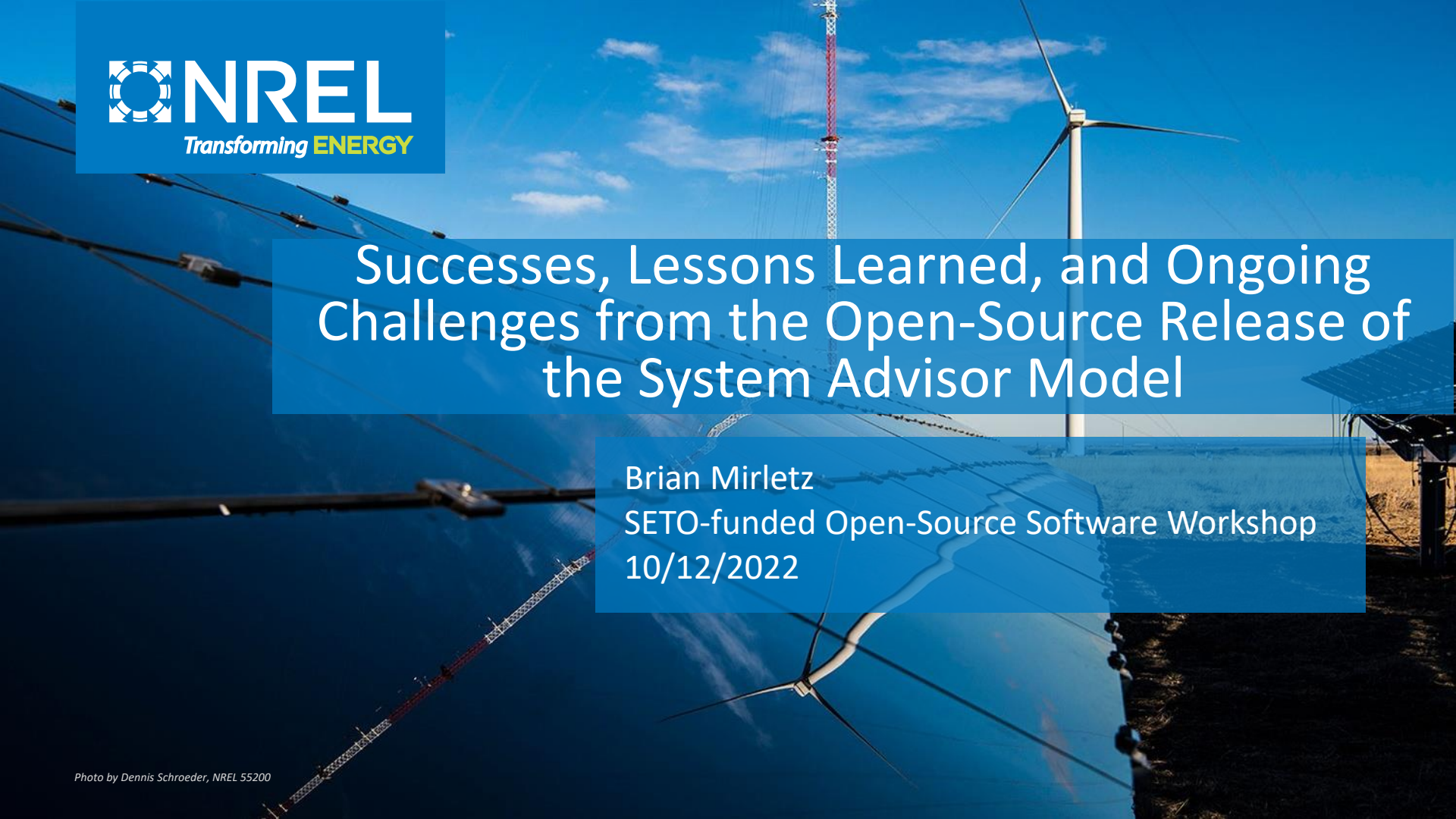


Successes, Lessons Learned, and Ongoing Challenges from the Open-Source Release of the System Advisor Model

Brian Mirletz

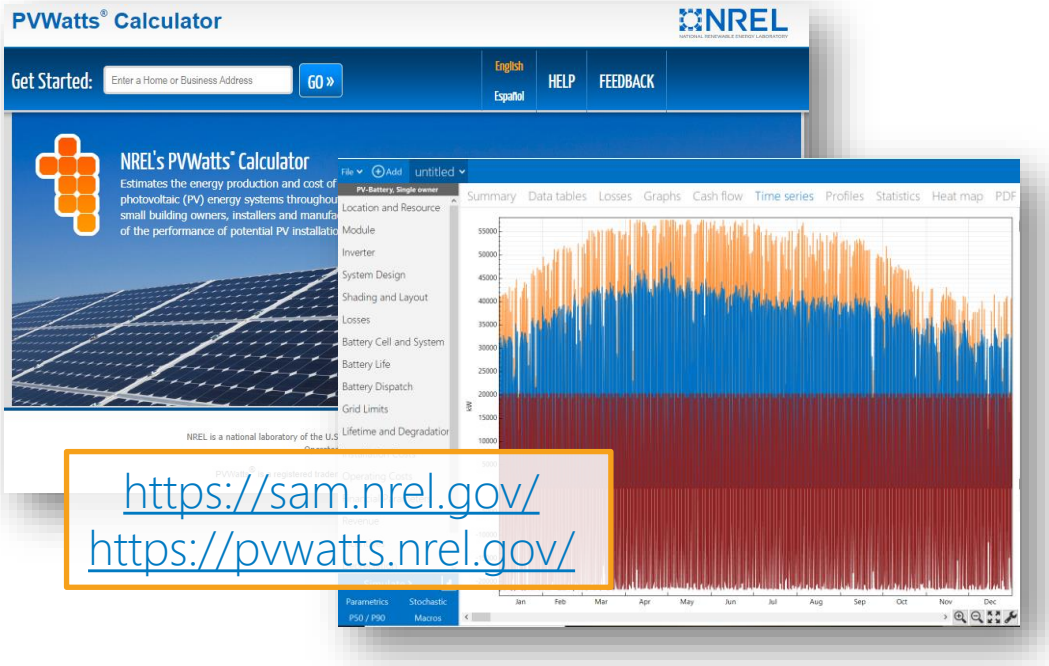
SETO-funded Open-Source Software Workshop

10/12/2022

Photo by Dennis Schroeder, NREL 55200

System Advisor Model (SAM) & PVWatts

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



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

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

SAM Users

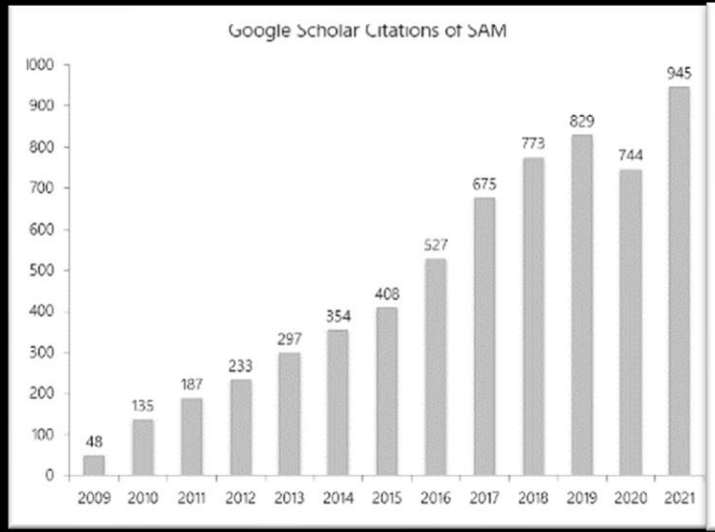
SAM is started **once every 2 minutes**

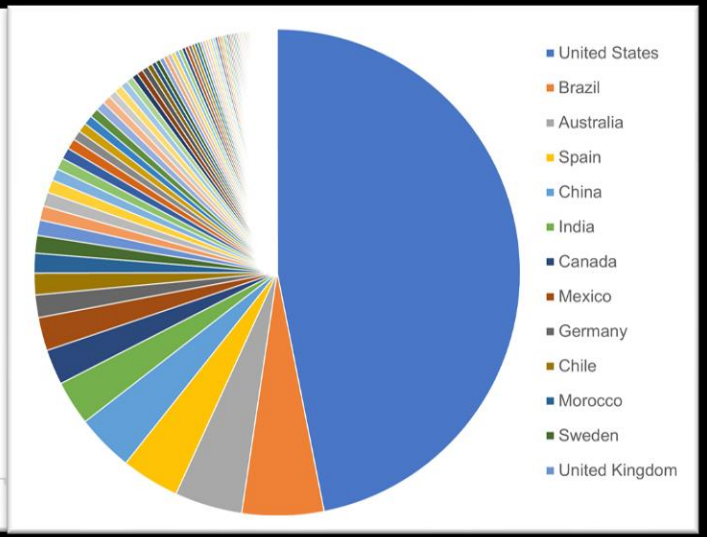
PVWatts receives over **17.5 million hits per month**

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

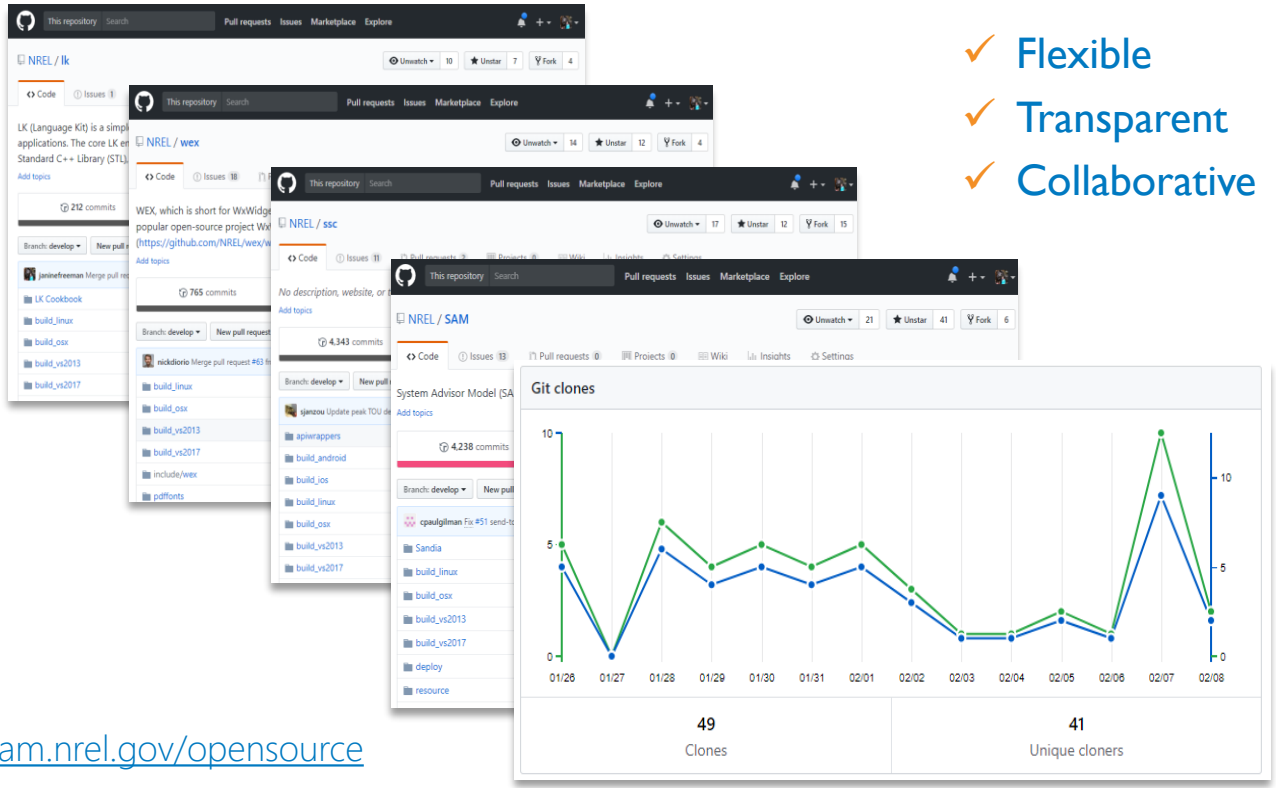
120+ webinars with **over 280,000 views**

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





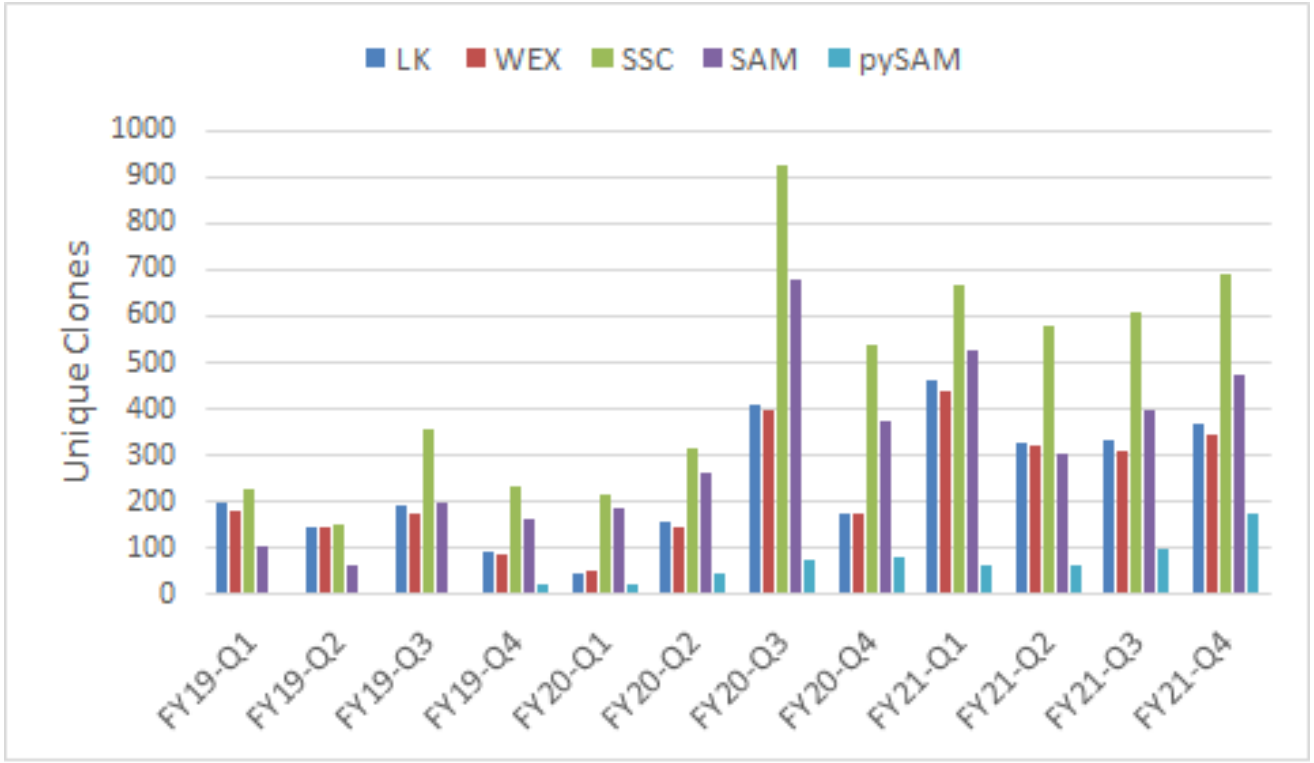
Open-Source Code



- ✓ Flexible
- ✓ Transparent
- ✓ Collaborative

http://sam.nrel.gov/opensource

Open-Source Usage



History

Developed by

- Department of Energy
- National Renewable Energy Laboratory
- Sandia National Laboratories

Originally launched closed-source in 2004

- Model different renewable energy projects in a single platform
- Facilitate technology comparison by handling performance, costs and financing consistently across technologies

Motivation for Open-Source

Open-source Launch in 2017. Provides:

Transparency

- Look at the underlying code of models

Flexibility

- Can tweak models to represent a new or unusual configuration

Standards

- Provides standards for all models, including closed-source

Collaboration

- New technology models that might not yet have a commercial market
- Encourages collaboration amongst taxpayer funded projects

Licensing

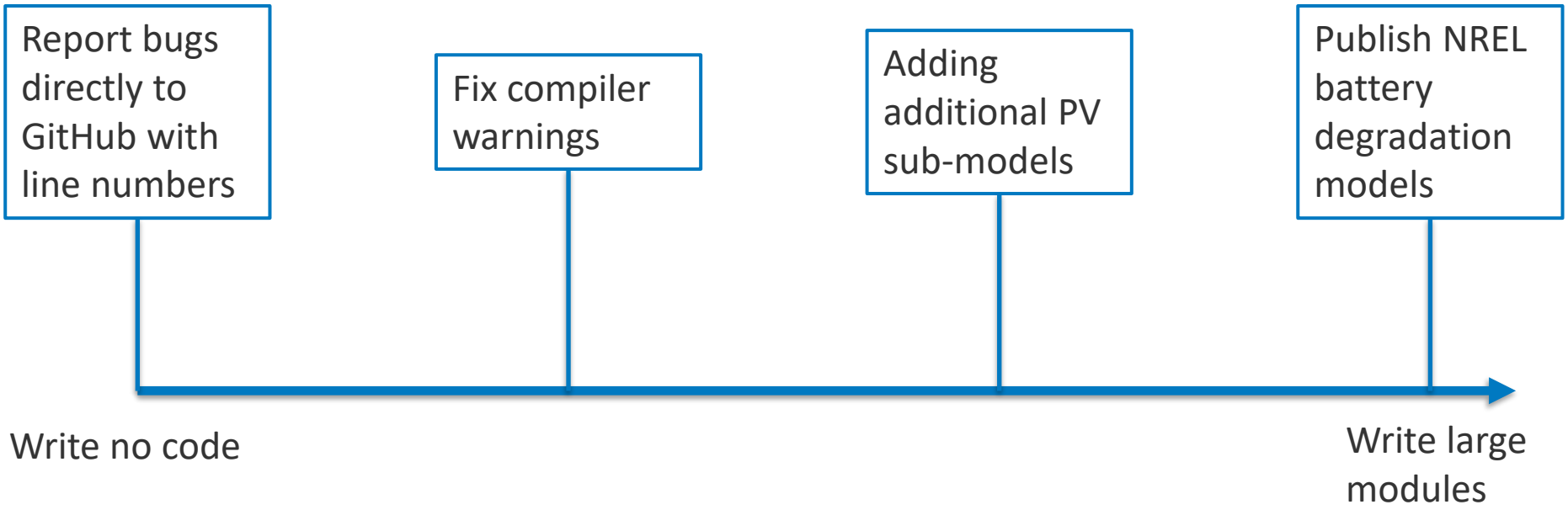
Entity	2017-2019 License	Current License
Commercial Entities	MIT-type license with no sharing restrictions	BSD3-clause (no sharing restrictions)
Research and Non-profit Entities	GPLv3 like license with sharing required	BSD3-clause (no sharing restrictions)

Lesson learned: standard licenses make it easier for contributors

Open-Source Contributors

- Other NREL teams
- Sandia National Laboratories
- Cypress Creek Renewables
- Envision Digital
- OpenInvest
- Passivenous Consulting
- Southern Company

Types of Contributions

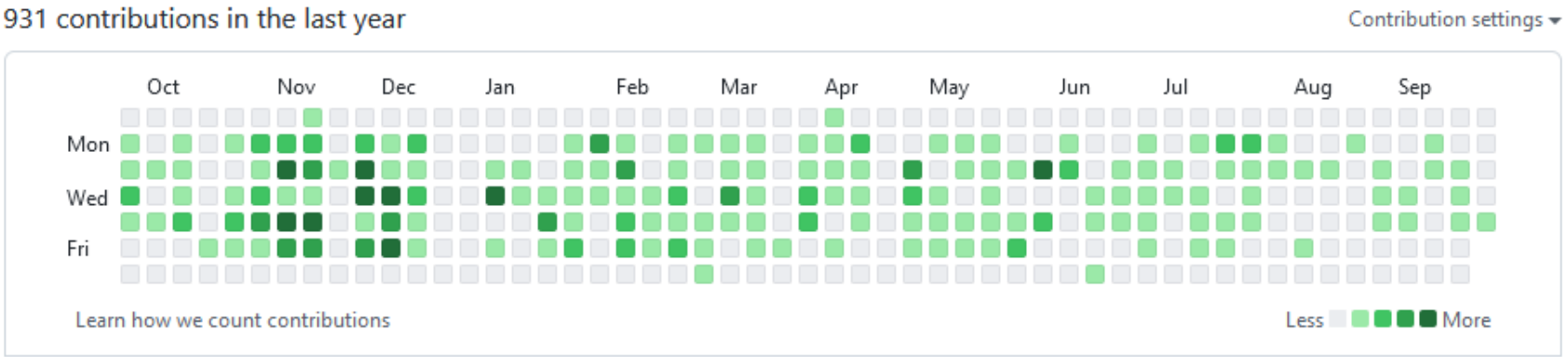


Large Successful Contributions

- Mermoud/Lejeune module model
  - Included unit tests, released as an SDK option
  - Received subsequent open-source contributions with extensions and fixes
- Slope-aware backtracking algorithm
  - Able to keep the original author aware of updates
- Chemistry specific battery degradation algorithms

Reasons to Contribute

- Prestige
  - Contributions are public
- Solving business needs
- Unofficial "stamp of approval"
  - Able to say changes are in the official NREL SAM repository



Challenges

- Language choice
  - C++ is fast, but smaller pool of developers
- Desktop GUI increases user base, but adds another barrier to contributions
  - Core team has needed to develop GUI interfaces for some contributed features
- Keeping some code private (usage tracking, API keys) adds development overhead

Contributor Outreach

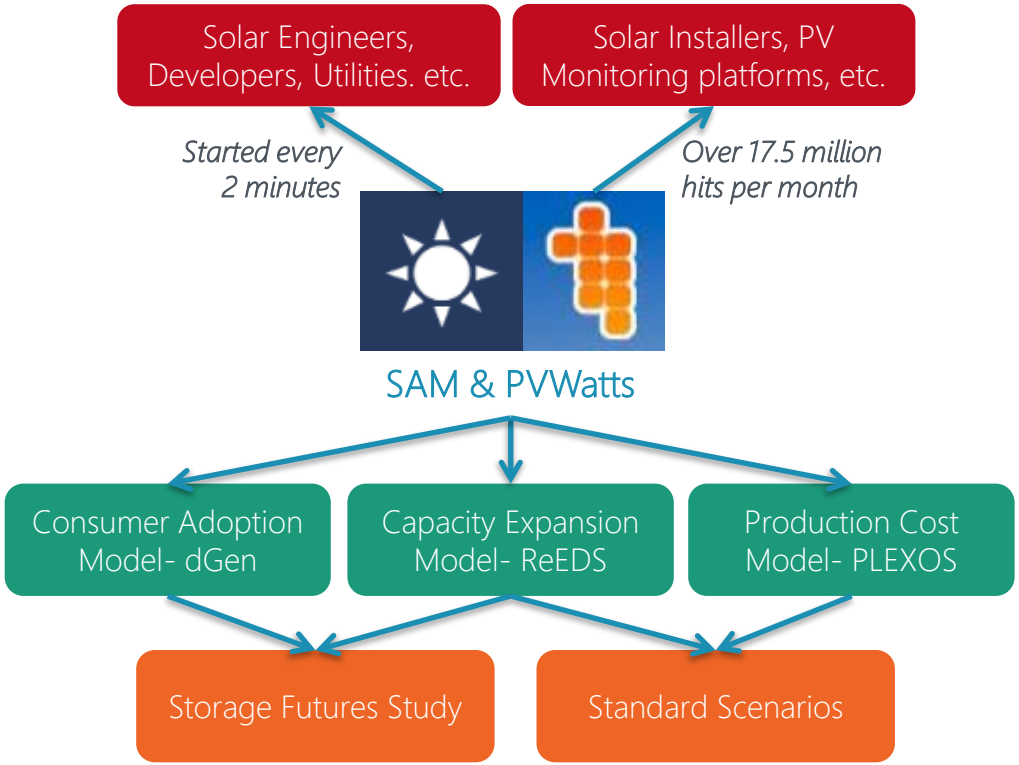
- Outreach is different when the primary interfaces is a GUI (vs code)
- Use in university courses provides opportunities to get programmers into renewable energy
- “Volunteer” contributors are rare
  - Contributors are usually affiliated with the energy field professionally
- How do we get companies to view using and contributing to open-source tools as an advantage?

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

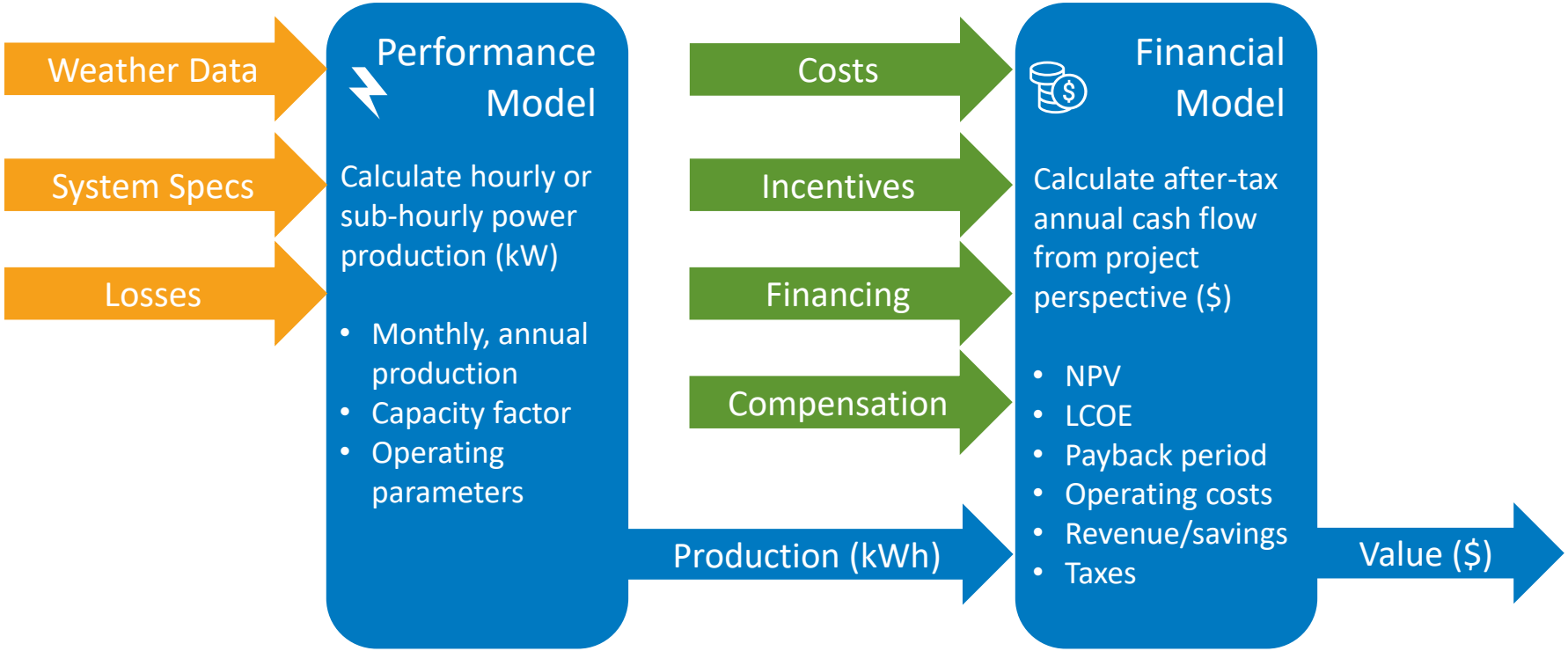
Photo from iStock-627281636

How SAM Fits in at NREL and Externally



- ✓ Grid integration studies
- ✓ Renewable energy futures
- ✓ LCOE of breakthrough technologies
- ✓ Policy and utility rate design
- ✓ Technical potential studies
- ✓ Commercial applications (e.g. Southern Company, AEP, Sunrun)

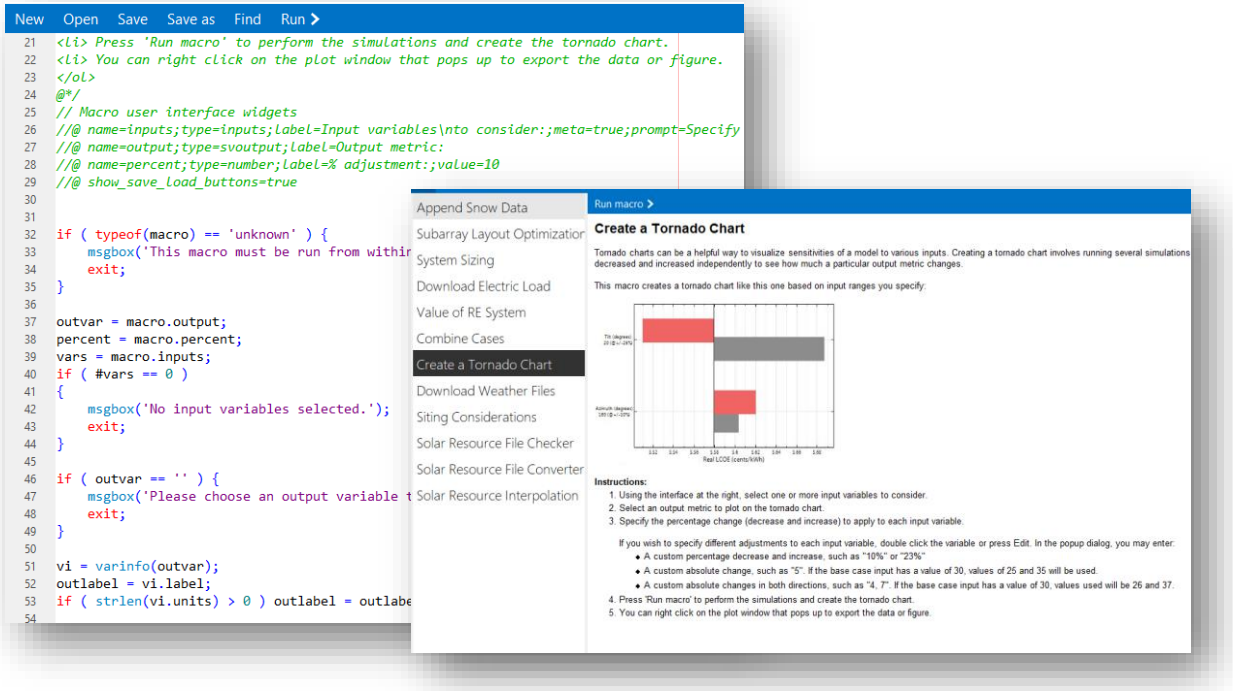
Model Structure



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

Built in Scripting Language and Macros



Flexible, lightweight scripting language built in to the SAM desktop tool, allowing users to quickly run custom analyses and read/write to other files