

Introduction to the
System Advisor Model (SAM)

Janine Freeman
July 22, 2020

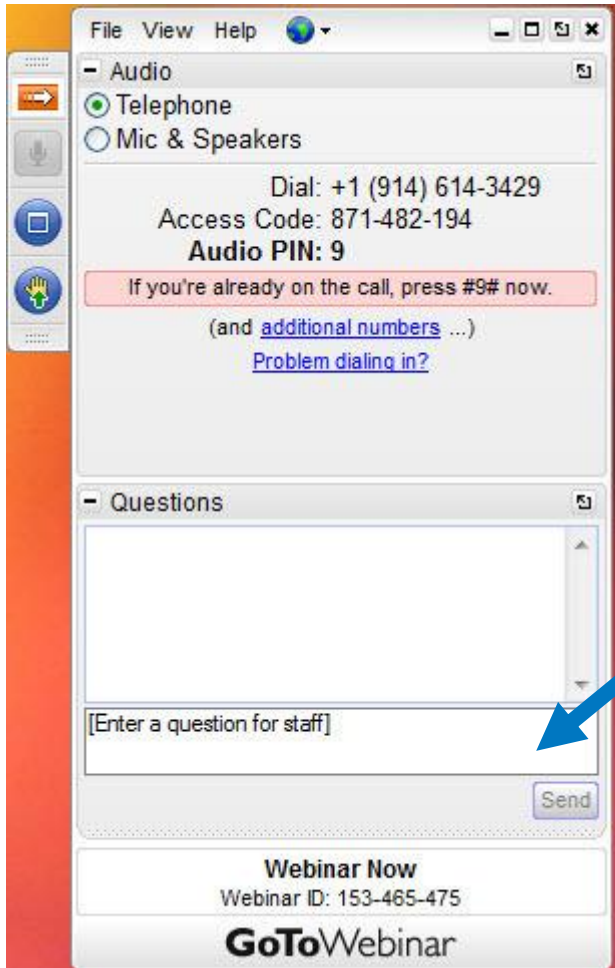


- Introduction to SAM Workshop July 22
- PV Systems in SAM 2020.2.29 Aug 5
- Batteries in SAM 2020.2.29:
 - Focus on Battery Technology Aug 19
 - Behind-the-Meter Systems Sep 2
 - Front-of-Meter Systems Sep 16

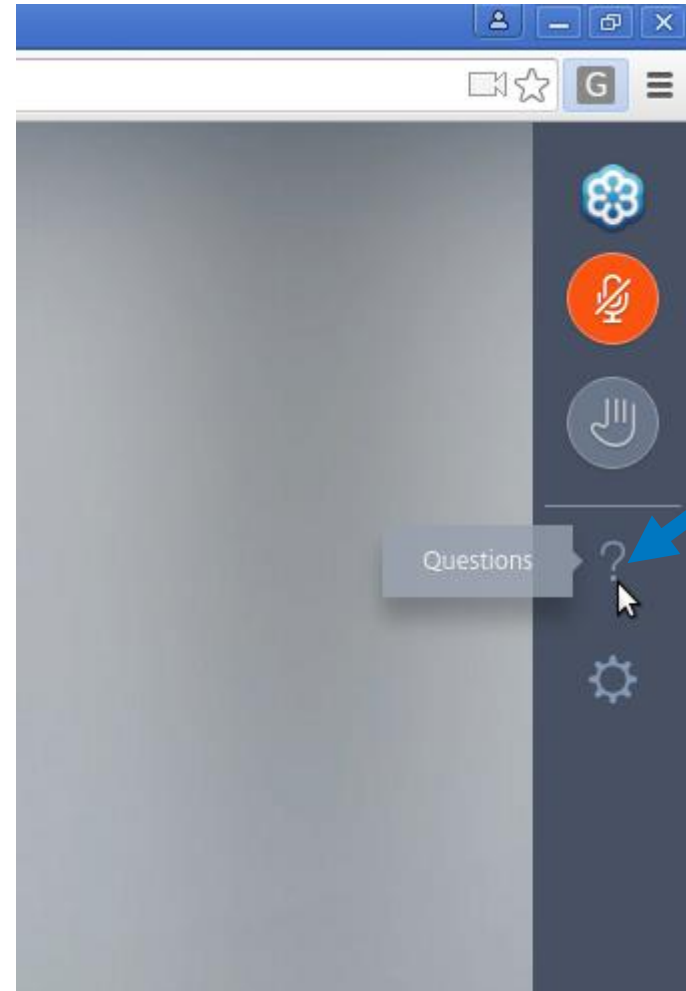
Register for free at: <https://sam.nrel.gov/events.html>

This webinar will be recorded and posted on the SAM website at <https://sam.nrel.gov/>

Use the GoToWebinar control panel to ask questions



Desktop application



Instant Join Viewer

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

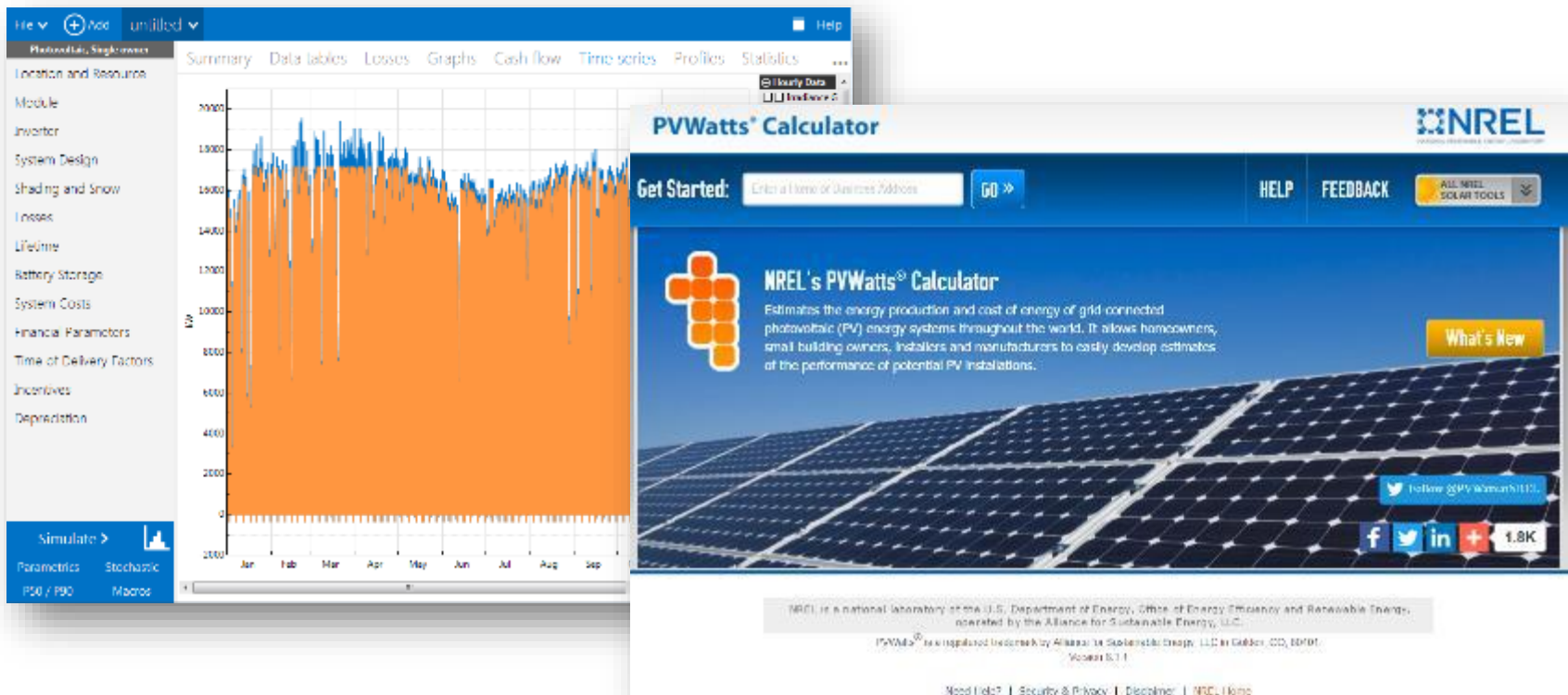
Webinar Outline

1. Introducing SAM
2. SAM User Interface Overview
3. New features in SAM 2020.2.29

Introducing SAM

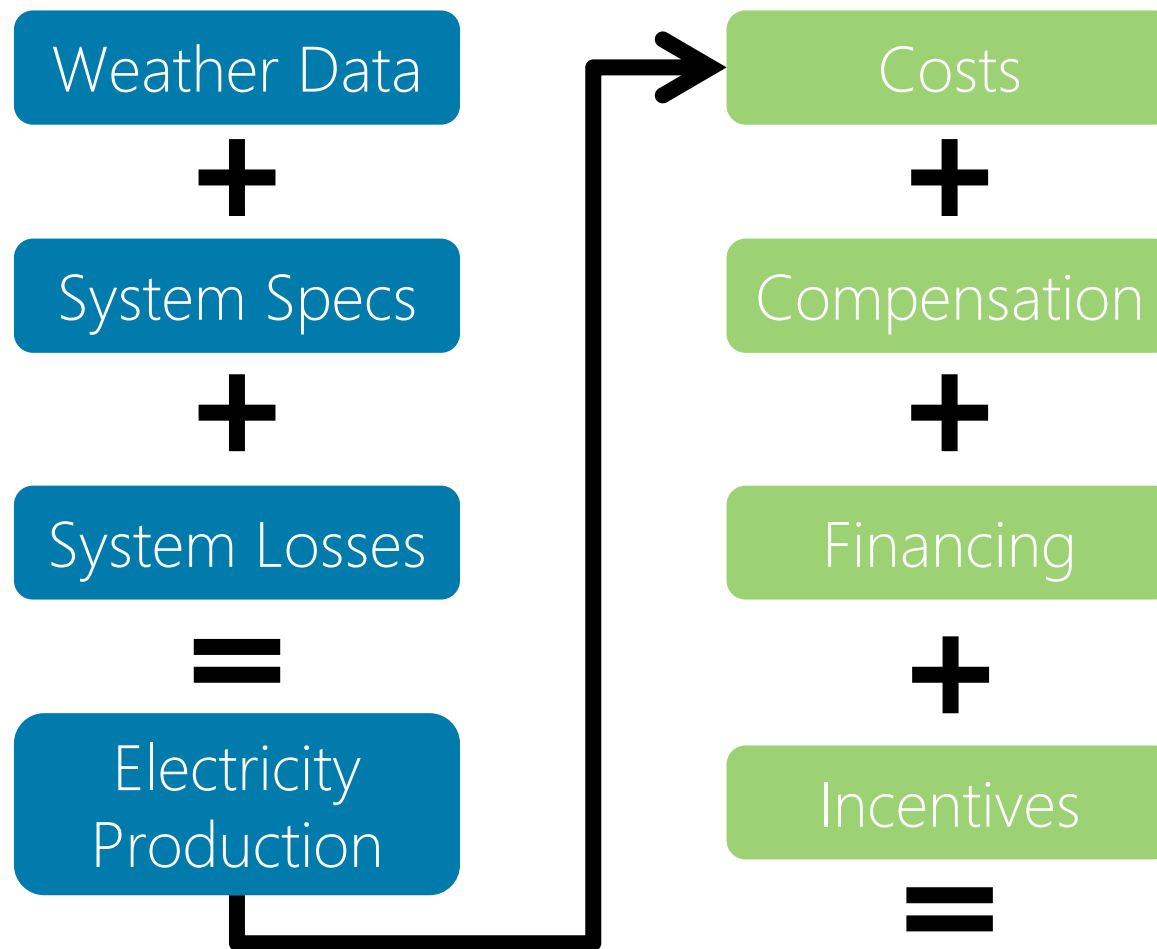


Free software that enable detailed performance and financial analysis for renewable energy systems



<http://sam.nrel.gov/download>
<https://pvwatts.nrel.gov>

Steps to Modeling Renewable Energy



Results

Annual, Monthly, and Hourly Output, Capacity Factor, LCOE, NPV, Payback, Revenue



Technologies

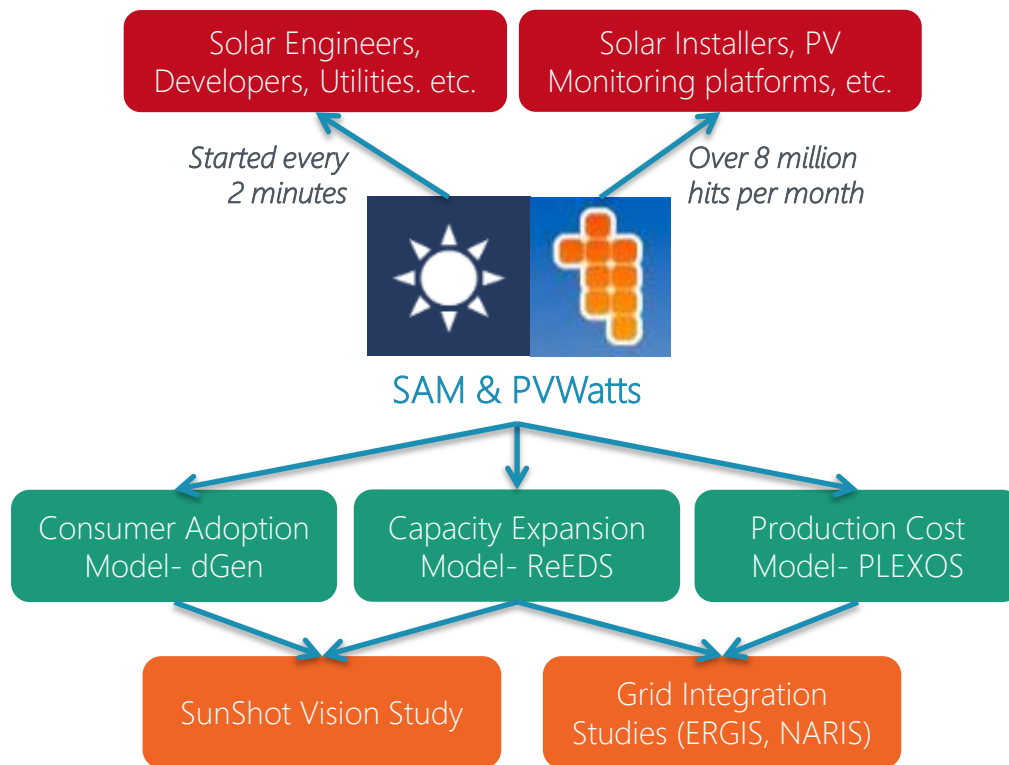
Photovoltaics
Detailed & PVWatts
Battery Storage
Concentrating solar power
Fuel cell-PV-battery
Wind
Marine Energy
Geothermal
Solar water heating
Biomass

Financial

Behind-the-meter
residential
commercial
third-party owned
Power purchase agreements
single owner
equity flips
sale-leaseback
Host/developer
Merchant plant
Simple LCOE calculator



- **Lawmakers and Utilities**
 - ... to study how a policy would affect the economics of a typical system
 - ... to analyze different types of utility rate structures for renewables
- **Developers and Engineers**
 - ... to compare technologies, sites, or configurations
 - ... to estimate the Levelized Cost of Energy for a system
- **Researchers**
 - ... to examine how an innovative concept might be able to lower the Levelized Cost of Energy
 - ... to estimate the technical potential of a technology in a region
- **Students**
 - ... to learn about renewable energy
 - ... to explore financing structures for renewable energy



- ✓ 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)



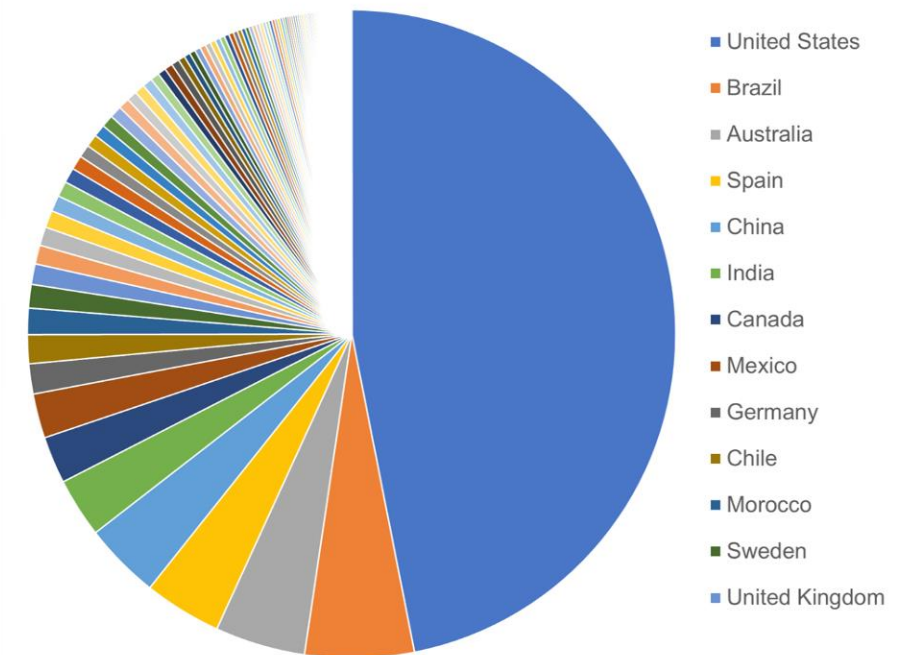
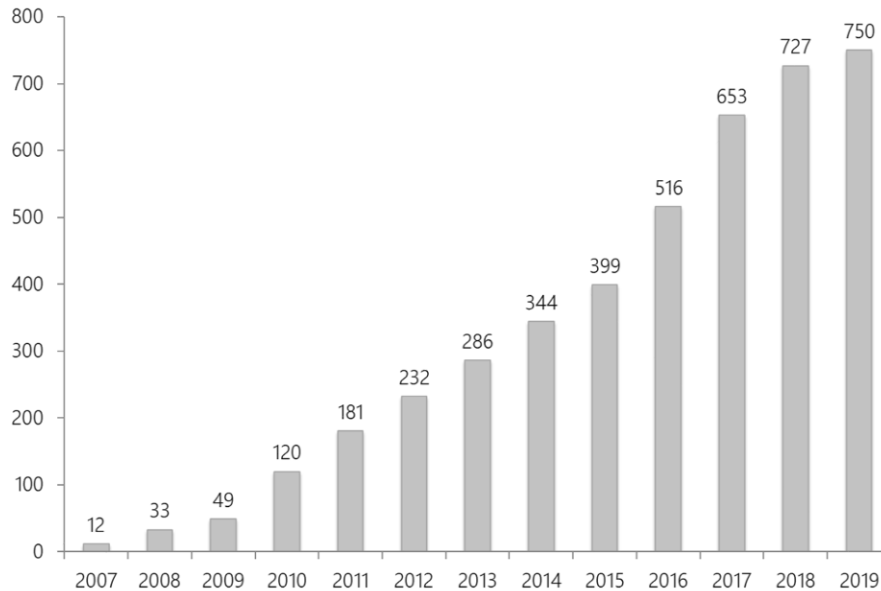
SAM is started **once every 2 minutes**
PVWatts receives over **8 million hits per month**

Over **130,000** users in 190+ countries

90+ webinars with **over 100,000 views**

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

Google Scholar Citations of SAM



What's unique about this platform?

Detailed Cash Flow Financial Models

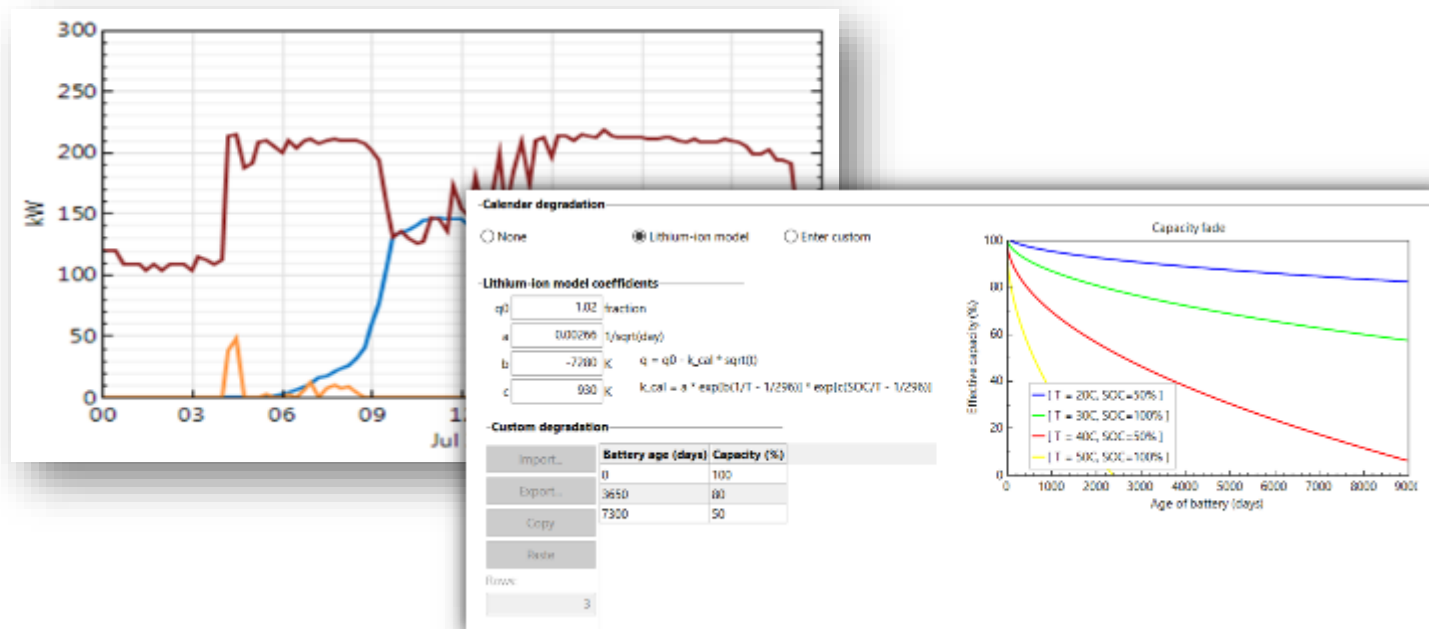


No other tool provides detailed, *time-based* financial modeling across multiple market sectors, including complex utility rates, combined with detailed performance modeling

The screenshot displays the System Advisor Model interface. On the left, a 'TOD factors' panel lists nine periods with values ranging from 0.7036 to 1.4514. Below this is a calendar heatmap showing values for each hour of the day across the months of the year. A time-series chart at the bottom left shows fluctuating data points. On the right, a financial summary table is visible, detailing production, revenues, and expenses over eight years.

	0	1	2	3	4	5	6	7	8
PRODUCTION (AC KW/E)									
Energy (MWh)	0	21,740,894	22,054,000	22,699,815	23,026,012	23,591,548	24,394,136	24,372,548	24,992,000
REVENUES									
PPA price (Cents/kWh)	0	6.6667	6.1346	6.8328	6.8700	6.5300	7.0920	7.6700	7.74
PPA revenue (\$)	0	2,463,276	2,481,571	2,507,424	2,526,203	2,512,514	2,543,252	2,597,651	2,570
plus FBT (Available for debt service)									
Subproducer (\$)	0	0	0	0	0	0	0	0	0
Total revenue (\$)	0	2,463,276	2,481,571	2,507,424	2,526,203	2,512,514	2,543,252	2,597,651	2,570
Property (net assessed value \$)	0	15,765,416	15,765,416	15,765,416	15,765,416	15,765,416	15,765,416	15,765,416	15,765,416
OPERATING EXPENSES									
O&M (fixed expense (\$))	0	0	0	0	0	0	0	0	0
O&M (production-based expense (\$))	0	0	0	0	0	0	0	0	0
O&M (capacity-based expense (\$))	0	180,000	184,500	189,120	193,840	198,640	203,600	208,720	214,000
Property tax expense (\$)	0	0	0	0	0	0	0	0	0
Insurance expense (\$)	0	165,000	166,110	167,260	168,450	169,680	170,950	172,260	173,610
Fixed operating expenses (\$)	0	265,000	280,610	297,380	305,290	312,920	320,790	328,810	337,000

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



- ✓ Currently integrated with PV and "Generic System" 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



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

Run simulations >

Configure

Input variables: Add... Edit... Remove

Tilt 1 (Normal [20,3])
Azimuth 1 (Normal [180,27])

Correlations: Add... Edit... Remove

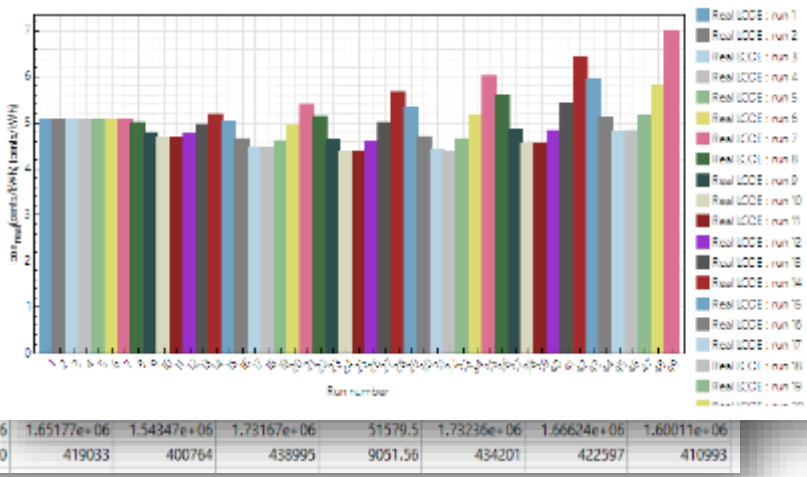
Enable weather file analysis DNI Select folder:

Quick setup... Inputs... Outputs... Run simulations >

	subarray_tilt(deg)	subarray_az(deg)	lcoe_real (cents/kWh)
20	200	20	4.84275
21	270	20	5.39946
22	90	30	5.134
23	120	30	4.63881
24	150	30	4.38055
25	180	30	4.17518
26	210	30	4.38793

Run P50/P90 simulations > Select weather file folder: C:\Code\sam-document

	P10	P50	P90
Annual AC energy (kWh)	374402	367119	3541
Inverter clipping loss DC MPPT voltage limits (kWh/yr)	402.66	233.596	114.1
Inverter clipping loss AC power limit (kWh/yr)	1330.57	1044.95	657.2
Inverter power consumption loss (kWh/yr)	597.443	582.173	569.6
Inverter night time loss (kWh/yr)	94.7722	94.6359	94.41
Annual GHI (Wh/m ² /yr)	1.90159e+06	1.85721e+06	1.81115e+06
POA front-side irradiance total nominal (kWh/yr)	2.47032e+06	2.41884e+06	2.33477e+06
POA front-side irradiance beam nominal (kWh/yr)	1.8137e+06	1.751e+06	1.65645e+06
POA front-side irradiance total after shading (kWh/yr)	2.47032e+06	2.41884e+06	2.33477e+06
POA front-side irradiance total after shading and soiling (kWh/yr)	2.3468e+06	2.2979e+06	2.21803e+06
POA front-side irradiance total after cover (kWh/yr)	2.27405e+06	2.2262e+06	2.14926e+06
POA irradiance total after cover (kWh/yr)	2.27405e+06	2.2262e+06	2.14926e+06
POA front-side irradiance beam after shading and soiling (kWh/yr)	1.72301e+06	1.66345e+06	1.57362e+06
Annual DC energy nominal (kWh/yr)	432430	423331	408700



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



- ✓ Flexible
- ✓ Transparent
- ✓ Collaborative

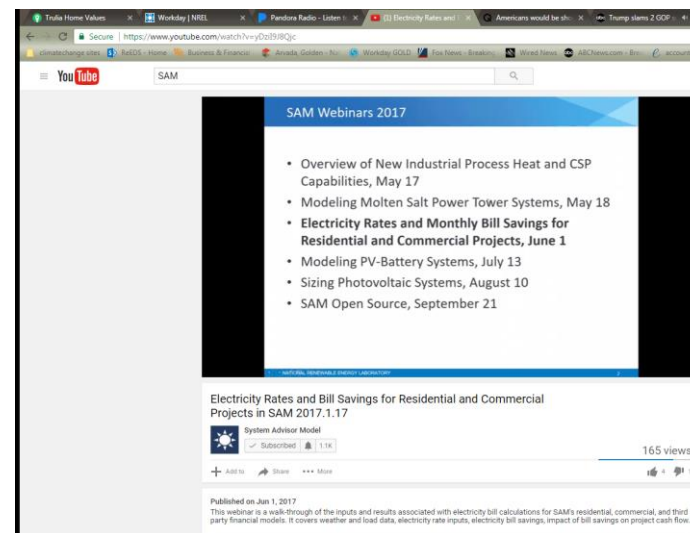
The collage features several GitHub repository pages for NREL, including 'lk', 'wex', 'ssc', and 'SAM'. The 'SAM' repository page is the most prominent, showing 4,238 commits and a list of sub-projects like 'build_linux', 'build_osx', and 'deploy'. Overlaid on the bottom right is a 'Git clones' line graph showing two data series (green and blue) from 01/26 to 02/08. The graph shows a significant peak on 02/07. Below the graph, the total number of clones is 49 and the number of unique cloners is 41.

Date	Clones (Green)	Clones (Blue)
01/26	5	4
01/27	0	0
01/28	6	5
01/29	4	3
01/30	5	4
01/31	4	3
02/01	5	4
02/02	4	3
02/03	1	1
02/04	1	1
02/05	2	1
02/06	1	1
02/07	10	8
02/08	2	1

<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



Live User Interface Overview

New Features in SAM 2020.2.29

Thank you! Questions?

Janine Freeman – project lead, photovoltaic and wind models

Nate Blair – emeritus lead, financials, costs, systems

Darice Guittet – software development, battery models

Brian Mirletz – software development, battery models

Matt Prilliman – photovoltaic and marine energy models

Steve Janzou – programming, utility rate structures (subcontractor)

Paul Gilman – user support and documentation (subcontractor)

Ty Neises – concentrating solar power models

Matt Boyd – concentrating solar power models

www.nrel.gov

<http://sam.nrel.gov>

