# System Advisor Model Release Notes

## Version 2014.1.14 January 2014

This is a maintenance update to SAM 2013.9.20 that addresses several bugs and other issues It does not add any new features.

### Photovoltaic

- Fixed a bug for the photovoltaic models with southern hemisphere weather files with the "Tilt=Latitude" option enabled that caused SAM to generate a simulation error message.
- Fixed a bug for the PVWatts system model with 1-axis tracking. The bug caused the model to enable backtracking with a GCR of -1. This caused unrealistic results for a few hours of the year, but did not noticeably affect the system's total annual output.
- Corrected the Flat Plate PV model's inverter library entry for the Toshiba (TMEIC) 500U. The correct values for the voltage and current ratings are: Vdcmax = 600 V, Idcmax = 1600 A, MPPT low = 320 V, and MPPT high = 550 V.
- Updated the CEC inverter library to the January 2014 version.
- Fixed a mistake in the PDF report for photovoltaic models with Commercial PPA, Utility IPP, or Single Owner financing in "Specify PPA Price" mode to show meaningless symbols for the PPA price value. This issue does not affect values that appear in the SAM user interface -- it only affects the PDF report.
- Changed the Flat Plate PV default assumption on the Array page for ground reflectance to not use the albedo value from the weather file by default because the albedo values in the standard weather files tend to be unreliable. By default, SAM uses the 0.2 value specified in the monthly albedo input table instead of reading hourly values from the weather file.

### Concentrating Solar Power

- Fixed a bug in the energy loss diagram for concentrating solar power models (CSP) with a large portion of the thermal energy to the power block supplied by the fossil backup system that caused the energy loss diagram to display an incorrect value for the "System Output to Grid" quantity.
- For the linear Fresnel model, fixed an issue with the the collector azimuth angle variable on the Solar Field page being disabled with the collector incidence angle table option on the Collector and Receiver page.
- Fixed an issue that caused the power tower model with thermocline storage to report an incorrect warning about the storage fluid temperature being outside of its operating range.
- For the physical trough and generic solar system concentrating solar power models Thermal Storage page, fixed the units in the thermal storage capacity label. The correct units are MWht, not MWt. This is a mistake in the user interface label and does not affect simulations.
- Fixed a mistake in the Linear Fresnel PDF report that showed aperture area of a single collector instead of the total aperture area.
- Updated the TRNSYS source code files.

### Residential and Commercial Financial Models

- Fixed a bug for the residential and commercial financial models, that caused SAM to apply the "percent of annual output" factor from the Performance Adjustment page twice.
- For the residential and commercial financial models with net metering, corrected the Sales/Purchases without System value for January. (The values for February through December were correct.) This caused the Net Savings with System value in the Metrics table to be incorrect.

- For the residential and commercial financial model results, corrected the monthly "Energy Rate Charge in [mmm] ($)" label, and added the missing "Year 1 monthly sales/purchases without system ($)" variable is missing. The label should be "Energy Charge in [mmm] ($)."
- For the residential and commercial financial models with the "Normalize supplied load profile to monthly utility bill data" option on the Electric Load page enabled, SAM used the original, non-normalized peak load to calculate monthly demand charges. With this update, SAM uses the normalized peak load values to calculate the demand charges. Although the old behavior is appropriate with 10- or 15-minute load data when the magnitude of the normalized data is similar to the original data and you want to preserve the original peak values, we decided to change it because it may be unexpected behavior, and is not appropriate when you normalize the load to much higher or lower magnitudes than the original data.
- Fixed the formula in the cash flow spreadsheets with equations for residential and commercial financial models to correctly calculate state ITC amount. The formula in Cell B51 was incorrect.

## Version 2013.9.20 September 2013

This version includes several improvements to photovoltaic modeling, utility rate and net metering calculations, bug fixes to concentrating solar power models, a revised and much faster solar water heating model, new wake modeling for wind farms, and updated default input values. In addition, this version comes with several new sample files to demonstrate various SAM features, including how to calculate net metering impacts with different utility rates and electric loads.

### General

- Fixed an issue on OS X systems when editing the library and weather file search path.

### Residential and Commercial Financial Models

- Updated utility rate inputs to be compatible with Version 2 of the OpenEI Utility Rate Database. For each utility in the database, SAM groups rate structures by category to make it easier to find a specific structure.
- Net metering algorithm now carries over monthly credits and applies an optional year end sell rate. (Older versions of SAM assumed used hourly accounting for net metering.)
- Renamed hourly and monthly results variables, and removed duplicate and confusing variables.

### Photovoltaic

- Added two options to model inverters not in the Sandia inverter database: The "datasheet" option allows you to enter parameters from a manufacturer datasheet. The "part load curve" option allows you to enter part-load efficiency curve that is linearly interpolated across the range of operation.
- For self-shading shading of 1-axis trackers, a new ground coverage ratio input replaces the row width and spacing inputs to avoid being able to model systems with inconsistent array layout inputs.
- Added estimation of output reduction due to self-shading of 1 axis trackers using an approximation that calculates geometric beam irradiance shading fraction from the GCR and assumes a “long” row. The diffuse sky and reflected irradiance is also reduced based on the view factor reduction to adjacent rows. Note: does not currently model nonlinear impact of electrical mismatch losses
- Added additional detail in energy loss diagram to better characterize the source of each loss: irradiance reductions due to shading, inverter operation and clipping, and others.
- Improved labeling of results variables.

- Bug fix to backtracking algorithm: The rotation angle limit is now applied correctly for backtracked systems.
- Bug fix in fixed tilt system self-shading code: The diffuse irradiance view factor reduction calculations were modified slightly to more accurately characterize the light blocking on the array.
- Added an option in PVWatts to change the mounting configuration of the PV array. The selection of an open rack or roof-standoff mounting system adjusts the installed nominal operating cell temperature (INOCT) of the modules in the system.

## Solar Water Heating

- Replaced the solar water heating performance model with a faster model.

## Concentrating Solar Power

- Physical trough, power tower, direct steam tower and linear Fresnel: Fixed an error in the powerblock startup calculations. This isn't a problem for simulations where the startup time is less than the simulation timestep, so the default cases (direct steam power tower & linear Fresnel) that use this model are not affected. Models where the startup time is greater than the simulation time may have been underpredicting the required startup energy.
- Physical trough, power tower, direct steam tower and linear Fresnel: Corrected an error in the hybrid cooling model that decreases annual results using hybrid cooling model between by as much as 0.5% for the Molten Salt Tower and 1.75% for the Physical Trough model. These are worst case differences at small wet cooling fractions. Larger wet cooling fractions result in smaller differences.
- Dish Stirling: Fixed a significant bug that underestimated shading losses in the default dish Stirling model. The annual energy in the default case decreases by 6.5%. As the spacing between modules increases, the difference between the old and new codes decreases and eventually disappears.
- Empirical trough and the generic solar system model: the turbine startup energy calculation was not properly deducting energy for systems without thermal energy storage and with a large turbine thermal startup requirement. For these cases, the error in annual output could be greater than 12% (output went up after the fix), depending on the power block startup energy requirement. The impact for the default values in both the GSS and Empirical trough was minimal.
- Generic solar model: the optical efficiency table is accompanied by a checkbox indicating whether the table should be interpolated or should simply return the nearest value. The checkbox values were backwards – i.e. checking "interpolate" actually caused the model to return the nearest value, and vice versa. This bug would be most significant in cases with significant optical efficiency variation over small changes in the angular inputs, or in tables with a small number of values that differ substantially from each other. For the default case, change in annual output was less than 1%.
- The powerblock model for the physical trough and molten salt power tower models was not correctly accounting for powerblock startup times greater than 1 hour (note the default is 0.5). The fix will cause annual energy output to decrease for these cases. For example, in the molten salt power tower, using the defaults and changing the powerblock startup time to 1.5 hours decreases the annual energy by about 4%. This bug will also affect custom simulations using timesteps less than the powerblock startup time.
- Improved TRNSYS convergence of molten salt power tower during periods when the solar field is off but storage and the powerblock are still operating. The default case shows around a 0.2% increase in annual energy, and an elimination of TRNSYS convergence errors reported in the log file.
- Improved startup and pumping power calculations in direct steam power tower. Default case annual energy increases around 0.8%.
- Fixed bug in air cooling model that caused fan parasitics to switch to 0 in some cases where it was operating. The fixed version reduces the default power tower models annual energy output around 1%.

## Wind

- Created the ability to import a user defined turbine layout for a wind farm.
- Added the ability to model wind wake effects using the Eddy-Viscosity model.
- Added the ability to model wind wake effects using the Park model.
- Worked with Mistaya Inc to develop the capability for Windographer software to export data in SAM's .srw wind resource file format.
- Increased the maximum number of turbines that can be analyzed in a wind farm from 250 to 300.
- Added a capability to display information about siting considerations for a particular location. SAM communicates with the NREL Wind Prospector online tool to obtain the information.

## Geothermal

- Fixed a bug where certain calculation were not updated during parametric runs.
- Fixed a bug that caused SAM to calculate the temperature drop for an EGS resource incorrectly.

# Version 2013.1.15 January 2013 (Update)

SAM 2013.1.15 is a maintenance update that addresses a few issues with the previous version. For a full description of new features in this version, see the SAM 2012.11.30 description below.

## General

- Fixed an issue that caused SAM to stop responding when viewing SRW wind data files with invalid format.
- Updated Performance Adjustment variable group names so they appear correctly in lists of variables (parametrics, etc.).
- Resized boxes on input pages to fit notes in orange font.
- Fixed an issue with the advanced utility IPP financial models that prevented the model from converging when the LCOE was very small.
- Fixed an issue with the cash flow Send to Excel feature that that caused percentages to be incorrectly displayed in Excel, and caused inaccurate escalation rate calculations.
- Disable Excel Exchange by default.
- Fixed a problem with TOU adjustment rates issues with net metering and load.
- Made the utility rate database window resizable and added scrollbars to make it easier to see long names and descriptions.
- Fixed a problem with cash flow graphs in reports for the advanced utility IPP financial models that caused multiple bars to appear on the graph.
- Fixed a problem with the weather data reader so that it correctly exports data headings.
- Fixed a problem with the Save with Hourly Options result that prevented SAM for saving data with unusual numbers of values (e.g., 200 values for statistical simulation).
- SAM now prompts you for a folder to save reports, and uses the .zsam file location by default instead of automatically saving it in the user folder without any feedback.

## SamUL

- PtOptimize() script function returns true/false depending on whether solar field optimization was successful.
- Added PtGetOutput() script function to return all messages from running PTGen via PtOptimize()

## Photovoltaic

- Flat plate PV did not read shading inputs for Subarray 1.
- Flat plate PV azimuth angle value did not import correctly from files saved with older.
- Updated report templates for PV systems to correct formatting and logic issues.
- Flat plate model now correctly imports azimuth angle value from files saved with SAM 2011.12.2.
- Fixed HCPV system costs page icon in navigation menu.
- Fixed tab order on photovoltaic input pages.
- Removed parentheses in photovoltaic model results labels so they appear correctly in the time series data viewer.

## Concentrating Solar Power

- Update TRNSYS source code files for all CSP models
- Fixed a problem with the empirical trough model when the solar field stow angle was 180 degrees.
- Fixed bug that results in Empirical trough model annual output error of 4%.

- Improved input variable labels on Solar Field page for "exact area" and "actual aperture."
- Fixed issue with empirical trough model solar field initial temperature. This had a very small impact on the system's total annual output.

### Wind

- Fixed a problem for the wind cost model that caused values to be zero.
- Corrected the wind PTC default value.
- Added a limitation of 300 turbines to the total number of turbines in a system with an error message when more turbines are entered into the farm layout.

### Geothermal

- Fixed a problem with energy values shown in the Geothermal report.

### Biopower

- Fixed a problem with the energy loss diagram that caused labels to overlap.

## Version 2012.11.30 November 2012

This version includes several improvements to the existing performance models and enhancements to the user interface. The new solar wizard makes it easier to get started using SAM to model solar projects. This version also includes a new energy loss diagram, new report templates, and an option to export cash flow data to Excel with formulas.

### General

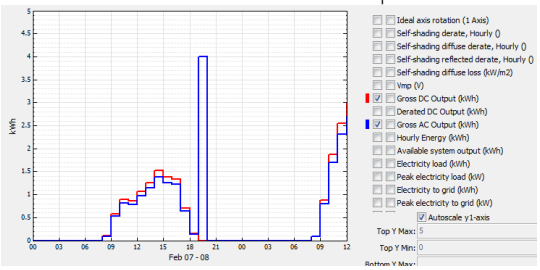
- Automatically download tax credit and incentive data for United States locations from the online Database of State Incentives for Renewable Energy (DSIRE).
- SAM Solar Wizard steps you through the minimum number of inputs to set up a basic analysis for a photovoltaic (PVWatts), parabolic trough (Empirical Trough), or solar water heating system.
- Loss diagrams for all performance models except wind and geothermal show where energy losses occur in the system.
- Export cash flow tables to Excel with formulas for the residential, commercial, commercial PPA, and utility IPP financial models.
- Expanded list of retail electricity rate structures available for download from the NREL OpenEI utility rate database.
- Improved Performance Adjustment page (replaces Annual Performance page) to model curtailment, degradation, availability, and other operating losses with new hour-by-month factors.
- New report templates.
- Reorganize navigation menu and input page to make input variables easier to find.
- Remove graph sliders and optimization analysis options because the Parametric Analysis option is a better and more transparent way to show variation of results over a range of inputs.
- Change the default value of some input variables to better match current market conditions, including changing the default analysis period from 30 years to 25 years.

### PVWatts System Model

- Bug fix: When "Force tilt=latitude" is enabled, surface tilt is now calculated as the absolute value of the location latitude to ensure that for locations in the southern hemisphere, the tilt value is positive. (SAM requires all array tilt values to be positive.)
- Bug fix: PVWatts will generates an error message if it reaches an invalid data line in the weather file. Previously, PVWatts may have continued through the file using unpredictable values as input.

## Flat Plate PV – Component Models

- Enhancement: SAM has been upgraded to allow specifying up to four subarrays with different orientation, shading, and soiling inputs. The subarrays are assumed to have the same number of modules per string, and are wired in parallel connected to the single inverter.
- Enhancement: Relative air mass is reported as an hourly output.
- Enhancement: System performance ratio (factor) is calculated in a consistent manner between flat plat and CPV systems. See documentation for more details. The calculation method does not change the results.
- Enhancement: DC and AC derate factors are specified as fractions, not percentages. This makes the derate convention consistent with PVWatts. SAM automatically updates values in files created with older versions with percentage values.
- Bug fix: The single point efficiency (SPE) inverter occasionally produced nameplate power with zero incident irradiance. An example is shown in the plot below, for a 4 kW SPE inverter.




  In the default residential PV system with a 4 kW SPE inverter, this fix reduces the annual AC kWh by approximately 1.8 %.
- Bug fix: The Sandia PV module model did not correctly use the database-specified temperature coefficients. The temperature coefficients used were A = -3.56, B=-0.075, dT=3 when the 'Use database values' option was selected in the user interface. For the default utility scale system in SAM, the fix increases the annual output using the default Sandia module by approximately 0.3 %.
- Bug fix: The Sandia PV module model now reports the module temperature as the ambient temperature under zero irradiance conditions. The previous version of SAM reported 0 deg C under some zero irradiance conditions. This does not change the results.
- Bug fix: Night-time inverter parasitic power is now correctly deducted from the total energy. This reduces SAM's annual AC power production by approximately 0.03 %, using the utility scale default system as a reference.
- Updated module and inverter databases.

## High-X Concentrating PV System Model

- Revision: Tracker power is now specified as a fraction of nameplate capacity. As a result, tracker parasitic power by default scales with system size. Project files from old versions of SAM are upgraded accordingly.
- Updated inverter database.

## Concentrating Solar Power Models (CSP)

- Updated HTF fluid library.
- Bug fix: The molten salt power tower now allows the user to locate a heliostat on the x axis.
- The runner and header heat loss calculations in the physical trough model were modified. The reported losses should approximately double for the default case. The net electric energy output will decrease around .1 - .2% for most cases. For systems with a larger number of field subsections, the effect will be slightly more significant.
- Therminol 66 & 59 are now available as heat transfer fluids for the trough models. Rough guidelines for temperature limits of all HTFs are provided in the user interface.

- The absolute pipe roughness in the external molten salt and direct steam tower models was changed from 1.5E-5 to 4.5E-5 m. This change results in a high pumping parasitic, but in regards to net energy is largely offset by an increased thermal efficiency caused by improved convective heat transfer coefficients.
- The flux map DELSOL returns for the external molten salt and direct steam receiver now reports normalized values that indicate for each node 1-12 the fraction of the total power incident on the receiver that is absorbed. This revised metric corrects for a mismatch between the DELSOL reported field efficiency and the efficiency that can be calculated from the flux map output.

### Wind

- A new Turbine input page with an option to either choose a turbine power curve from a library of commercially available turbines, or to specify a turbine's performance characteristics (coefficient of power, tip-speed ratio, etc.)
- Location Lookup now accesses the NREL Eastern Wind Integration Dataset in addition to the Western dataset.
- Added a set of representative wind data files for typical resource and terrain types in the United States.
- Improved the wind data file format to make it easier to edit with spreadsheet software and changed the wind data file extension from .swrf to .srw.
- The Wind System Costs page has a new option to estimate costs for onshore and offshore wind projects using the NREL Capital Cost model.
- New hour-by-month performance adjustment inputs to facilitate modeling operating losses due to curtailment and maintenance downtime.

### Biopower

- The Feedstock page now provides access to the U.S. Billion Ton Update study for dedicated energy crops in addition to the agricultural residue database.
- A new life-cycle emissions model estimates greenhouse gas emissions of biomass collection, transport, pre-processing, combustion, and CO2 re-uptake.

### Geothermal Power

- Added the ability to estimate plant costs for binary geothermal units.

## Version 2012.5.11 May 2012

For SAM 2012.5.11, we added one new performance model, made several improvements to algorithms to decrease simulation run times, and made the usual bug fixes, usability improvements, and documentation revisions. We re-wrote the flat plate PV simulation engine to reduce computational overhead and remove the dependence on the TRNSYS engine. The new code runs nearly 10 times faster than previous versions of SAM. This will reduce the time required for parametric and other analyses that require multiple simulations. The new High-X Concentrating Photovoltaic (HCPV) model is a new performance model that replaces the CPV option on the Module page. The new model includes CPV-specific derate factors, an estimate of spectral effects, and is structured to allow us to improve the model as new data and algorithms for CPV systems becomes available. We've created a set of new report templates for PV, wind, biopower, and geothermal systems that show a summary of key inputs and results in a PDF document.

## Photovoltaic Models

- Improved simulation engine for faster simulations. (see Summary above for details)
- Remove CPV model option from Module page, and replaced it with a new High-X Concentrating PV (HCPV) performance model. The new HCPV model includes CPV-specific derates, and air mass correction to simulate spectral effects.
- Rename "Component-based PV" model to "Flat Plate PV" model.
- Change azimuth angle convention for Flat Plate PV model to be consistent with PVWatts convention: 0=N, 90=E, 180=S, 270=W. If you use SAM 2012.5.11 to open a file you last saved in a previous version, SAM correctly converts the azimuth value for northern hemisphere locations only. For southern hemisphere locations, you should change the azimuth value yourself.
- Improve sun position calculations for Flat Plate PV model. This causes a small difference in the Flat Plate PV system output due to more accurate sun position calculation (ref comparison of TRNSYS to PVWatts sunpos calculation - PDF report from U.Wisc)
- Improved Flat Plate PV Backtracking algorithm. Simplified inputs significantly, improved runtime, results show better comparison with other tools (PVsyst)
- For the Flat Plate PV, CEC Performance Model with User Entered Specifications module model option, allow temperature coefficients to be entered either in A/°C, V/°C, or %/°C.

## General

- Improved usability of P50/P90 simulation option. Report P50/P90 values for all results shown in the Metricsd table on the Results page.
- Developed new report templates for PV, biopower, wind, and geothermal systems.
- Improved web update system to add automatic notification when software updates are available.
- Added 'Library()' function in SamUL to query library types and entry names. One application of the function is to run through different modules in one of the PV module libraries.

## Biomass Power

- Some Input pages rearranged and streamlined for clarity.
- Changed “Emissions Comparison” page to “Life-Cycle Impacts” page. The new page allows users to see the emission effects of transportation fuel, transportation mode, and pre-processing method. The overall greenhouse gas emissions results are displayed graphically, broken into general categories such as transportation, collection, combustion, and biomass uptake. This page does not affect the performance or cost model in any way. It is purely informational.
- Removed the option to specify biomass power plant capacity. This option was confusing to users, since intuitively, this option would back-calculate the amount of biomass used to achieve a plant of the specified size and the corresponding collection radius. The back-calculation of feedstock radius is not a current capability of SAM Biopower.

## Concentrating Solar Power (CSP) Models

- Fixed stow angle bug in empirical trough model. Should not affect results unless stow angles were set to an angle much less than 180º.
- Thermal storage tank heater efficiency was not being applied to tank heater parasitic losses. This should have minimal impact on results for most cases because tank heater is typically not frequently used and default heater efficiency is 0.99.
- Fixed thermal storage tank freeze protection calculations. Impact on annual performance results should be negligible.
- Optical efficiency did not include cosine effects. Modified version will significantly change optical efficiency results. Annual energy is not affected.

- Fix field defocus calculation for physical trough and molten salt power tower models. Impact on gross and net annual energy is negligible. May have larger impact (~5%) on the energy from the field in some cases.
- Fix bug in empirical trough model that allowed storage to over-discharge under some conditions. Impact on annual energy should be negligible.
- Fix bug in freeze protection calculations for the physical trough model. Impact should be negligible for systems with low freeze protection loads. Systems with higher freeze protection loads may see a noticeable decrease in required freeze protection energy.

### Wind

- Consolidate small-scale and large-scale wind models into a single Wind Power model that uses the swrf wind data format and files from the Western Wind Dataset.

## Version 2011.12.2 December 2011 (Update)

SAM 2011.12.2 is a maintenance update that addresses a few issues with the previous version including:

### General

- Error when opening zsam files by double-clicking the file name
- Issue with power tower models in Mac version.
- Handling of PV soiling derating factors when opening files created in older versions.

For a full description of new features in this version, see the SAM 2011.11.29 description below.

## Version 2011.11.29 November 2011

SAM 2011.11.29 adds three new technologies and several tools and capabilities, in addition to bug fixes, usability improvements, and documentation revisions (see below for detailed descriptions):

### New technologies

- CSP Linear Fresnel
- CSP Direct Steam Power Tower
- Biomass Power

### New capabilities

- Model PV modules with spec sheet data
- Monthly soiling derates for PV systems
- P50/P90 analysis
- Model a generic system using hourly or sub-hourly generation profile as input

### New tools

- Integrated time series data viewer
- Report Generator
- Case Compare

## Photovoltaic Component-based

- Ground Reflectance (albedo): Removed ground reflectance with snow input (albedo w/ snow) from the Array page. If the weather file contains valid albedo values between 0 and 1, they are in the simulation. Otherwise, the single ground reflectance value from the Array page is used. When comparing results from the current version with older versions of SAM, for locations that experience snowfall, a weather file format that includes snow depth, (Boulder CO.tm2 for example), and the default ground reflectance inputs, the annual output predicted by the current version will be typically slightly lower than the output predicted by older versions. Older versions of SAM predicted higher system output during snow cover periods by assuming that all PV panels would be cleared of snow, and that the more reflective ground would reflect more diffuse radiation onto the panels. The current version does not make this assumption for the PV component based models, but rather limits the input to a single average ground reflectance input.
- Tilted Surface Irradiation Models: Removed the Hay & Davies, and Perez 1988 diffuse irradiation models options from the Array page. This change simplifies the user interface while keeping the Isotropic, HDKR, and Perez 1990 models available.If you open a SAM file created with an older version of SAM and using the old Hay & Davies option, SAM will change the setting to the HDKR option in the new version . Similarly, the Perez 1988 option from the old version upgrades to the Perez 1990 option in the new version. The HDKR model typically will predict slightly higher diffuse irradiation on a tilted surface than the Hay & Davies model because of its treatment of additional diffuse irradiation components. The Perez 1990 model is based on coefficients extracted from a larger input dataset than the Perez 1988 model.
- Irradiance Component Input Option: Removed the option on the Array page for using total (global) horizontal and diffuse components of irradiation. The current options are total and beam, and beam and diffuse. By default, SAM uses beam and diffuse from the weather file. There should be no difference in results between the current version and older versions for weather file with self-consistent irradiance values. This change simplifies the user interface while still providing sufficient options for nearly all modeling needs.
- Soiling: Added an option for entering monthly soiling derates. The derate is applied equally to all components of the calculated plane-of-array (POA) irradiance before the DC module power is calculated. This is different from previous versions of SAM, in which the soiling derate was applied to the DC output of the module. The new approach is more consistent with real systems, where soiling blocks irradiance before reaching the module, which both reduces POA irradiance and affects cell operating temperature. The approach in the new version tends to slightly reduce the system's annual output compared to the approach in older versions, assuming a constant soiling derate for all months.
- Shading: Added an option to import Solar Pathfinder Month x Hour or Obstruction table shading input files.
- PV Module Model: Added a "CEC Performance Model with User Entered Specifications" option on the Module page. This model allows the user to enter module datasheet specifications directly into SAM, which calculates coefficients to drive the CEC performance model. The coefficients are calculated using a method detailed in the SAM help system.
- PV Databases: The CEC PV Module, Sandia Module, and Sandia Inverter databases were updated to the latest available versions.
- Monthly Soiling Derates: The PV Component-based model includes an option to specify 12 monthly values for the soiling derate factor on the Array page.
- Backtracking: The backtracking option in SAM was temporarily removed for this version because the SAM team did not have confidence that it was working correctly in all configurations. We are developing an updated algorithm and expect it to be faster and easier to use for future versions of SAM.

## Photovoltaic PVWatts

- Cell Temperature: PVWatts in SAM now reports cell temperature as equal to ambient temperature (dry bulb) when the sun is down. Previous versions reported 999 during non-solar hours. This change has no impact on results.
- Handling of Snow Depth: PVWatts in SAM now uses the snow depth data in a TMY2 weather file (if available) to adjust the ground reflectance (albedo) from 0.2 (no snow) to 0.6 (with snow cover). This change makes the results match the online PVWatts V.1 exactly for TMY2 files. When comparing results with previous versions of SAM, for locations with measured snow cover, this change will typically increase the annual output from a system because snow cover hours will reflect more diffuse irradiance from the ground surface onto the panels. This assumes that panels are always cleared of snow.

## Physical Trough System

- Improved the iterative solution algorithm for solar field mass flow rate. The previous release used the successive-substitution method for determining convergence of the HTF mass flow rate in the solar field. While generally successful, this method is prone to error in situations where the initial guess values do not closely resemble the final converged solution. This release uses the "hybrid false-position" iterative method which has proved to be significantly more robust and stable than the previous method in solving for the solar field mass flow rate. The modified solver algorithm also allowed us to place thermal inertia and heat loss calculations inside of the primary iteration loop, thus improving the accuracy of the solar field calculations and reducing solver time. Potential impacts include: This is the most significant modification to the solar field algorithm in this release. The more accurate solver ensures energy/mass/temperature balance in a wider range of operating conditions, and thus impacts the annual and hourly energy production. The net impact was shown to slightly reduce annual energy output and have a varying effect on individual time step calculations.
- Adjusted the design-point mass flow rate in the solar field to more correctly calculate the absorbed thermal energy and thermal losses from the loop at design. This change slightly increases the thermal performance of the solar field according to the design-point calculations, thus setting the design mass flow rate to a higher value. Potential impacts include: Defocusing of the solar field caused by mass flow exceeding its maximum limit will occur less frequently. The design-point mass flow rate is also used to size the piping and header diameters. This change leads to potentially slightly larger diameter piping, increasing the thermal inertia of the modeled plant, increasing the piping thermal losses, and decreasing the pumping parasitic through the headers.
- Updated pipe diameter sizing algorithm to correctly handle systems where the number of SCA's in the loop is 1 or 2 (8 is the default value). Potential impacts include: Addresses a bug causing the simulation to crash in this scenario.
- Correction to header piping length calculation. Potential impacts include: The piping length was calculated to be artificially low. This fix correctly calculates the header length, thus impacting the thermal inertia of the solar field and piping thermal heat losses. The net effect of this changed was observed to decrease the annual energy production for the default system.
- Added an algorithm to the solar field model that avoids recalculating the solar field during multiple iterations if the inputs to the module do not change. Potential impacts include: Improved simulation speed, no changes to performance calculations are anticipated.
- Correction to the calculation of optical efficiency during the first and last hour of the day in which the solar field operates. Potential impacts include: This fix applies only to simulations with sub-hourly time steps. During this type of simulation, thermal energy produced during the first and last time step of solar field operation is reduced slightly, depending on the time step duration.

- Optical "end loss" (light reflected at an angle off the end of the last collector in a row that is not absorbed) was previously applied as an average optical loss to each collector in the loop. The code was updated to apply this loss to only the relevant collectors in the loop. Potential impacts include: Total solar field optical efficiency is unchanged, though the energy absorbed by each collector will be distributed slightly differently. This slightly impacts thermal losses from the receivers, but is likely unnoticeable in annual simulation results.
- Improved the solar field freeze protection algorithm. The previous release assumed that freeze protection would be applied locally in the calculations for the solar field to maintain the HTF at the desired freeze-protection temperature. In other words, the freeze protection was (unrealistically) "injected" into any given calculation node in the solar field that fell below the minimum temperature. The model was updated to a predictive algorithm that applies fossil backup to heat the HTF at the inlet of the solar field to a sufficient temperature such that the HTF exiting the loop matches the desired freeze protection temperature. This more accurately captures thermal losses in the circulating fluid and the required energy contribution from the auxiliary fossil boiler. Potential impacts include: Improved accuracy in freeze protection calculations, including thermal losses and fossil energy requirement.
- Updated pressure loss calculation in the hot and cold headers to scale more accurately with mass flow rate. Potential impacts include: Reduced pumping parasitic requirement at part-load operation.
- Improved evacuated tube receiver thermal loss model to account for the temperature gradient across the SCA instead of calculating the thermal losses at an average temperature only. Potential impacts include: Improved accuracy in thermal loss calculations for the solar field receivers.
- Removed the minimum power cycle restart requirement. The functionality of this value was compromised by the turbine startup time requirement and the turbine startup energy requirement, and thus is no longer necessary. Potential impacts include: None
- Corrected a bug in the thermal storage system that allowed a negative mass in the tank under some conditions. This caused the simulation to crash. Potential impacts include: No performance impacts. Reduced likelihood of simulation crash in some situations.
- Corrected the calculation for thermal load into the power block during standby mode operation. The previous release underestimated the thermal requirement to maintain standby operation. Potential impacts include: Increased thermal requirement during standby operation (if applicable). Impact is expected to be minimal for most cases.
- Improved steam property lookup accuracy. Potential impacts include: Improved convergence of steam property calls and calculation of steam-related values such as heat rejection evaporative loss and power cycle water blowdown loss.

### Power Tower System

- Implemented a bug fix for calculating heliostat efficiency at negative solar azimuth angles. The previous release used the heliostat field component from the TRNSYS STEC library to interpolate solar field efficiency from a matrix defined by solar azimuth and zenith angles which artificially limited the solar azimuth angle to zero. The TRNSYS definition for solar azimuth angles applies a range of -180° to +180° (North to North, clockwise), thus the solar field efficiency was incorrectly interpolated at an azimuth angle of 0° for all solar azimuth angles less than zero (morning hours). Potential impacts include: Solar field optical efficiency was over-estimated for most systems during morning hours, resulting in an annual over-estimate of approximately 3% for the default external receiver system and 5% for the default cavity-north system. This is the most significant modification in the tower models for this release.
- Added outputs to report HTF pressure drop across the receiver. Potential impacts include: The user is now able to review the HTF pressure drop, including gravity and frictional head loss.

- Removed the minimum power cycle restart requirement. The functionality of this value was compromised by the turbine startup time requirement and the turbine startup energy requirement, and thus is no longer necessary. Potential impacts include: None
- Corrected a bug in the thermal storage system that allowed a negative mass in the tank under some conditions. This caused the simulation to crash. Potential impacts include: No performance impacts. Reduced likelihood of simulation crash in some situations.
- Corrected the calculation for thermal load into the power block during standby mode operation. The previous release underestimated the thermal requirement to maintain standby operation. Potential impacts include: Increased thermal requirement during standby operation (if applicable). Impact is expected to be minimal for most cases.
- Improved steam property lookup accuracy. Potential impacts include: Improved convergence of steam property calls and calculation of steam-related values such as heat rejection evaporative loss and power cycle water blowdown loss.

### Generic Solar System

- Updated the optical table interpolation algorithm to allow simultaneous interpolation of multiple tables. This change was made to support the Linear Fresnel system, which also uses the algorithm developed within the GSS model. Potential impacts include: No performance impacts are expected.
- Improved performance calculations to determine the design-point solar field optical efficiency based on the actual solar zenith at solar noon on the summer solstice. This allows the model to choose a more representative design-point mass flow rate. Potential impacts include: Minimal changes to the annual energy production.

### Generic System

- SAM's Generic System model now allows you to provide either hourly generation data or sub-hourly data with up to one-minute resolution as input, which makes it possible to use results from an external performance model with SAM's financial models.

### Solar Water Heating

- Collector Specification: Updated simulator to correctly use number of collectors specified by user. Also made collector database on user interface searchable.
- Draw Profile: Added option to scale hourly draw profile to an average daily hot water draw of kg/day.

### Geothermal Power

- Removed some unnecessary inputs, and updated default values.
- Allow pump work as input.
- Added the power block component, which to allow for modeling of a geothermal system using SAM's power block component.

### Geothermal Co-production

- None

### Biomass Power

- The utility-scale biopower model was developed by the SAM team with internal funding from NREL. The model accesses online NREL databases of biomass resource to model a biopower plant.

### Tools

- Integrated time series data viewer. SAM's new Time Series Data Viewer replaces DView for displaying graphs of time series data. The new viewer is integrated into the user interface, and runs on both Windows and Mac OS versions of SAM. DView is still available in SAM via the Results menu.

- Report Generator. The new report generator allows you to design and generate reports in PDF format with tables of both input data and results, along with text, and images. Once you design a report template, you can use it with different SAM files. This should facilitate generating reports for project reports.
- Case Compare. The Case Comparison window shows inputs and results from all of the cases in a file in a single, editable table. You can quickly identify differences between cases, and update values of inputs directly from the window.
- Search Box: For inputs that use a list to populate values (weather file, PV modules and inverters), a search box makes it possible to type a few characters of the input name.

### Cost and Financing

- Land Cost for Solar Systems: The land cost category on the System Costs page for PV and CSP systems is now linked to the land area input on the Array or Solar Field page.

### Weather Files

- Location lookup allows for choosing specific year or "typical DNI year" file. Previous versions only downloaded the typical year file.

## Version 2011.6.30 June 2011 (Update)

This version includes updated default input values across all technologies and several bug fixes.

### Financing

- Reorganize and rename financing options in the Technology and Market window: The Utility Independent Power Producer (IPP) option is equivalent to the Utility IPP options in pre-2011.5.4 versions of SAM, and the new utility financing options are listed under the "Advanced Utility IPP Options" heading.
- Removed the mid quarter MACRS depreciation option from the Utility IPP and Commercial PPA options.
- Added a custom depreciation option for the new utility financing options to facilitate analysis of depreciation schedules other than those typically available under U.S. tax law.
- Corrected a problem with the units in the Production Tax Credit calculation that affected analyses involving the PTC. SAM 2011.5.23 and earlier incorrectly overestimated the PTC amount by a factor of 1000.
- Fixed convergence issues in the PPA price calculation algorithm in the Utility IPP and Commercial PPA models when used with Wind, Generic, and PVWatts system models.

### PV

- Updated CEC PV Module and Updated Sandia PV Inverter databases.
- Corrected a problem with reading Solmetric SunEye shading files.
- For the advanced Multiple Systems simulation option, corrected the PV capacity factor and system performance factor calculation.

### General

- Updated default input values across all technologies.
- Added PDF export for single graphs.
- Corrected a problem with SAM window placement on a multiple monitor setup.

- Corrected a problem with axis labels in graphs of parametric results that included variable linkages. SAM now displays the value of one of the linked variables instead of using long labels that include all variable names and values.
- Added a search box to selection windows such as the Choose Parametrics window. You can now type a few characters of a variable name to find it in the list.
- Fixed a problem with the Mac version on some older 32-bit Mac OS systems.

### Weather Data

- Improved error checking for weather files, and in the TMY3 weather file creator

### Power Tower

- Fixes issue in power tower model and north field calculations.
- Corrected units for DNI in hourly results.

### Wind

- Added the No Financials option for the Utility Scale Wind technology option.

## Version 2011.5.23 May 2011 (Update)

This version addresses a problem with the PV O&M default values and includes some formatting changes to the Help system.

## Version 2011.5.4 May 2011

This version adds many new features in addition to fixing bugs in existing models. It adds several new utility scale financing models that more accurately represent some common financial structures used for renewable energy projects than SAM's original Utility-IPP model. Other improvements include a generic system model that can accept hourly energy input from other models, enhanced temperature correction algorithms for the CEC PV module model for various mounting options, more detailed accounting for PV cost details, a new model for calculating geothermal co-production in conjunction with an oil or gas well, and a utility scale wind model that can directly access a large database of hourly wind data at various hub heights.

### General New Features

- Improved welcome screen with news feed to show updates about upcoming versions, bug fixes, webinars, and other SAM-related information
- Additional graphs automatically generated to show cost breakdowns in stacked cost per watt ($/W) and LCOE (cents/kWh) on y axis
- New sample file for showing scripting (SamUL) capabilities
- Updated reference manual for scripting (SamUL)

### Financial Models

- Added an "All Equity Partnership Flip" financing structure that represents a power generation project with a tax investor and developer and no debt. You specify a target IRR and year or target PPA price with the allocation of cash and tax benefits to each partner before and after the target year. SAM calculates the project PPA price and the NPV and IRR for each partner.

- Added a "Leveraged Partnership Flip" financing structure that represents a power generation project with a tax investor and developer and debt. You specify a target IRR and year or target PPA price with the allocation of cash and tax benefits to each partner before and after the target year. SAM calculates the project PPA price and the NPV and IRR for each partner.
- Added a "Sale Leaseback" financing structure that represents a power generation project with two partners. The tax investor purchases the project from the developer and leases it back to the developer. The tax investor receives lease payments from the developer along with tax benefits and incentives. The developer keeps any excess cash flow after operating costs and lease payments are made. You specify a target IRR and year or target PPA price and lease terms. SAM calculates the project PPA price and the NPV and IRR for each partner.
- Added a "Single Owner" financing structure that represents a power generation project with one owner. The owner receives all of the cash and tax benefits from the project. The owner may be the original project developer or a third party investor if the developer is unable to use the tax benefits or lacks sufficient capital to construct the project. You specify debt terms, and a target IRR and year or target PPA price. SAM calculates the project PPA price, IRR and NPV.
- Merged "Residential Cash" and "Residential Loan/Mortgage" financing options into single "Residential" model. To model cash financing, set the debt fraction to zero.
- Merged "Commercial Cash" and "Commercial Loan" financing options into a single "Commercial" model. To model cash financing, set the debt fraction to zero.
- Renamed "Third Party Ownership" to "Commercial PPA" to better reflect calculations. User can now specify either the IRR target or the First Year PPA price and solve for the other.
- Merged "Utility IPP", "Utility Dispatch", and "Utility Bid Price" options into single "Independent Power Producer" option that handles all three cases. The user can specify the IRR target or the First Year PPA price, along with time-dependent valuation factors (dispatch).
- Simplified inputs for tax credits and incentives to remove unnecessary complexity.
- Handling of property tax fixed. Previous versions overemphasized the valuation of property taxes, and an improved method is implemented.

### Weather Data

- Bug fix for copy/paste into TMY3 creator wizard on Mac OS X

### Photovoltaics

- Updated CEC and Sandia module databases to most recent available versions.
- Updated Sandia Inverter database to most recent available version.
- Added detailed thermal modeling of mounting options. Available only with the CEC module model.
- Added an array backtracking algorithm for one axis tracking systems.
- Fixed calculation of nominal DC array output for the CEC module model. Does not affect energy calculations.
- CPV tilt and azimuth inputs now work correctly with the selected tracking mode
- Updated CPV module page with temperature corrections to Pmp, added cell temperature calculation
- Updated curve fit calculations for Sandia inverter input page
- Updated default values for a, b, dT mounting coefficients on Sandia module page
- Fixed tilt=latitude bug for southern hemisphere

### Solar Water Heating

- Added a database of SRCC solar thermal collectors.
- Added input for maximum auxiliary power to allow for modeling of larger systems
- Added input for circulation pump power

### Parabolic Trough (Physical)

- The solar field inlet HTF temperature calculation was corrected to better model plant behavior during shutdown. Previously, the field inlet temperature remained tied to the power block outlet temperature when the solar field was not producing power, but thermal storage was providing energy for power cycle operation. This prevented accurate modeling of nighttime solar field cool down behavior. Potential impacts include: Observed field inlet/outlet temperature during nighttime operation for systems with thermal storage or auxiliary fossil backup, required solar field startup energy
- The pipe sizing algorithm was modified to match calculated piping diameters to a common piping schedule. The piping schedule is now selected based on the minimum available schedule diameter that exceeds the calculated diameter requirement. Potential impacts include: Piping thermal loss, piping pressure drop and parasitic power requirement, solar field thermal inertia (from modified piping HTF volume calculation)
- The field piping thermal inertia term on the Power Cycle page was split into three separate inertia terms and moved to the Solar Field page. The new inputs include specific thermal inertia terms for the cold header piping, hot header piping, and collector loop piping. Potential impacts include: Solar field transient behavior during startup and shutdown
- The convergence tolerance on the solar field and controller algorithms was tightened. The former tolerance values proved to be insufficient for simulations with sub-hourly time steps. Potential impacts include: Annual energy output, longer simulation time
- An error in the collector loop HTF temperature calculation was corrected. The error related to the fraction of energy involved in warming/cooling the HTF during non-steady-state operation. Potential impacts include: Transient behavior during startup, shutdown, and rapidly changing DNI levels
- The mass flow rate calculation within the solar field was improved. Previously, it was possible for the mass flow rate to indicate convergence with small remaining convergence error in the field energy balance. The improved calculation eliminates this error. Potential impacts include: Small differences in the solar field mass flow rate or thermal energy output
- On the Thermal Storage page, an input was added for the Hot tank heater set point. This allows the tank model to maintain a temperature set point for the auxiliary heater for both the cold and hot storage tanks separately. Potential impacts include: Differences in predicted tank heater parasitics, difference in thermal energy storage performance throughout the year
- On the Power Cycle page, an input was added for the Minimum power block restart time. This input allows the user to control the amount of time that the power cycle will require to resume producing electricity if the cycle trips during daytime operation because of low solar resource. Potential impacts include: Annual electricity production, electricity production on partially cloudy days
- On the Power Cycle page, an input was added for the Turbine inlet pressure control method. This allows the user to select the power cycle performance model as either fixed pressure or floating pressure. Previously, only fixed pressure operation was modeled. Potential impacts include: None for fixed pressure mode; For floating pressure mode - power cycle performance during part load operation, power cycle outlet temperature during thermal storage discharge
- On the Thermal Storage page, an input was added to allow the user to select the auxiliary fossil backup dispatch mode. Options now include Minimum backup level, and Supplemental operation. Previously, only the Minimum backup level mode was included. The Supplemental operation mode allows fossil backup to provide thermal energy to the system in addition to thermal energy provided by the solar field or TES. The maximum rate of energy delivery is the fraction of design point power specified in the Fossil Fill Fraction inputs under the Thermal Storage Dispatch Control group, and the total fossil contribution plus the energy from the field and TES can't exceed the corresponding Turbine Output Fraction value. Potential impacts include: None for Minimum backup level. For supplemental operation – modified fossil backup control

- The solar field defocusing algorithm was modified to more accurately model field defocusing during over-design operation. Modifications improved the model's ability to avoid excessive defocusing and reduce dumped energy during over-design operation. These changes are most prominent in systems where frequent defocusing is required. Potential impacts include: Annual electricity output, solar field performance during over-design operation, dumped thermal energy, model convergence issues
- The measure for power cycle over-design operation within the model was changed from total thermal energy input to HTF mass flow rate. This change reduces instances of excessive HTF mass flow rate through the power cycle and more accurately simulates real plant operation strategies. Potential impacts include: Observed power block HTF mass flow rate, peak electric power generation
- The solar field inlet HTF temperature calculation was corrected to better model plant behavior during shutdown. Previously, the field inlet temperature remained tied to the power block outlet temperature when the solar field was not producing power, but thermal storage was providing energy for power cycle operation. This prevented accurate modeling of nighttime solar field cool down behavior. Potential impacts include: Observed field inlet/outlet temperature during nighttime operation for systems with thermal storage or auxiliary fossil backup, required solar field startup energy
- The field configuration option on the Solar Field page was modified to allow the user to specify the number of subfields rather than the configurations "I" or "H". This change improves the model's ability to capture the piping performance of a wider range of field layouts. Along with this change, internal piping layout algorithms were updated to accommodate the range of subfield selections. Potential impacts include: Piping thermal loss, piping pressure drop and parasitic power requirement, solar field thermal inertia (from modified piping HTF volume calculation)

### Parabolic Trough (Empirical)

- The startup criteria in the plant control algorithm incorrectly restricted startup to conditions above the power cycle dispatch requirement, when startup should have been allowed above the minimum power block operation level. This problem was corrected to represent a more realistic startup procedure. Potential impacts include: Small impact on annual energy production, small impact on electricity output during morning operation

### Power Tower

- The existing control strategy encompassing all plant operation and dispatch decisions was deemed to be limited in flexibility and prone to convergence errors. To improve the tower model and ensure a common simulation platform for all CSP models, the previous control algorithm was replaced by the algorithm developed for the Physical Trough model. This switch has significant benefits in ensuring the quality of the results over a wide input variable space, and provides improved results especially in simulation cases where solar multiple, thermal storage sizing, or auxiliary fossil backup sizing deviate significantly from the optimal. This modification applies to both the "external" and "cavity" receiver models. Potential impacts include: Improved solar field defocusing control, improved plant startup behavior, improved thermal storage or auxiliary fossil backup dispatch control, increased annual electricity output especially for systems with no storage
- Added fossil dispatch control scheme option on the Thermal Storage page. Refer to the Physical Trough release notes
- The pumping power requirement for HTF passing through the power block was previously calculated on a thermal power basis – meaning the total thermal power passing through the pump was used to calculate an estimated electrical pumping power requirement. This calculation was replaced by an estimate on a mass flow basis, where total pumping power is given in terms of kJ per kg of HTF (equivalently kW per kg/s of mass flow). This change makes the tower model consistent with the pumping power convention for the parabolic trough model. Potential impacts include: Modified parasitic pumping power for HTF through the TES/Power Cycle system

- Added sliding pressure operation for the power cycle. Refer to the Physical Trough release notes
- An error in the natural convection thermal loss calculation used the wrong temperature value for the conductivity of air. A second error in the calculation used the wrong active area for convection between the tube wall and the HTF. Both were corrected and resulted in a minor difference in annual energy production. Potential impacts include: Small difference in thermal losses from the external receiver.

### Wind Systems

- Addition of utility scale wind model. The SAM team has added a utility scale wind option for SAM users. The new option uses the same algorithm to determine wind farm output (including a simple wake analysis), but provides a new list of turbines, new financing options, and a new source for wind resource data. The new wind resource data is more granular in coverage and provides for measurements at hub heights more appropriate for utility scale wind turbines.
- •Added several hourly wind resource data files. More can be accessed via the online database connection that is integrated into SAM.
- •Enhancements to the small scale wind turbine model. The small scale model has been improved to run more quickly and some minor bugs have been addressed. In addition, new turbines have been added to the Small Scale Wind turbine library, bringing the total to 16.

### Geothermal

- Addition of geothermal co-produced electricity model. The Co-Production model in SAM estimates power output from co-production resources based on the resource temperature and flow rate and the power plant model chosen. The power plant model calculates the plant net power output based on either the thermal efficiency or utilization efficiency assumed for the power plant.

### Generic Model

- Can accept hourly energy production values as input, calculated by an external model.

## Version 2010.10.8 October 2010

This version adds many new features in addition to making improvements to existing ones. It adds a non-solar technology models for small wind and geothermal power systems. It also adds options for modeling complex utility rate structures for residential commercial projects, and time-of-use pricing through the use of energy payment allocation factors for utility projects. This version allows modeling of two new utility financing options. For PV systems, this version adds a more sophisticated shading model. The Results page has been improved to make it easier to display and export hourly data, regardless of operating system (Windows or Mac), and to display hourly data for simulations involving multiple runs such as parametric analyses.

### Major Changes

- New generic solar system model for concentrating solar power systems that models the solar field using a table of optical efficiency values that you specify.
- New geothermal power system model.
- New small scale wind power model.
- Addition of time of dispatch and bid price utility financing models to allow modeling of projects in California under the California Public Utilities Commission rules, and to calculate the project internal rate of return when you know the power purchase price.

- For PV systems, addition of a more sophisticated array shading model that allows you to import shading data from the PVsyst simulation software and SunEye shading analysis tool.
- New utility rate page for complex rate structures for residential and commercial projects that includes time-of-use rates, peak demand charges, and tiered rate structures.
- Improved electric load modeling for residential and commercial projects.
- New cavity receiver model for power tower systems.
- Remove electric storage option from photovoltaic model pending improvements.

### General

- New hourly data browser on Results page allows viewing and exporting of hourly data tables on both Windows and Mac computers (does not require Microsoft Excel) and viewing of hourly results for analyses that involve multiple model runs such as parametric analyses.
- Improvements to statistical simulation option to add integrated regression and selection of multiple outputs.
- Better error checking with display of warnings for some simulation issues on Results page (warning message button at top right of Results page.)

### Residential and Commercial Projects

- An improved utility rate model allows specification of a range of rate structures from simple flat rate with net metering, to complex structures with time-of-use rates, demand charges, and tiered rates. The model also allows rate structures to be imported from NREL's new rate database hosted on the OpenEI website.
- Financing page includes an input to specify salvage value.

### Utility Projects

- New models for utility financing options allowing specification of power purchase price as an input, and use of energy payment allocation factors to model time-of-use pricing.
- New inputs on the Financing page for specifying construction interest costs that accrue before the analysis period begins.
- Financing page includes an input to specify salvage value.

### Photovoltaic Systems

- Array sizing calculator allows you to specify the system DC capacity, and automatically calculates the values for modules per string, strings in parallel, and number of inverters on the Array page.
- Improved array shading model allows specification of beam shading factors using a table of 8,760 hourly values, a 24 by 12 month by hour table, or an azimuth by altitude table. Other options are to import shading data from the PVsyst simulation software or the SunEye shading analysis too. Finally the new shading model allows modeling of self-shading within the array (without backtracking).
- Detailed derate factors can be specified directly on the Array page.
- Improved error checking to help ensure inverter and array capacities are matched.
- Updated module and inverter databases.
- The electric storage (battery) model has been removed in this version.
- Array page allows specification of the land area as a multiple of the total module area for reference. (Land area is not accounted for in cost calculations.)
- New option for using updated Perez model for calculating incident radiation from data in weather file.
- Fixed a problem with the way SAM calculated inverter AC output for hours when the DC input exceeded the inverter capacity.
- Removed reference variables for CEC module model.

### Power Tower Systems

- Improvement of condenser modeling in power block.

- New cavity receiver model.
- Add hybrid cooling.
- Renaming of input and output variables for clarity.
- Improved modeling of parasitic losses.
- Add storage bypass valve control.
- Receiver maximum flow rate based on HTF properties and maximum over design operation fraction.
- New solar multiple input variable.
- New receiver control variables.
- Added specification of the land area as a multiple of the total module area for reference. (Land area is not accounted for in cost calculations.)

### Parabolic Trough Systems

- Improvement of condenser modeling in power block. (physical model)
- Added specification of the land area as a multiple of the total module area for reference. (Land area is not accounted for in cost calculations.)
- Improved modeling of fossil fuel usage for systems with fossil backup.
- Add hybrid cooling. (physical model)
- Improved heat loss calculation. (empirical model)

### Generic Solar System

- Added new model to facilitate modeling of concentrating solar power systems not handled by parabolic trough, power tower, and dish-Stirling models. Allows modeling of solar field based on a table of efficiency values.

### Geothermal Power Systems

- New model for utility-scale geothermal power generation projects based on the U.S. DOE's GETEM model.

### Small Scale Wind Systems

- New model for small wind systems that consist of one or more turbines for residential and commercial projects. Current version relies on wind speed data in solar TMY data.

## Version 2010.4.12 April 2010 (Update)

### This update corrects several issues with SAM 2010.3.31.:

- System summary: Units for the total installed cost per capacity were incorrect for photovoltaic, solar water heating, and generic systems.
- Financing: Projects with commercial or utility financing and an analysis period less than the depreciation period caused simulations to fail. (This was also true for previous versions.)
- Incentives: Production-based incentives (PBI), production tax credits (PTC), and investment tax credits (ITC) were incorrectly calculated.
- Photovoltaic systems: The annual energy production was incorrect for systems with bipolar inverters from the Sandia inverter database.
  Solar water heating: System energy savings were incorrectly calculated.
- Parabolic trough (physical): Receiver heat loss calculation was incorrect for receivers with lost vacuum or hydrogen leakage.
- Power tower: Water usage was incorrectly reported, values of the solar field delivered energy and power block input energy were incorrectly reported in the hourly results worksheet, and default values of some input variables were incorrect.

- Parabolic trough and power tower: Power block capacity-based costs were incorrectly calculated based on the net capacity instead of the gross capacity.

The update includes the following improvements:

- Several new functions and improvements to the SamUL scripting language, including the ability to run scripts from the command line.
- Revised user documentation.

## Version 2010.3.31 March 2010

This version adds a solar water heating model and a new parabolic trough model to Solar Advisor, improves the display of graphs on the results page, and adds capabilities to the statistical analysis simulation option. It also includes interface improvements to the photovoltaic module and inverter pages, improves modeling of temperature effects on module performance, and includes the latest module and inverter databases from the CEC and Sandia. Finally, this version adds a weather data download feature for U.S. locations, and a function to create weather files in TMY3 format.

General New Features

- New solar water heating model for residential systems.
- Tax credits and incentives can be defined as annual schedules.
- Add levelized cost of energy (LCOE) with and without incentives.
- New functions in SamUL
- Graph thumbnails on Results page.
- Input window for loads (photovoltaic, solar water heating) adds options for specifying load data: Daily profiles by month, cut and paste from clipboard.

Weather Data

- Location lookup option automatically downloads NREL Solar Prospector weather data for U.S. locations using an address or latitude and longitude.
- TMY3 creator facilitates creating custom weather files.

PV

- Simple load and storage models added to all photovoltaic models. Was only available in PVWatts model in previous versions.
- Revised default rating conditions for concentrating photovoltaic (CPV) model. This will affect capacity-based calculations including LCOE when the module cost is specified in $/W.
- Temperature correction added to concentrating photovoltaic (CPV) model, and improved in simple efficiency and Sandia models to include more options for specifying mounting options.
- Improved layout of Module page for CEC and Sandia model. Display I-V curve and other changes.
- Improved layout of Inverter page. Display inverter efficiency curves and rename input variables.
- Azimuth tracking option added to photovoltaic models.
- New hourly output data columns added to hourly outputs.
- Corrected system performance factor calculation for systems with shading.

Parabolic Trough

- New physical model for parabolic trough systems. Original trough model renamed "empirical trough model." Both trough models are available in the current version.

### Power Tower

- New field land area variables on Heliostat Field page.
- Variables on input pages reorganized.

### Generic Fossil

- Allow generic fossil input variables to be parametric variables.

## Version 2009.10.2 October 2009

### General New Features

- Significantly faster model runs and smaller project file sizes.
- Both Windows and Mac OS X-Intel versions are available.
- A SCIF file importer for opening files saved with previous versions of SAM.
- A new graphs page can display up to four graphs simultaneously and has new controls for creating and modifying graphs.
- Tornado-chart type analysis is built-in as a specific Sensitivity analysis.
- Optimization allows you to maximize or minimize a metric with respect to inputs.
- Multiple sub-systems allows you to model systems made up of two or more subsystems. Weather model reads TMY3, EPW, and TMY2 files.
- Scripting and batch-mode capabilities with Excel and other programming languages.

### PV

- Update CEC module database (10/2)
- Simple Efficiency Model allows for multiple radiation level/efficiency pairs (Flat Plate & CPV)
- Incorporated PVWatts model

### Dish-Stirling

- No updates.

### Parabolic Trough

- Update HCE library.
- Improvements to thermal storage dispatch strategies.
- Can accept custom HTF fluids using a table-lookup mechanism.

### Power Tower

- Improved heliostat layout mechanism and optimization wizard.
- Can accept custom HTF fluids using a table-lookup mechanism.

## Version 3.0 June 2009

### New Features

- Power tower model.

### PV

- Simple array shading model.
- Add energy flow graph to standard graphs on Results page.
- Update Sandia inverter database.
- Update CEC module database.

### Dish-Stirling

- No updates.

### Parabolic Trough

- Update HCE library.
- Tracking of backup boiler fuel cost in cash flow and cost of energy calculations.
- Improve calculation of backup boiler fuel usage.

### General

- Updated help system and user guide, including topics for power tower model.

### Minor changes

- Update and rename sample files.
- Improvements to user-defined variable implementation.
- For cases using Excel optimization (utility financing model), Excel file runs in background by default.
- Improve handing of SCIF files.
- Show incentive tax details by default on Incentives page.
- General improvements to speed up run times.

## Version 2.5 November 2008

### New Features

- Parabolic dish-Stirling engine model.
- Time-of-use utility rates.
- User documentation available as both context-sensitive Help and PDF file.
- Automated optimization of power purchase agreement (PPA) price escalation rate and load fraction for projects with IPP and Utility financing.

### PV

- Revise inverter and array sizes in sample file.
- Update Sandia inverter database.
- Update CEC module database.
- Change module and inverter database format to Excel from MDB.
- Display voltage and capacity variables on array page to facilitate inverter and array sizing.

### Dish-Stirling

- Add dish-Stirling sample file.
- Implement dish-Stirling model.

### Parabolic Trough

- Remove unused variables from user interface: number of receivers per SCA, HTF flow control, HTF night flow control, and turbine start-up time.
- Rename "time-of-use" variables to "time-of-dispatch" and move them from Utility page to Storage page.

### General

- Remove Utility - IOU option from list of financing types on Financials page, and rename "Utility - IPP" option to "IPP and Utility".
- Improve graphing options.
- Change utility rate units from cents/kWh to $/kWh.
- Add Excel-based optimization of PPA escalation rate and debt fraction for IPP and Utility financing.
- Improve installation on Windows Vista.

- Improve sliders interface.

### Minor changes

- Fix time format issue with parabolic trough time of dispatch schedule.
- Improve file compression to minimize file size.
- Allow long variable names in parametric analyses.
- Revise WACC calculation.
- Read all significant digits from linked spreadsheets.

## Version 2.0 June 2008

### PV

- Implement new inverter performance model: Sandia Performance Model for Grid-connected PV Inverters
- Removed previous curve-fit inverter model
- Implement new photovoltaic module performance model: California Energy Commission Performance Model.
- Update Sandia PV Array Performance Model with additional modules. (Was King Model in previous versions.)

### CSP

- Implement dry cooling capability for CSP systems.
- Add new Solel UVAC3 HCE to CSP model library.

### General

- Add generic technology option: The simple heat-rate model allows comparisons between solar technologies and conventional fuel-based technologies in all markets.
- Add Third Party Ownership option to commercial projects.
- Allow operation and maintenance costs and annual degradation rates to be entered on a year-by-year basis.
- Add new results workbook that stores complete set of calculated metrics, hourly data, monthly averages, and annual averages to facilitate reviewing results in Excel.
- Improve display of results page: Move results button to bottom of navigation menu; replace single button with three, Results Summary, Spreadsheet, and Time Series Graph; implement new Run Analysis button to replace "results pending" status. Also add new Results menu.
- Replace LCOE stacked bar graph with stacked cost graph to correct error in LCOE cost breakdown under certain conditions.
- Add several new standard graphs, including monthly output, monthly inverter efficiency (PV only), and energy flow (CSP only).
- Add new graphs that are available when one or more Independent parametric groups are defined.
- Create new compressed file format (SCIF) that stores only inputs in small files for easier file sharing. Cases can be imported and exported from SAM files in the SCIF format.

### Minor changes

- Minor bug fixes
- Reduce required disk storage space by deleting workbooks and other files from temporary folder when closing SAM.
- Add transformer derate category to Array page for PV systems.
- Display weighted average cost of capital (WACC) on Financials page.
- Improve internal rate of return (IRR) calculation for utility and third party ownership projects.

- New Fixed (per year) operation and maintenance category.
- New folder (Samples\Financial_Spreadsheets) contains sample workbooks illustrating Solar Advisor financial calculations. Workbooks are also posted on the Solar Advisor website.
- Solar Advisor opens with an empty window instead of automatically opening previous file.
- Add close file button to menu bar.

## Version 1.3 October 16, 2007

### General

- Add capability to use EnergyPlus Weather file format (EPW) files for weather data.
- Add capability to add weather files to the collection of built-in files.
- Add weather data viewing tools, links to weather data web sites, and Help button to the Climate page.
- Add ground reflectance with snow input variable to Array page for PV systems. SAM Applies the snow ground reflectance value during hours that the weather data indicates there is snow on the ground.
- Fix a bug in the inverter model for low part-load operation.
- Add waterfall graph capability in DView on Results page for CSP systems.
- Update user guide.
- Improve overall performance of model.

### Other changes

- Add start up mode settings (File, Settings) and change tab names in Settings window.
- Add help button to Climate page that opens a help page describing weather file options.
- Improve search algorithm that finds a solution for systems using utility financing.
- Improve calculation of number of TRNSYS runs displayed in information message.
- Change hourly output buttons on Results page for CSP systems.
- Improve handling of files created by different versions of SAM.
- Improve automatic graph scaling.
- Improve message for users attempting to run SAM when the Windows language setting is not English.
- Improve automatic scale on sliders.
- Improve file navigation for File, Open and File, Save As commands.

## Version 1.1 August 10, 2007

### General

- Photovoltaics Array: Add detailed derate factors.
- Results: Add Slider column to results summary table that displays output measures based on the position of visible sliders.

### Results

- Change the units of ITC and IBI incentives that appear with sliders and in graphs from % Max to %.
- Improve the functioning of the Notes box.
- For utility systems with IOU financing, remove first year PPA from the results summary table.
- For utility IPP financing, improve the LCOE calculation algorithm.

### Incentives

- Cursor changes to an hourglass while resetting default market values.
- Correct default settings for tax details to show that for residential systems, all utility incentives are taxable, and that utility incentives do not reduce the ITC basis.

### Photovoltaics Array

- Changed default total derate factor in sample files to 84% to match PVWATTS.

### Costs

- Correct the way the sales tax rate and module cost per unit values are displayed.

### Parametrics

- Fixed a bug related to incentives.
- Fixed a bug related user-defined variables.

### External Spreadsheets

- Improved handling of missing workbooks.
- Fixed a bug related to working with external spreadsheets.

### Menus

- Add the Release notes command to Help menu to display a list of version numbers and the new features and fixes associated with each version number.
- Reorganize the list of commands on the Case menu.