

Financial Models for Utility- scale Projects in SAM

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July 19, 2023

SAM Webinar Series 2023

Geothermal Electricity Technology Evaluation Model (GETEM) in SAM	January 19
Linkages between NREL's dGen, REopt and SAM Models	July 11
Financial Models for Utility-scale Projects in SAM	July 19
Modeling Utility-scale Photovoltaic Projects in SAM	August 23
Modeling Behind-the-meter (BTM) Batteries in SAM	September 20

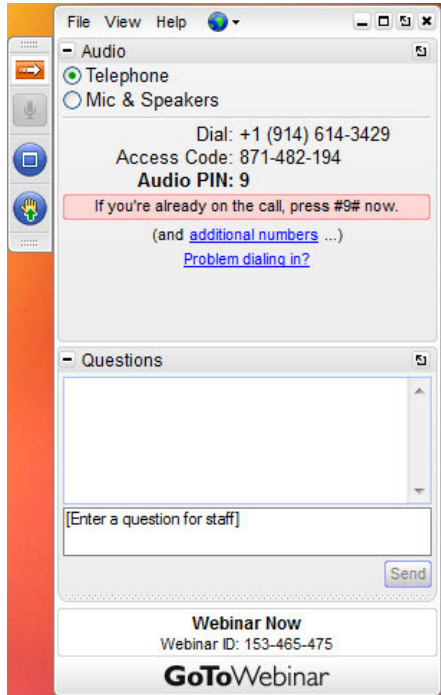
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- Register at <https://sam.nrel.gov/events>

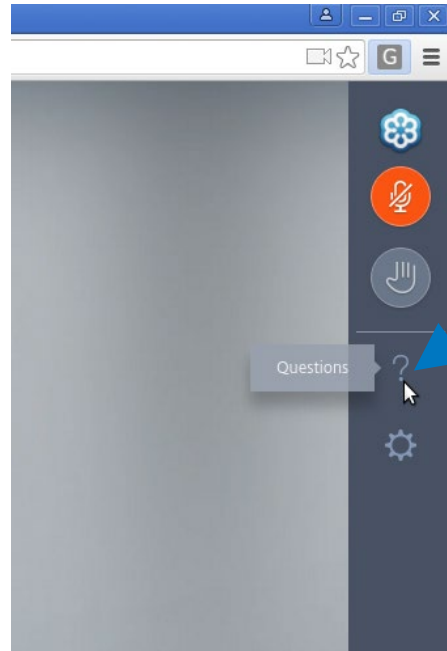
Webinars are recorded

- <https://www.youtube.com/@SAMDemoVideos>
- “Videos” pages at <https://sam.nrel.gov>

Questions and Answers



Desktop application



Instant Join Viewer

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

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

Agenda

1 Intro to SAM and overview of financial models

2 Ownership structures

3 Cash flow


4 Financial metrics

5 Revenue options

6 Live demonstration

7 Q&A

Update to 2011 and 2013 webinars



Utility Financing Options


System Advisor Model


5 videos 3,624 views Last updated on Apr 2, 2013


⋮ ↻


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New utility financing options: Single owner, partnership flip, and sale leaseback. Recording of webinar offered in July 2011. Based on SAM 2011.6.30

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SAM Financing Part 1 of 5: Background
System Advisor Model • 2.6K views • 11 years ago
10:42
- 

SAM Financing Part 2 of 5: Federal Tax Incentives and Tax Equity
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SAM Financing Part 3 of 5: Project Financial Structures
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SAM Financing Part 4 of 5: SAM Demonstration
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SAM Financing Part 5 of 5: Question and Answer Session
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<https://www.youtube.com/playlist?list=PLB249A380C49AA176>

<https://www.youtube.com/watch?v=QZvPweCzxkl>

Information Resources

Help System

- Press F1 key or click **Help** in SAM software
- Web version at <https://sam.nrel.gov/help>

SAM Forum

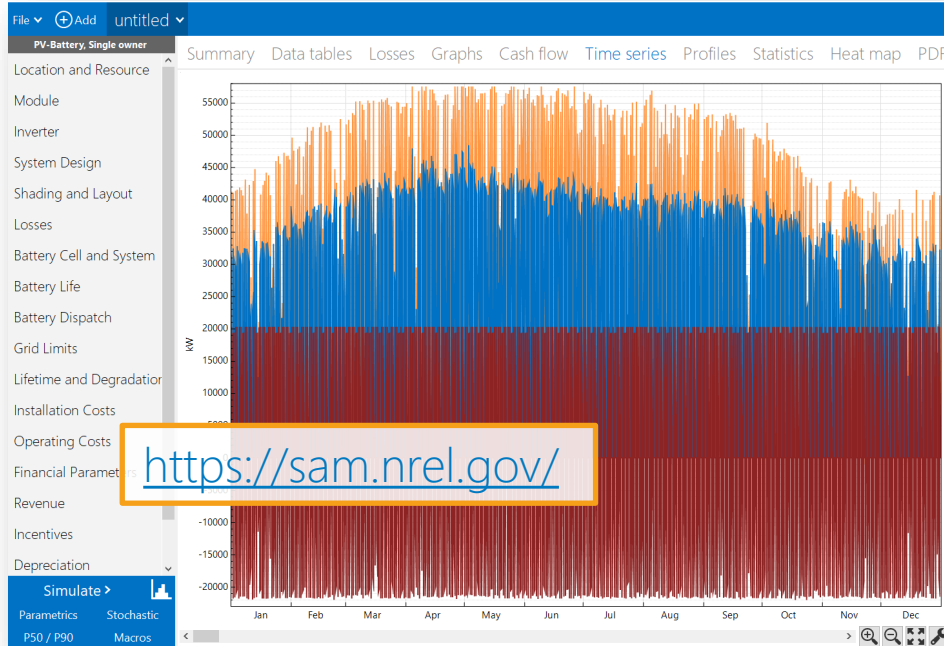
- <https://sam.nrel.gov/forum>
- Use search box to find information
- Register on website to post questions

Email

- sam.support@nrel.gov

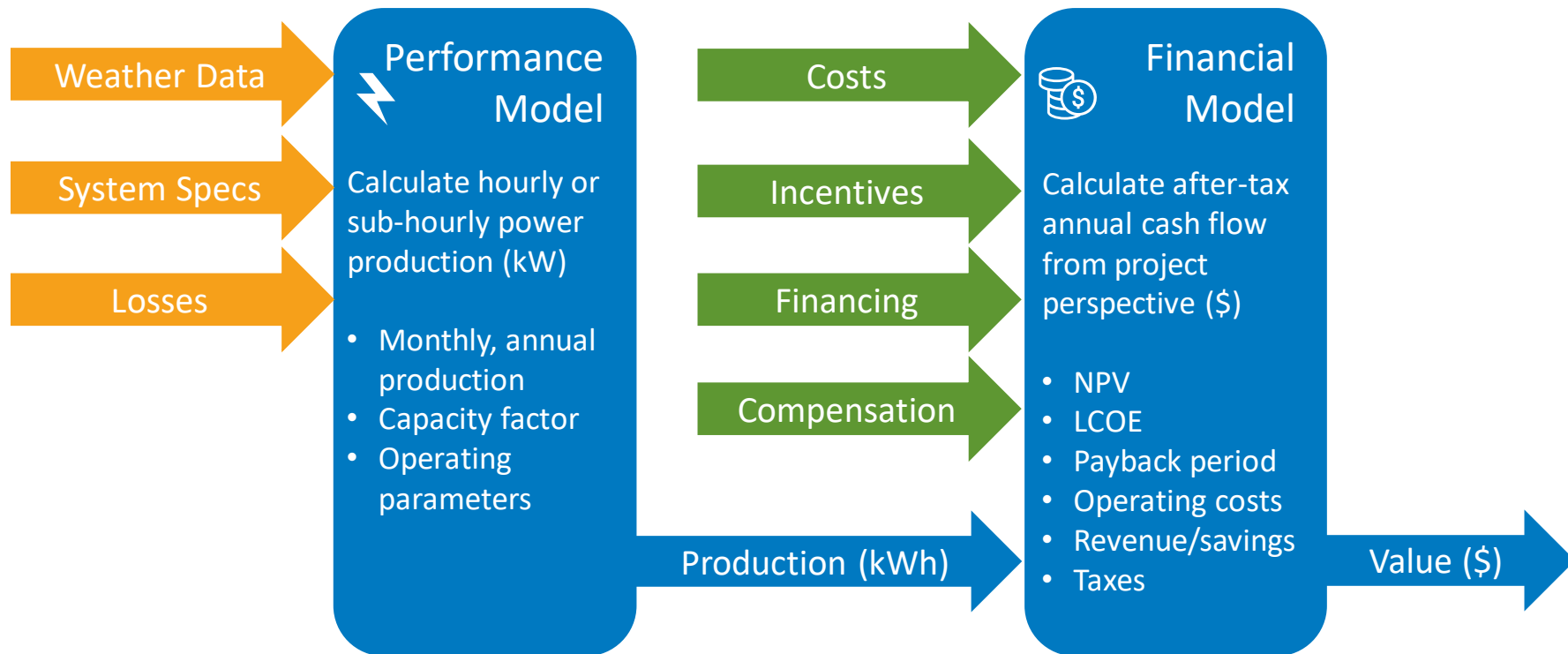
System Advisor Model (SAM)

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

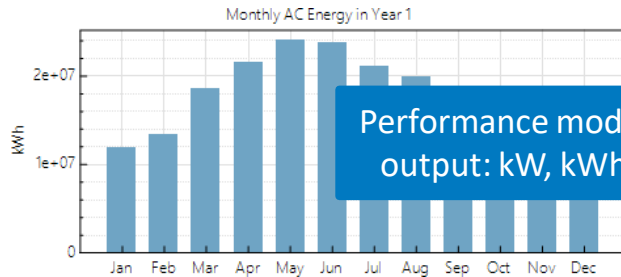
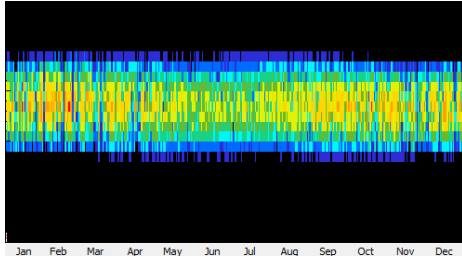


- ✓ Desktop application
- ✓ Software development kit with PySAM Python package
- ✓ Open source code repositories

Model Structure



Financial model inputs include energy, costs, incentives, financial parameters, and revenue



Performance model output: kW, kWh

User inputs for costs, incentives, financial parameters, revenue options

	0	1	2	3	4	5	6
ENERGY							
Electricity to grid (kWh)	0	211,907,456	210,847,920	209,793,680	208,744,704	207,700,992	206,661,120
Electricity from grid (kWh)	0	0	0	0	0	0	0
Electricity to grid net (kWh)	0	211,907,456	210,847,920	209,793,680	208,744,704	207,700,992	206,661,120
REVENUE							
PPA price (cents/kWh)	0	4	4.04	4.0804	4.1212	4.16242	4.2
Finan		8,476,290	8,518,256	8,560,421	8,602,795	8,645,379	8,688,160
Reve		0	0	0	0	0	0
Incentives		0	0	0	0	0	0
Depreciation		0	0	0	0	0	0
Total revenue (\$)		8,476,290	8,518,256	8,560,421	8,602,795	8,645,379	8,688,160
Property tax net assessed value (\$)	0	106,498,000	106,498,000	106,498,000	106,498,000	106,498,000	106,498,000

Result: Project Cash Flow



Performance Models

- 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



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FOM and BTM Models

Power Purchase Agreement (PPA), or Front of Meter (FOM)

Power generation projects

- Electricity is delivered to the grid
- Sell electricity at negotiated or market prices
- Earn revenue
- “Feasible” project: Revenue is greater than project costs

Distributed Energy, or Behind the Meter (BTM)

Customer side of meter

- Electricity meets load with excess delivered to grid
- Buy and sell electricity at retail rates
- Reduce annual electricity bill
- “Feasible” project: Bill savings are greater than project costs

Ownership Structures

Single entity owns, builds, and operates project

- PPA single owner
- Merchant plant
- Community Solar

Separate tax equity and investor partners

- PPA Partnership flip
Tax investor and developer share cost and benefit of project, benefits go to developer after “flip year”
- PPA Sale leaseback
Tax investor purchases project from developer and leases it back to the developer

Equity Flip Structure

	Tax Investor		Developer	
Share of equity	98%		2%	
	Pre-flip	Post-flip	Pre-flip	Post-flip
Share of project cash	98%	10%	2%	90%
Share of tax benefits	98%	10%	2%	90%

Sale Leaseback

Developer (lessee) operating margin	20	\$/kW
Developer (lessee) margin escalation	2	%/year
Tax investor (lessor) required lease payment reserve	6	months of reserve

Financial Model Notes

Models are based on a high-level, pro-forma cash flow

- Annual cash flows
- Simple enough to generate quick results
- Detailed enough for pre-feasibility project evaluation
- General enough to be useful for a wide range of applications

Cash flow and metrics are from the project perspective

- Account for project installation and operating costs, incentives, debt
- Do not account for external factors that may affect decision-making

Project Cash Flow

- Year zero value accounts for initial investment, incentives, and construction financing cost
- Years 1 and later account for revenue, expenses, taxes, incentives, and debt costs
- From project perspective, and from each partner's perspective as applicable
- You specify costs in Year 1 \$, SAM applies inflation to calculate out-year values
- SAM does not apply inflation to revenue. Use the PPA escalation rate to inflate revenue.

Summary Data tables Losses Graphs Cash flow Time series Profiles S						
Copy to clipboard Save as CSV Send to Excel Send to Excel with Equations						
	0	1	2	3	4	5
ENERGY						
Electricity to grid (kWh)	0	225,640,656	224,720,608	223,784,848	222,830,368	221,856,1
Electricity from grid (kWh)	0	-55,056	-55,056	-55,068	-55,068	-55,0
Electricity to grid net (kWh)	0	225,585,600	224,665,536	223,729,792	222,775,296	221,801,0
REVENUE						
PPA price (cents/kWh)	0	4	4.04	4.0804	4.1212	4.162
PPA revenue (\$)	0	9,025,626	9,078,712	9,131,317	9,183,294	9,234,5
Curtailement payment revenue (\$)	0	0	0	0	0	0
Capacity payment revenue (\$)	0	0	0	0	0	0
Salvage value (\$)	0	0	0	0	0	0
Total revenue (\$)	0	9,025,626	9,078,712	9,131,317	9,183,294	9,234,5
PROPERTY TAX						
Property tax net assessed value (\$)	0	106,498,768	106,498,768	106,498,768	106,498,768	106,498,7
OPERATING EXPENSES						
O&M fixed expense (\$)	0	0	0	0	0	0
O&M production-based expense (\$)	0	0	0	0	0	0
O&M capacity-based expense (\$)	0	1,500,011	1,537,511	1,575,949	1,615,348	1,655,1
Electricity purchase (\$)	0	2,202	2,224	2,247	2,269	2,2
Property tax expense (\$)	0	0	0	0	0	0
Insurance expense (\$)	0	0	0	0	0	0
Land lease expense (\$)	0	0	0	0	0	0
DEPRECIATION AND ITC: STATE						
	% of Total Depreciable Basis	Gross Amount Allocated	IBI Reduction	CBI Reduction	Depreciable Basis Prior to ITC	ITC Qualifying Costs
MACRS 5-yr	92.78	102,632,864.00	0	0	102,632,864.00	102,632,864.00
MACRS 15-yr	1.55	1,710,547.75	0	0	1,710,547.75	0

Financial Metrics

Net present value (NPV), \$

- The present value of after-tax cash flows over the analysis period
- A negative value may indicate a financially infeasible project

Internal rate of return (IRR), %

- The discount rate at which NPV = 0
- A measure of profitability

Power price, \$/kWh

Size of debt, \$

Metric	Value
Annual AC energy in Year 1	211,907,456 kWh
DC capacity factor in Year 1	24.2%
Energy yield in Year 1	2,119 kWh/kW
PPA price in Year 1	4.00 ¢/kWh
PPA price escalation	1.00 %/year
LPPA Levelized PPA price nominal	4.32 ¢/kWh
LPPA Levelized PPA price real	3.45 ¢/kWh
LCOE Levelized cost of energy nominal	4.27 ¢/kWh
LCOE Levelized cost of energy real	3.41 ¢/kWh
NPV Net present value	\$1,025,574
IRR Internal rate of return	7.26 %
Year IRR is achieved	20
IRR at end of project	9.57 %
Net capital cost	\$113,663,144
Equity	\$53,756,996
Size of debt	\$59,906,152
Debt percent	52.70%

Consider metrics as a set!

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- NPV > 0
- Reasonable PPA price
- Reasonable IRR
- IRR achieved by target year
- Reasonable debt size

“Reasonable” depends on the context.

Sources of Revenue

Single owner, partnership flip, sale leaseback

PPA price with optional annual escalation

- Time-of-delivery (TOD) multipliers for price that varies daily and/or seasonally, or by time step
- Capacity payments
- Curtailment payments

Merchant plant model

Time series power price and cleared capacity

- Energy market
- Ancillary service market (up to 4)
- Capacity payments

Sources of Revenue

Community solar

Subscriber payments

- Up-front
- Annual
- Generation

Solution Mode

Specify PPA price, SAM calculates IRR

Solution Mode

Specify IRR target

Specify PPA price

IRR target % IRR target year

PPA price \$/kWh

Escalation Rate

PPA price escalation %/year

Inflation does not apply to the PPA price.

Specify target IRR and year, SAM calculates PPA price

Solution Mode

Specify IRR target

Specify PPA price

IRR target % IRR target year

PPA price \$/kWh

Escalation Rate

PPA price escalation %/year

Inflation does not apply to the PPA price.

Electricity Purchases

Electricity purchases are for power from the grid n
power prices from the Revenue (or Financial Parar

Use PPA or market prices

Use retail electricity rate(s)

Can't use PPA price for electricity purchases

Demonstration

The screenshot displays the SAM 2022.11.21 software interface. The top menu bar includes 'File', '+ Add', 'PV Single Owner', 'Partnership Flip', 'Sale Leaseback', 'PV Merchant', and 'Help'. The left sidebar lists various project settings: 'PVWatts, Single owner', 'Location and Resource', 'System Design', 'Grid Limits', 'Lifetime and Degradation', 'Installation Costs', 'Operating Costs', 'Financial Parameters', 'Revenue', 'Incentives', 'Depreciation', and 'Electricity Purchases' (which is currently selected). At the bottom of the sidebar are 'Simulate >', 'Parametric', 'Stochastic', 'Uncertainty', and 'Macros'.

The main content area is titled 'Electricity Purchases' and contains the following sections:

- Electricity Purchases:** A text box explaining that electricity purchases are for power from the grid required to meet inverter nighttime load, charge the battery, or for any other power required by the system at power prices from the Revenue (or Financial Parameters page) to calculate the annual operating expense for electricity purchases. The Use Retail Electricity R...
 - Use PPA or market prices
 - Use retail electricity rate(s)
- OpenEI U.S. Utility Rate Database:** A section with a text box: 'Download rate structures for electric utility companies included in the OpenEI Utility Rate Database. After downloading a rate structure, compare the inputs b...'. Below this is a 'Search for rates...' button and a link: '[Go to Open EI Utility Rate Database website...](#)'.
- Save / Load Rate Data:** A section with two buttons: 'Save rate to file...' and 'Load rate from file...'.
- Metering and Billing:** A section with radio button options:
 - Net energy metering
 - Net energy metering with \$ credits
 - Net billing
 - Net billing with carryover to next month
 - Buy all / sell allOn the right side of this section, there are labels for 'Compensation rate for net excess generation', 'Month for end of true-up period', and 'Hourly (subhourly) buy rates'. There are also checkboxes for 'Use hourly (subhourly) sell rates i...' and 'Use hourly (subhourly) buy rates'.

At the bottom of the 'Metering and Billing' section, there is a note: 'For front-of-meter systems, only the Buy All / Sell All metering option is available to define energy buy rates for electricity purchases to charge the battery, meet inverter nighttime consumption, solar field freeze protection, or any other electricity'.

Thanks! 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, battery models, utility rates

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

Bill Hamilton – concentrating solar power models

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