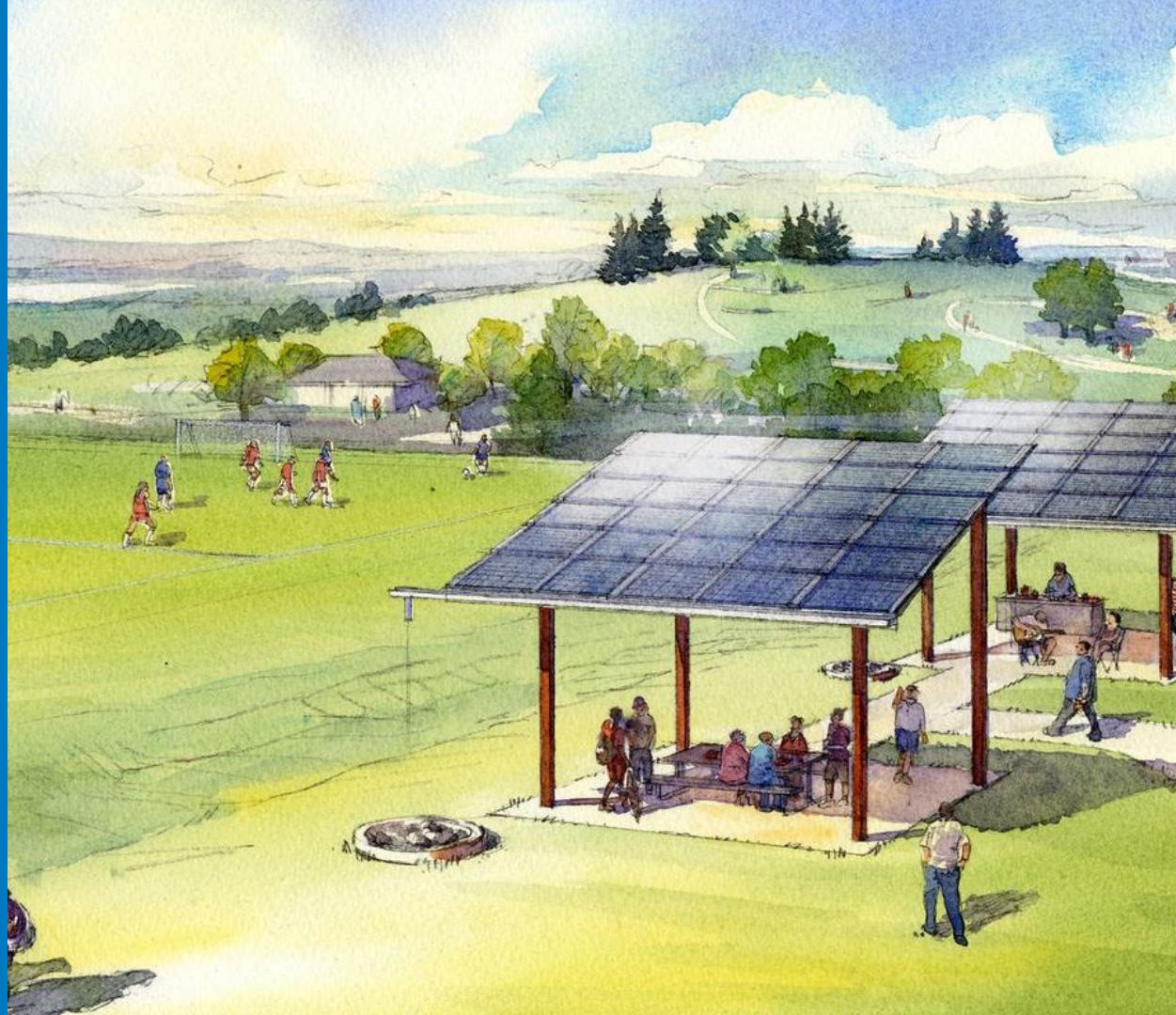


Image credit: https://www.vox.com/2016/3/24/11297054/shared-solar

New Technology Models

Image credit: https://www.mmc.gov/priority-topics/offshore-energy-development-and-marine-mammals/renewable-energy-development-and-marine-mammals/

PV+Battery+Fuel Cell

model within SAM with funding from Southern Company

Marine Energy

technology models for wave and tidal power

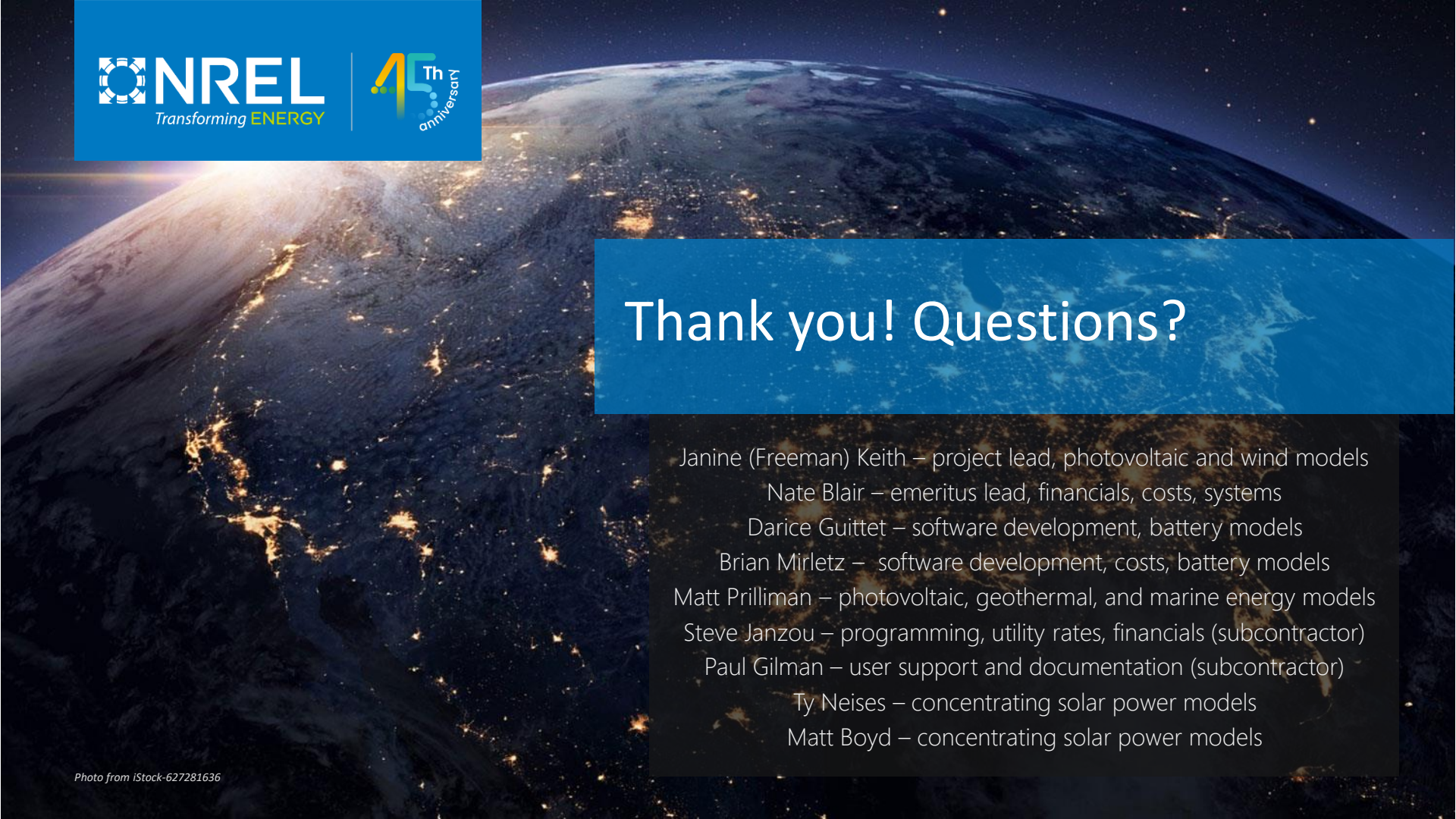
Image credit: https://www.nytimes.com/2012/10/02/business/energy-environment/marine-energy-projects-pick-up-momentum.html

Special Shoutouts

- "New" SAM team members!
  (Find them and say hi!)
- Open source code contributors
  - PySAM contributors

Brian Mirletz

Matt Prilliman

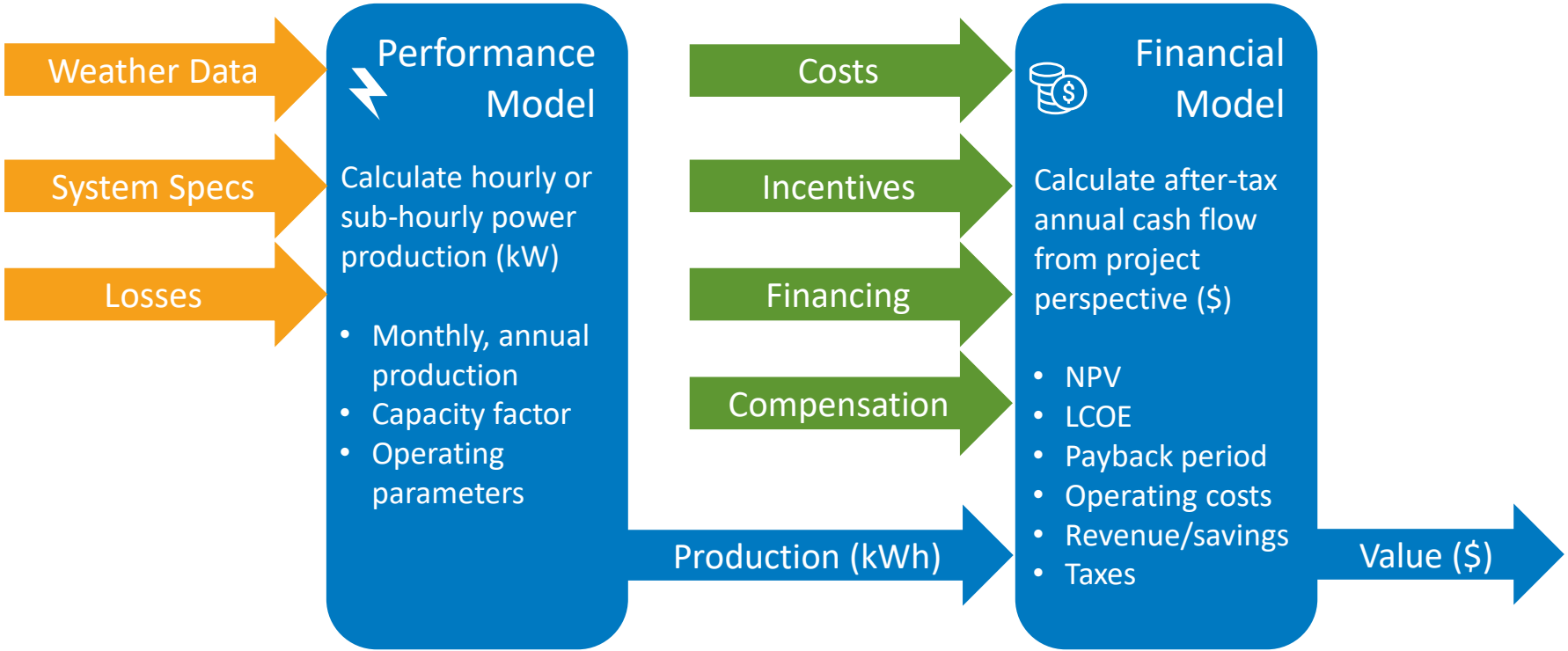


Thank you! Questions?

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

Model Structure



Technologies

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

Financial Models

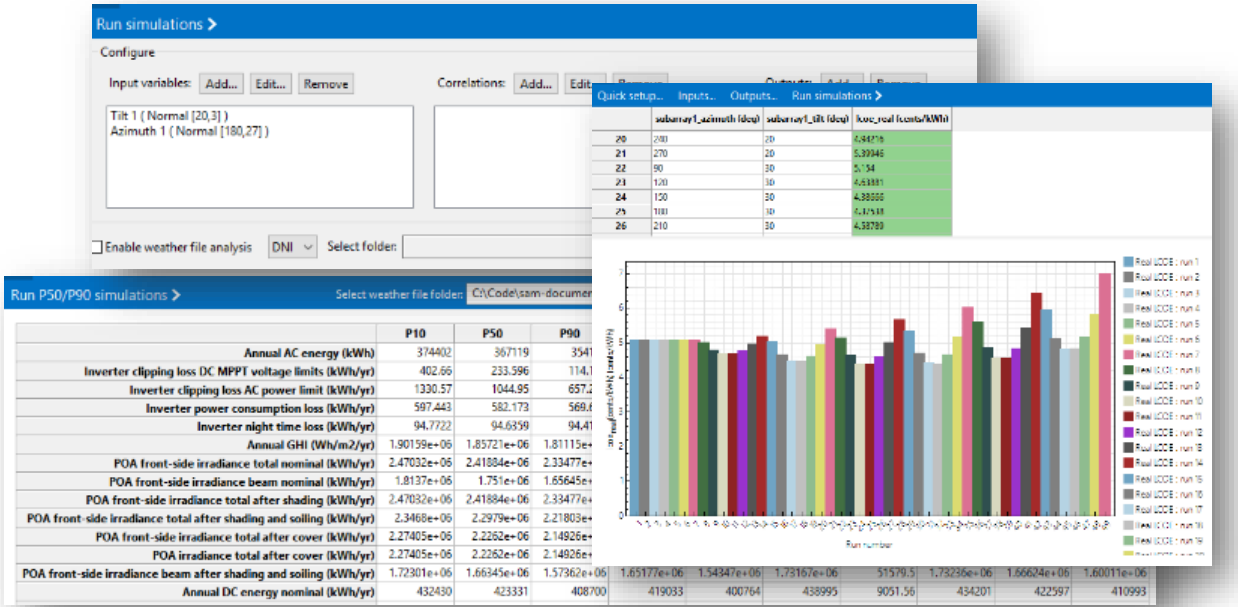
- Power purchase agreements
  - Single owner
  - Partnership flips
  - Sale leaseback
- Residential
- Commercial
- Third party ownership
- Merchant plant
- Community solar
- Simple LCOE calculator

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

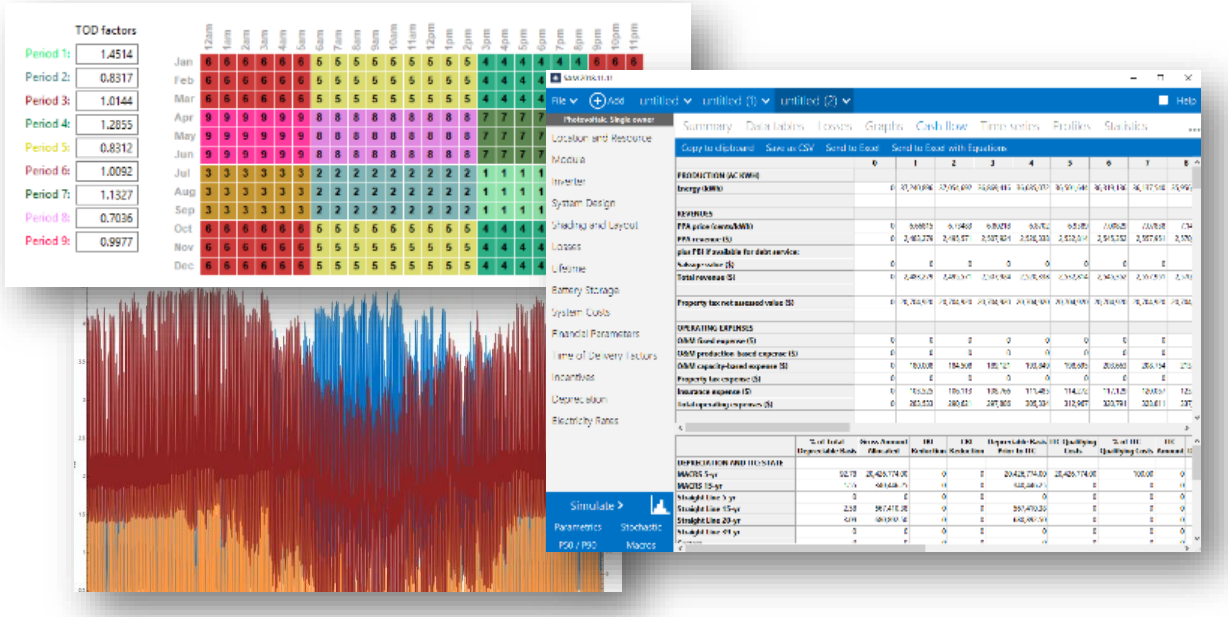
Advanced Analysis Features

Built-in parametric, stochastic, probability of exceedance (P50/P90), and scripting features enable complex questions to be answered quickly and easily



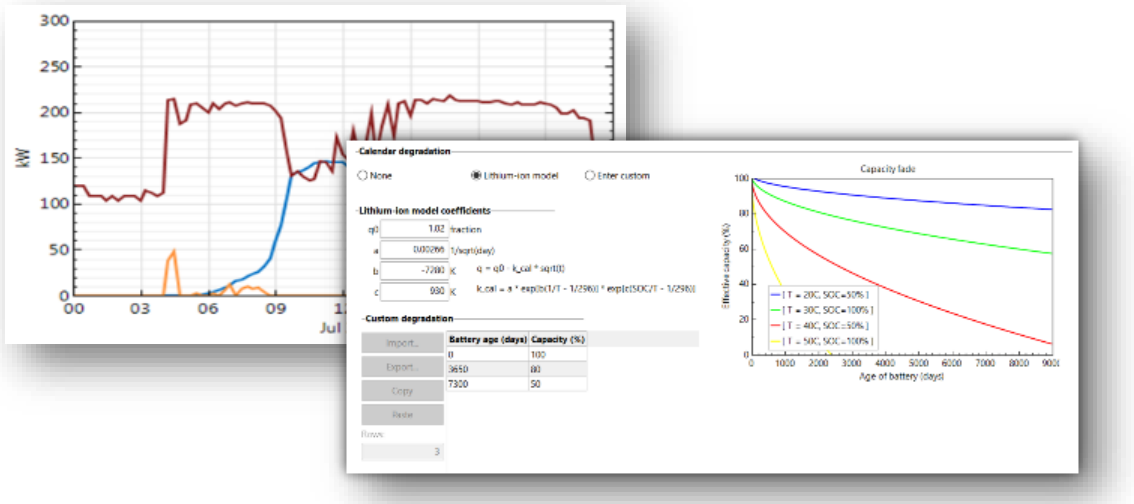
Detailed Cash Flow Financial Models

No other tool provides detailed, ***time-based*** financial modeling across multiple market sectors, including complex utility rates, combined with detailed performance modeling



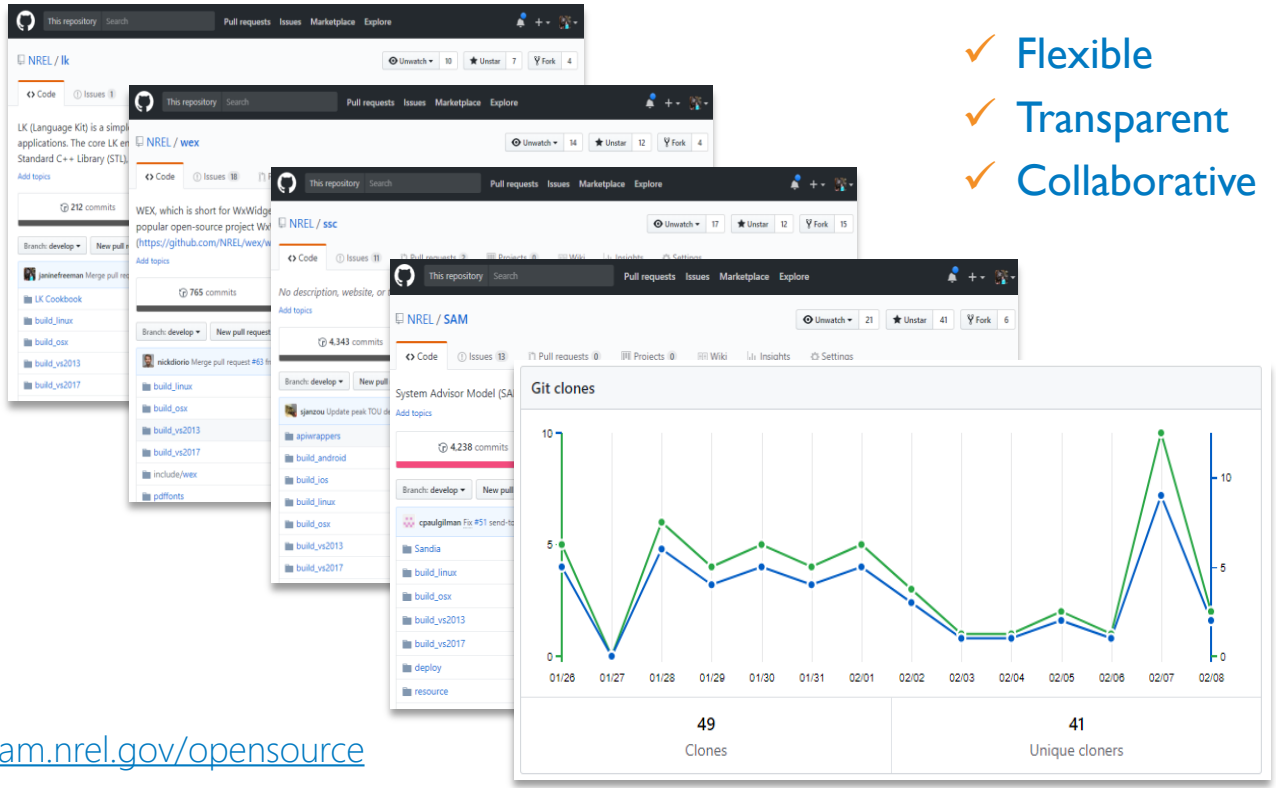
Detailed Battery Model

Only publicly available tool with detailed battery model that accounts for voltage characteristics, calendar and cycle degradation, etc



- ✓ Currently integrated with PV, "Generic System" model, Standalone battery model
- ✓ Available on DC or AC side of PV system
- ✓ Multiple automated dispatch strategies for different markets
- ✓ Behind-the-meter or front-of-the-meter operation

Open Source Code

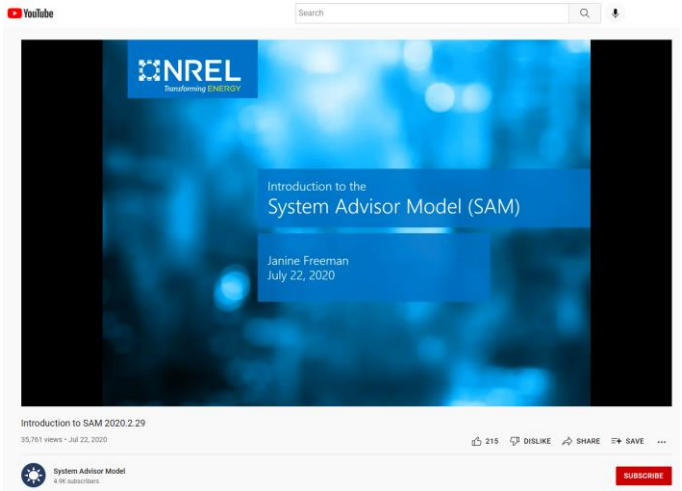


- ✓ Flexible
- ✓ Transparent
- ✓ Collaborative

http://sam.nrel.gov/opensource

Extensive Help Documentation

- Website – http://sam.nrel.gov
  - Support Forum – Ask your question!
  - General info/ online help file / contact info
- YouTube Channel
  - https://www.youtube.com/user/SAMDemoVideos
  - All prior webinars and seminars
- Bi-Monthly Round Table sessions
  - SAM team asks questions live and interactively
- Email Support
  - SAM support can provide email support if question/bug is involved



Other Resources Online

The following information resources about SAM are available.

- News
- Webinars (mostly on the SAM YouTube channel)
- Weather Data (Description of various weather data sources)
- Sample Files (particularly scripting language examples)
- Financial Model Documentation
- Performance Model Documentation (detailed descriptions)
- System Cost Data (sources and latest cost data discussion)
- Case Studies and Validation (all data/files from our validations)
- Libraries and Databases (i.e. module and inverter specs)
- Source Code (linkages to Open Source code on GitHub)

A Partial Web of NREL Data & Tools