

# System Advisor Model (SAM) Overview

Paul Gilman  
December 8, 2017  
paulgilman@earthlink.net

## What is SAM?

The System Advisor Model (SAM)

Free computer model

Calculates:

System's hourly (or subhourly) energy output  
over a single year

Project's cost of energy over years of  
operation

## Who makes SAM?

### Developed by

U.S. Department of Energy's National Renewable Energy Laboratory (NREL)



### Uses models developed by

NREL

Sandia National Laboratories

University of Wisconsin

Other partners



### Original vision in 2004

Allow DOE to make R&D choices based on analysis of the entire system including costs

Model different renewable energy projects in a single platform

Facilitate technology comparison by handling performance, costs and financing consistently across technologies

## Who uses SAM?

Project developers

Electric utilities

University researchers

Engineering firms

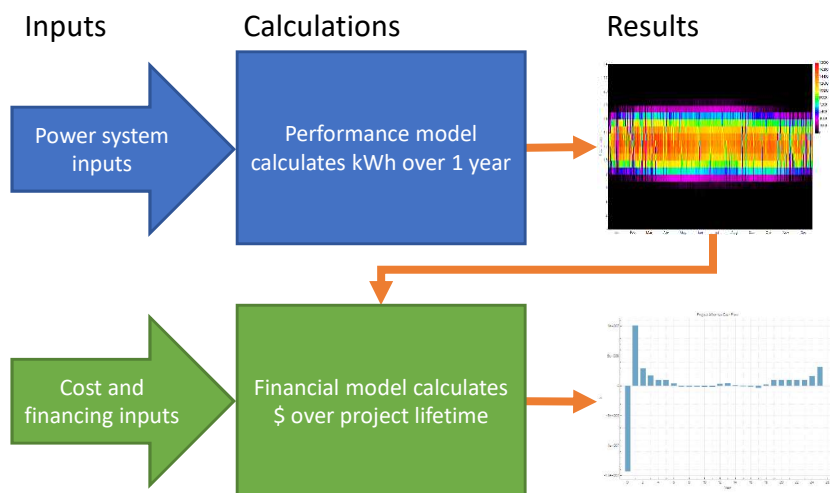
Government decision makers

Educators and students

## What can you do with SAM?

- Estimate energy production for a specific system
- Calculate net present value, levelized cost of energy, payback for a project
- Perform parametric and uncertainty analyses
- Present modeling results in graphs and tables
- Evaluate project proposals
- Generate data for geospatial analysis
- Develop templates for decision-making

## SAM combines performance model with financial model for techno-economic analysis



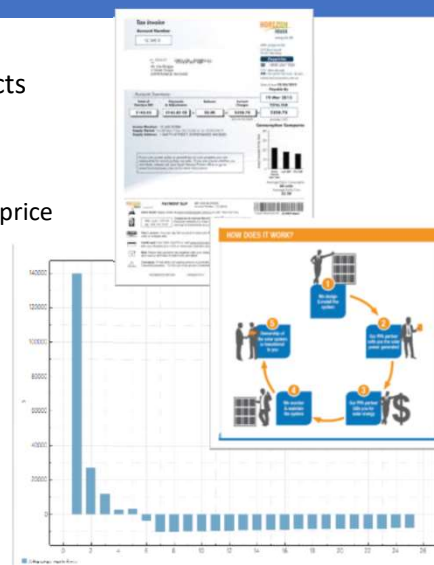
## Performance models

- Photovoltaic systems
- Concentrating solar power
- Industrial process heat
- Solar water heating
- Wind power
- Geothermal power
- Biopower
- Conventional thermal power

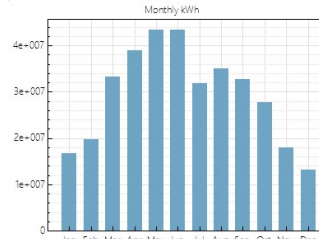
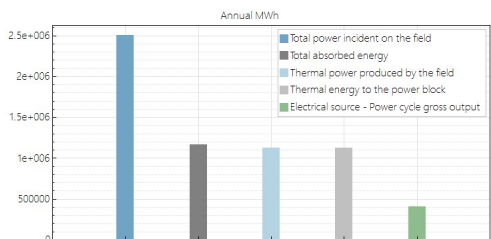


## Financial models

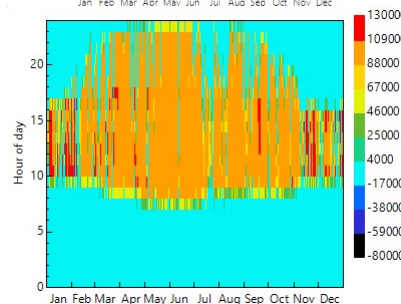
- Residential and commercial projects
  - Electricity bill savings
- PPA projects
  - Power purchase agreement (PPA) price
  - Internal rate of return
- Calculate cash flow based on
  - Installation and operating costs
  - Tax credits
  - Payment incentives
  - Time-of-use electricity rates
  - Project debt



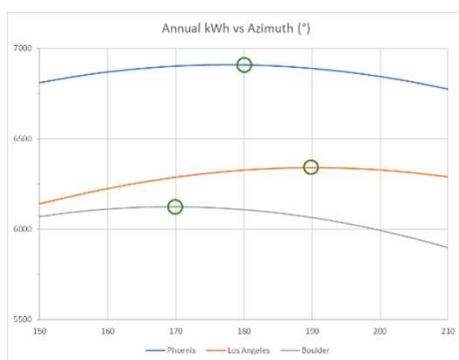
## Predict system energy output



Example: 100 MW  
Parabolic trough  
system with 6 hours of  
storage



## Optimize design parameters



- For Boulder, CO, orient array slightly eastward to avoid summer afternoon thunderclouds over mountains
- For Los Angeles, CA, orient array slightly westward to avoid morning fog
- For Phoenix, AZ, orient array due south

Example: Explore optimal array tilt and azimuth angles for a 4 kW residential photovoltaic system in three different locations



## Cash flow analysis

Copy to clipboard   Save as CSV   Send to Excel   Send to Excel with Equations

	0	1	2	3	4	5	6	7	8	9	10	11
<b>PRODUCTION</b>												
Energy (kWh)	0	341,153	339,448	337,750	336,062	334,381	332,709	331,046	329,391	327,744	326,105	324,472
<b>SAVINGS</b>												
Value of electricity savings (\$)	0	31,991	32,637	33,296	33,968	34,654	35,354	36,068	36,796	37,539	38,297	39,068
<b>OPERATING EXPENSES</b>												
O&M fixed expense (\$)	0	0	0									
O&M production-based expense (\$)	0	0	0									
O&M capacity-based expense (\$)	0	3,995	4,095	4,195	4,295	4,395	4,495	4,595	4,695	4,795	4,895	4,995
Property tax expense (\$)	0	8,499	8,499	8,499	8,499	8,499	8,499	8,499	8,499	8,499	8,499	8,499
Insurance expense (\$)	0	2,125	2,178	2,231	2,284	2,337	2,390	2,443	2,496	2,549	2,602	2,655
Net salvage value (\$)	0	0	0									
<b>Total operating expense (\$)</b>	<b>0</b>	<b>14,619</b>	<b>14,772</b>	<b>14,925</b>	<b>15,078</b>	<b>15,231</b>	<b>15,384</b>	<b>15,537</b>	<b>15,690</b>	<b>15,843</b>	<b>15,996</b>	<b>16,149</b>
<b>PROJECT DEBT</b>												
Debt balance (\$)	424,939	416,036	406,687	396,996	386,967	376,604	365,911	354,894	343,559	331,912	320,059	307,907
Interest payment (\$)	0	21,247	20,802	20,357	19,912	19,467	19,022	18,577	18,132	17,687	17,242	16,797
Principal payment (\$)	0	8,904	9,349	9,794	10,239	10,684	11,129	11,574	12,019	12,464	12,909	13,354

## Extending SAM

### Software Development Kit (SDK)

SAM simulations can be configured and run from computer programs without opening the SAM application

Allows researchers and software developers to make calls to SAM from their programs

### SAM scripting in LK

Built-in scripting language to automate complex analysis tasks

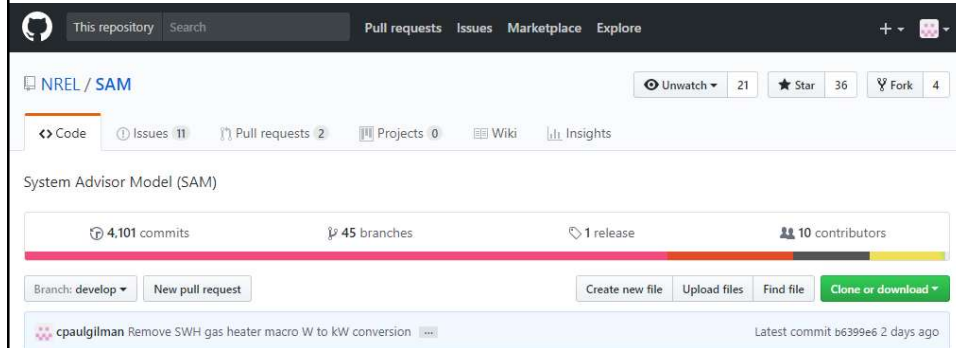
Allows you to extend the core functionality of SAM to suit your needs

```

Append Snow Data
-----
47  msgbox("Please choose an output variable to plot.");
48  exit;
49  ;
50  ;
51  v1 = varinfo(outvar);
52  outlabel = v1.label;
53  if (strlen(v1.units) > 0) outlabel = outlabel + " (" + v1.units + ")";
54  ;
55  // run base case simulation
56  outln("Running base case simulation...");
57  simulate();
58  baseoutput = get(outvar);
59  root = baseoutoutput;
60  {
61    var = vars[1][0];
62    ;
63    ;
64    v1 = varinfo(var);
65    ;
66    l = v1.label;
67    ;
68    updown = vars[1][1];
69    baseval = get(var);
70    ;
71    type = typeof(baseval);
72    arrow = false;
73    if(type == "array")
74      {
75        if baseval == 1) {
76          arrow = true;
77          baseval = to_real(baseval[0]);
78        }
79      }
80    elseif( type == "number" ) {
81      baseval = to_real(baseval);
82    }
83    ;
84    ;
            
```

## SAM Open Source

- Source code is available to public on GitHub repositories:  
<https://github.com/nrel/sam>
- Useful for researchers wanting to understand algorithms and see equations
- Makes it possible for software developers to build their own versions of SAM and contribute to the NREL versions



The screenshot shows the GitHub repository page for NREL/SAM. The repository name is "NREL / SAM" with 21 Unwatch, 36 Star, and 4 Fork actions. The repository is categorized as "System Advisor Model (SAM)". It has 4,101 commits, 45 branches, 1 release, and 10 contributors. The current branch is "develop". A recent commit by cpaulgilman is visible, titled "Remove SWH gas heater macro W to kW conversion", with the latest commit being b639e6, made 2 days ago.

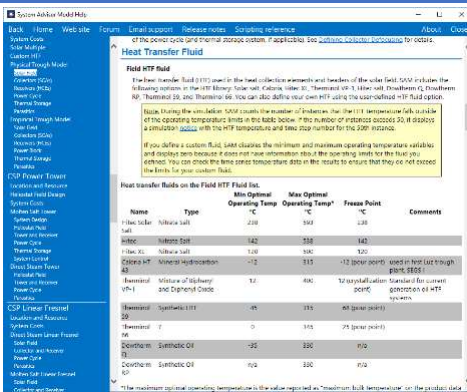
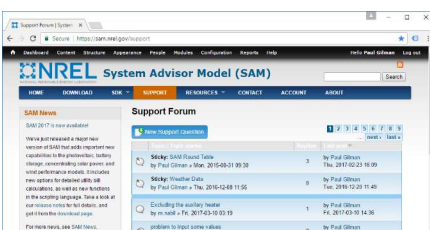
## Downloading SAM

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

Start software and submit email  
for free registration key

# Where to find help using SAM

Help system  
 Support forum:  
<https://sam.nrel.gov/support>  
 Email: [sam.support@nrel.gov](mailto:sam.support@nrel.gov)



# Garbage in, garbage out!

