2008 Solar Annual Review Meeting

Solar Advisor Model

Session: Modeling and Analysis

National Renewable Energy Laboratory

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National Renewable Energy Laboratory

Innovation for Our Energy Future

Budget and Solar America Initiative Alignment

National Renewable Energy Laboratory			
Project Beginning Date	**FY07 Budget**	**FY08 Budget**	**Total Budget**
FY03	$732k	$850k	$1582k

- This project supports the Solar America Initiative by:
  - Provide a consistent framework for analyzing and comparing power system costs and performance across the range of solar technologies and markets
    - PV, solar heating systems, CSP
    - Residential, commercial and utility markets
  - Developing and validating performance models to enable accurate calculation of Levelized Cost of Energy (LCOE)
  - Providing a consistent modeling platform for all TPP's
  - Supporting implementation and usage of cost models

Project Overview: SAM (Solar Advisor Model) Concept

- Original Vision (For DOE Multi-Year Planning by Lab analysts)
  - Combine all solar technologies in one modeling environment
    - concentrating solar power (CSP)
    - photovoltaics (PV)
    - solar heating (solar hot water, industrial process heat, etc.)
    - solar hybrid lighting
  - Model performance, costs and financing consistently across technologies for appropriate comparisons.
  - Calculate impact of R&D technology improvements on LCOE, NPV, etc. in various markets.
  - Extensive sensitivity analysis and output/ plotting capabilities
  - Do not reinvent the wheel (existing models when possible)
- Current Vision
  - Robust simulation tool that industry, the labs and DOE will use
  - Implementation of best performance models (Sandia PV module, NREL parabolic trough model, Sandia Inverter, 5-Parameter PV module via UW-Madison and CEC)
  - Policy, Markets and Technology Analysis
  - Siting Tool (especially with detailed Google-Maps solar satellite data)
  - Easy to Use interface with detailed analysis capabilities
  - Solar Hybrid lighting and Solar Heating are currently on hold

Current User Demographics

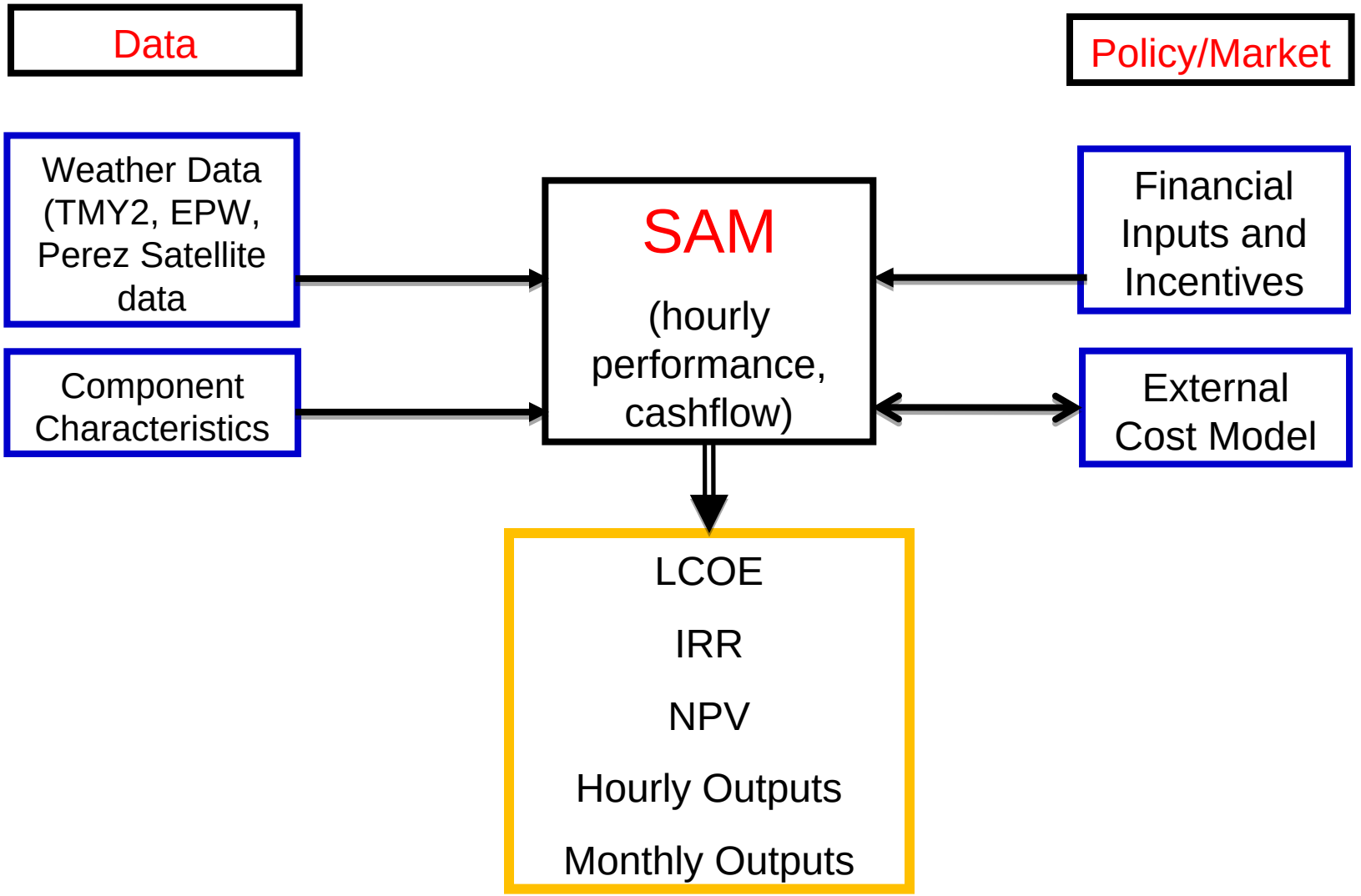
We currently have 1492 separate emails that have downloaded one or more versions of the software. Of those:

- Recognizable participants include Worley Parsons, Konarka, EPRI, GE, Dow, Solo Power, Evergreen Solar, GT Solar, Chevron, Nanosolar, Boeing, Sun Edison, UPC Solar, Alcoa, RWBeck, CH2MHill, Solfocus, APS, SunPower Corp., SkyFuel, Raytheon, HelioVolt, Solaria, Miasole, Siemens, SolucarPower, Strategen, Invenergy, McKinsey, Johnson Controls, Honeywell, FPL, Duke Energy, Constellation, Acciona, United, Sempra, Navigant Consulting, Black and Veatch

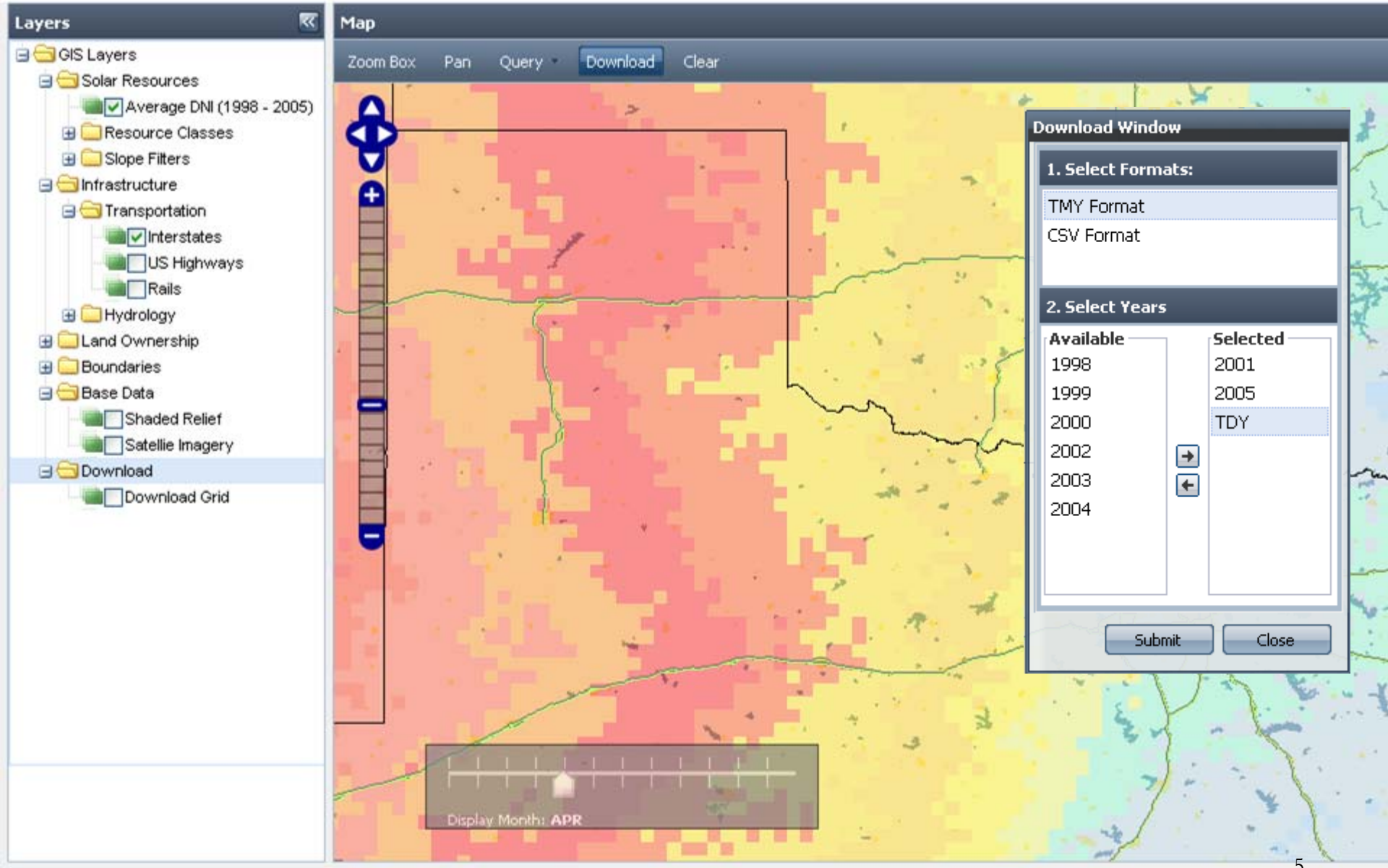
Other anecdotal examples of SAM use:

- Clean Energy Advocates
  - Encouraging NJ Clean Energy Program to adopt as standard.
- Alcoa
  - using SAM to investigate costs and finance options for CSP.
- Arizona Public Service
  - evaluate CSP and PV – want to use own weather data
- Federal Energy Management Program (FEMP)
  - Using SAM for feasibility of PV and CSP projects on federal lands
- PowerLight
  - using SAM's IPP financial analysis, apparently as a check on their internal calculations
- DOW
  - using the SAM model to validate various commercial installation options for roof mount, BIPV, and field mount PV systems around the world.

SAM Block Diagram

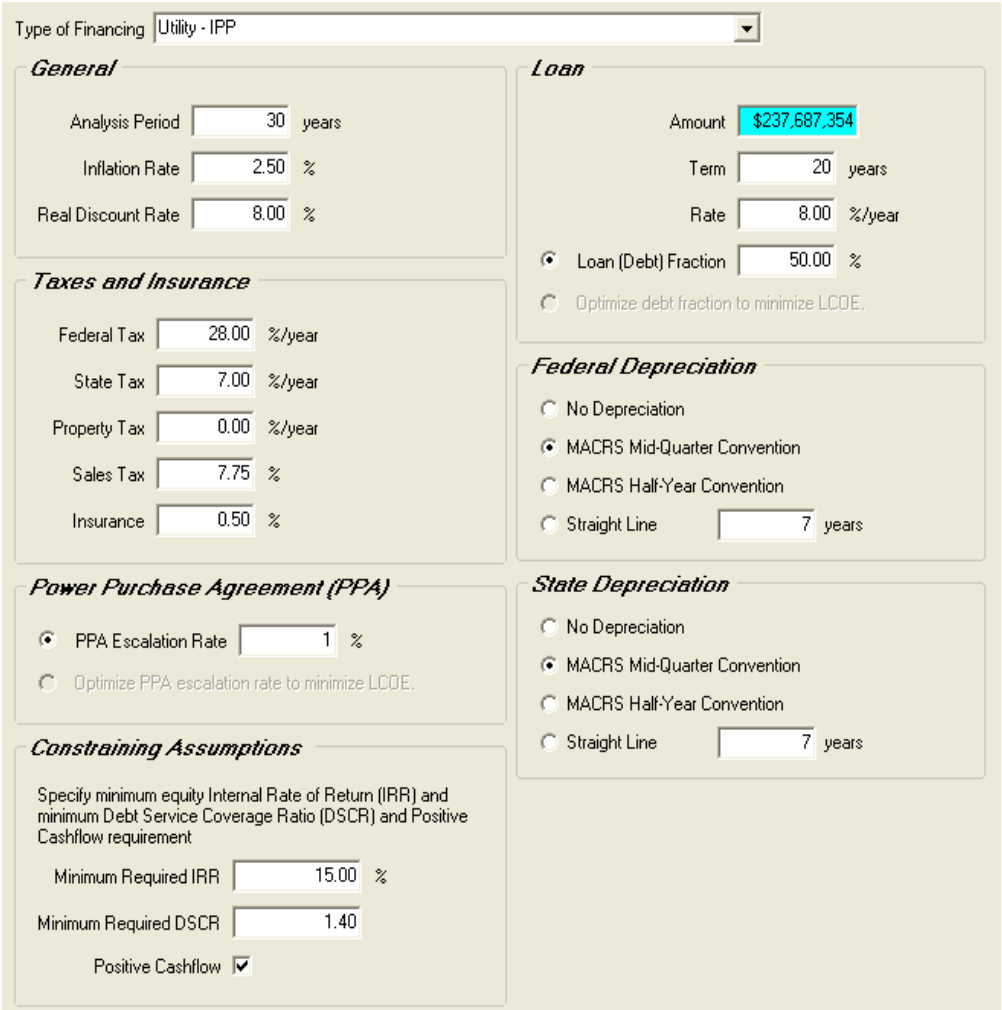


Download and use recent solar satellite data



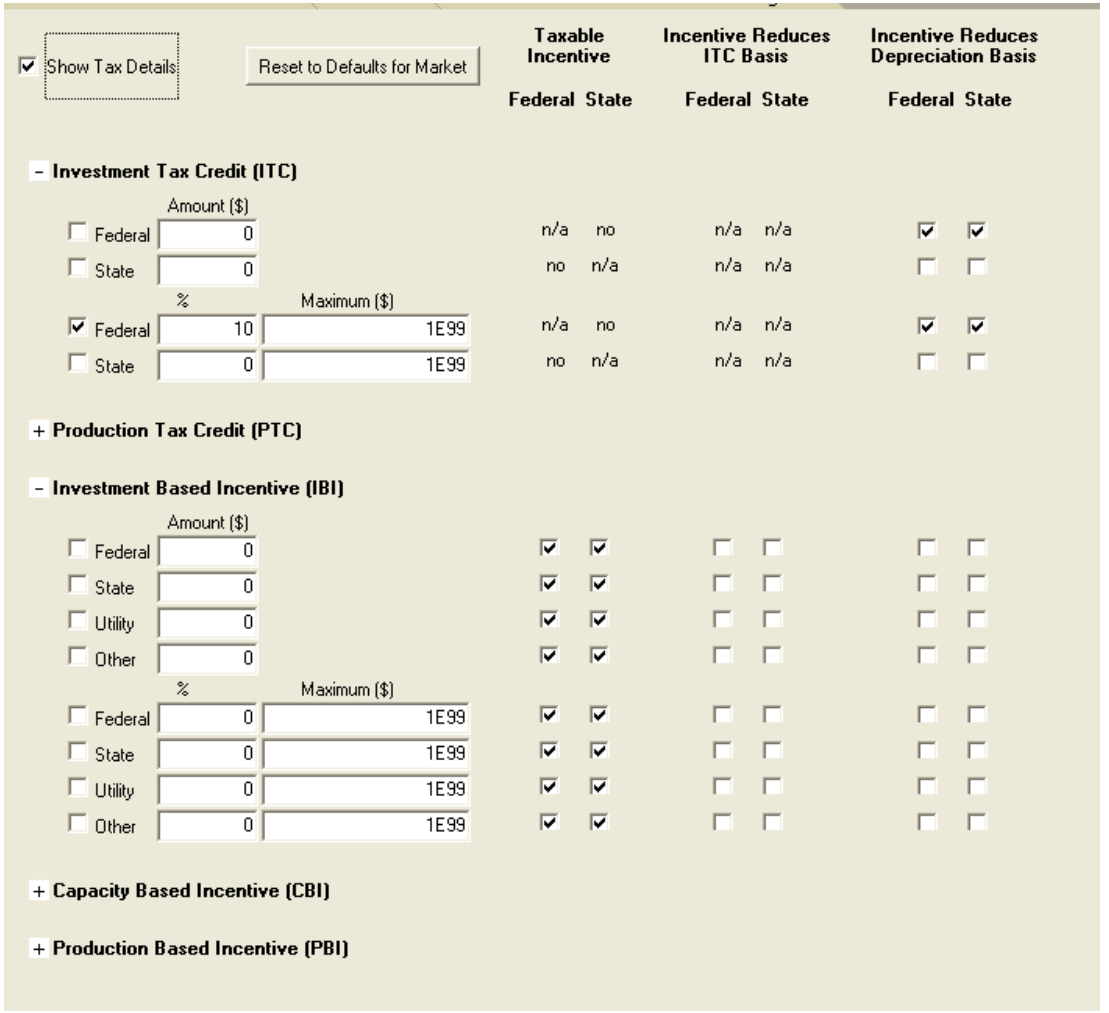
Finance Model

- Detailed Cashflow model
- Output
  - LCOE, NPV, IRR, Revenue, Taxes, etc.
- Residential
  - Cash, Loan or Mortgage
- Commercial
  - Cash, Loan or 3rd Party Owner
- Utility Scale
  - IPP (at right) or IOU



Financial Incentives

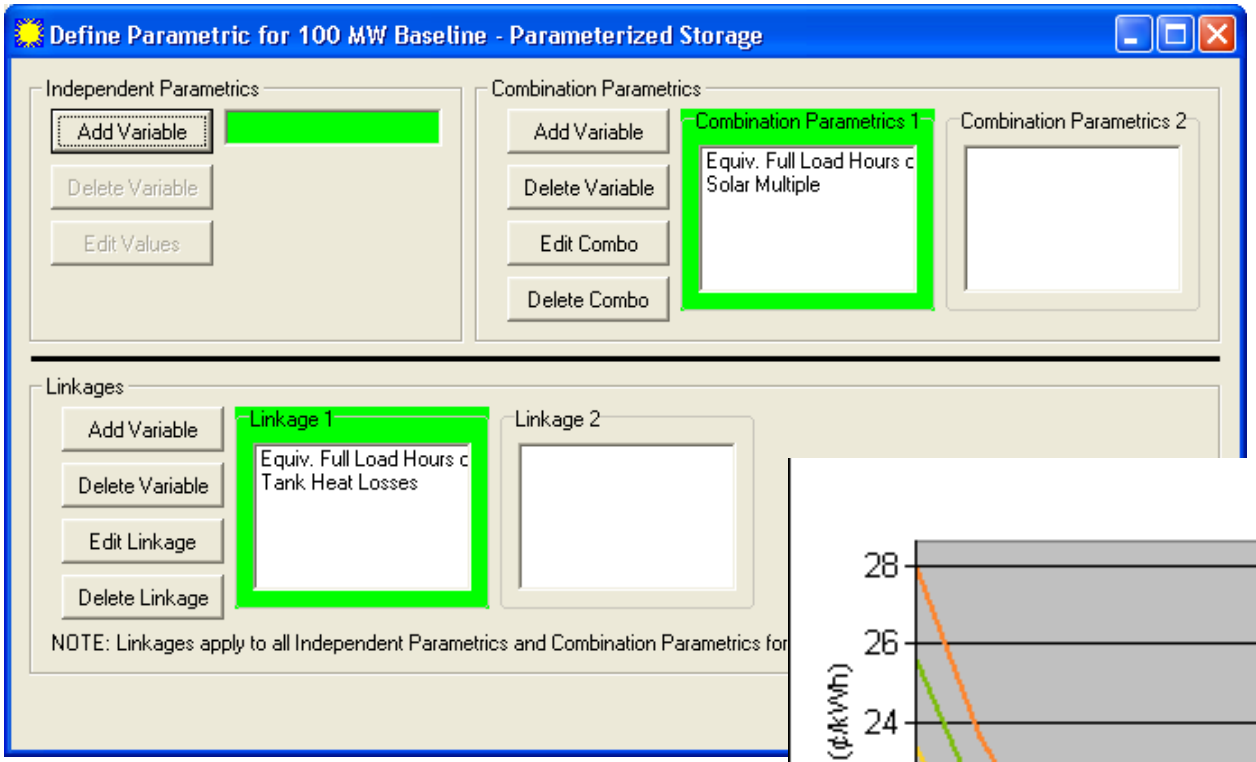
- Detailed Incentives available
- Separate possible entries
  - Federal
  - State
  - Utility
  - Other
- Variable Tax Implications
- Incentives
  - Tax Credits
    - Investment
    - Production
  - Investment Based Incentives (Buy-Downs)
  - Capacity Based Incentive
  - Production Based Incentive

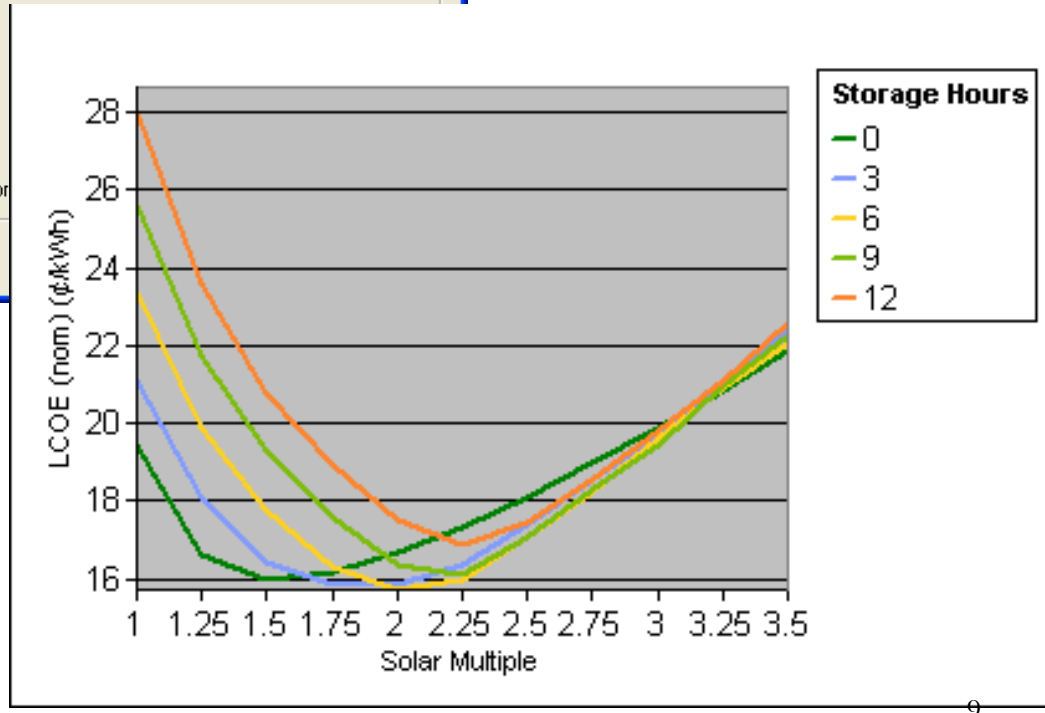


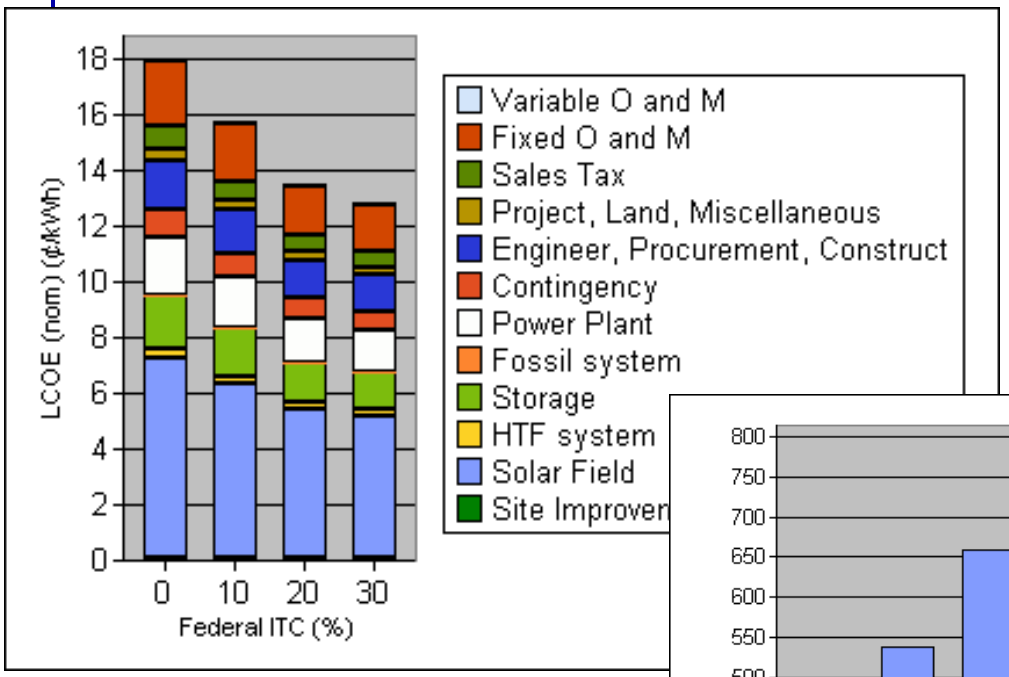
SAM Solar Performance Models

- PV Modules
  - Single-point efficiency with single temperature coefficient
  - Sandia PV Array Performance Model
  - CEC/Wisc 5-parameter model
- Inverters
  - Single-point efficiency inverter model
  - Sandia Inverter Performance Model
- CSP
  - Parabolic Trough (based on NREL's Excelergy model)
- Generic
  - Very simple capacity * capacity factor model for comparison with non-solar technologies
  - Able to run with externally calculated performance to take advantage of financing, incentives and parametric capabilities

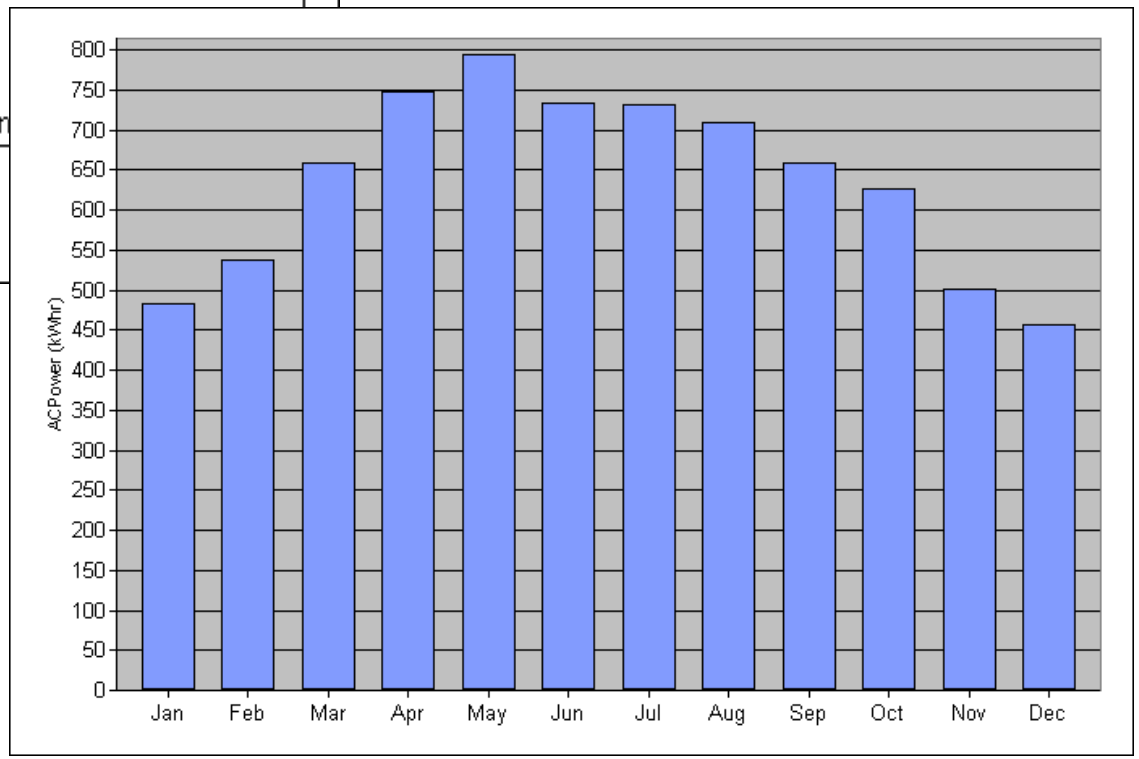
SAM Strength – Parametric Analyses





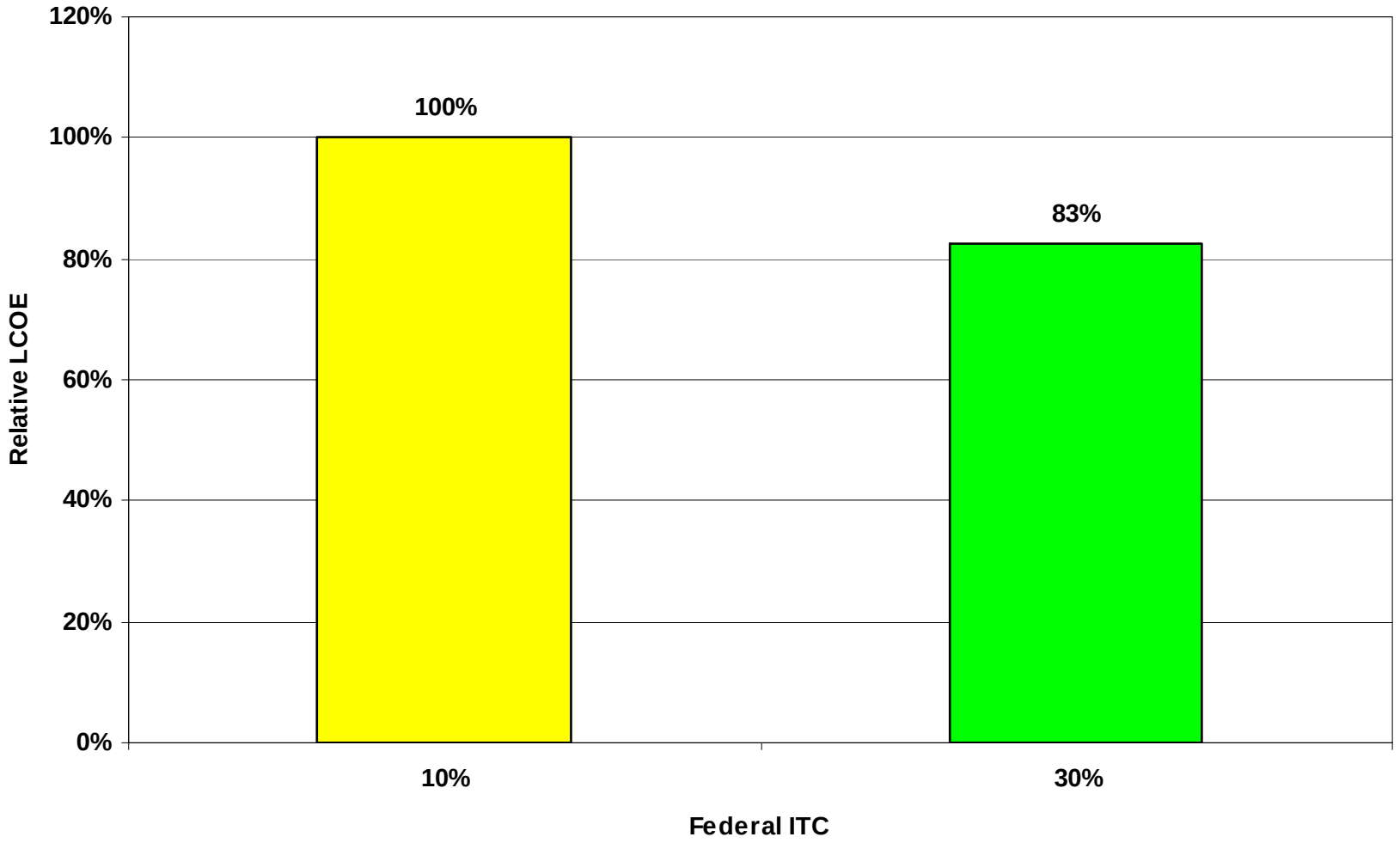


CSP System LCOE vs. Fed. ITC (%)

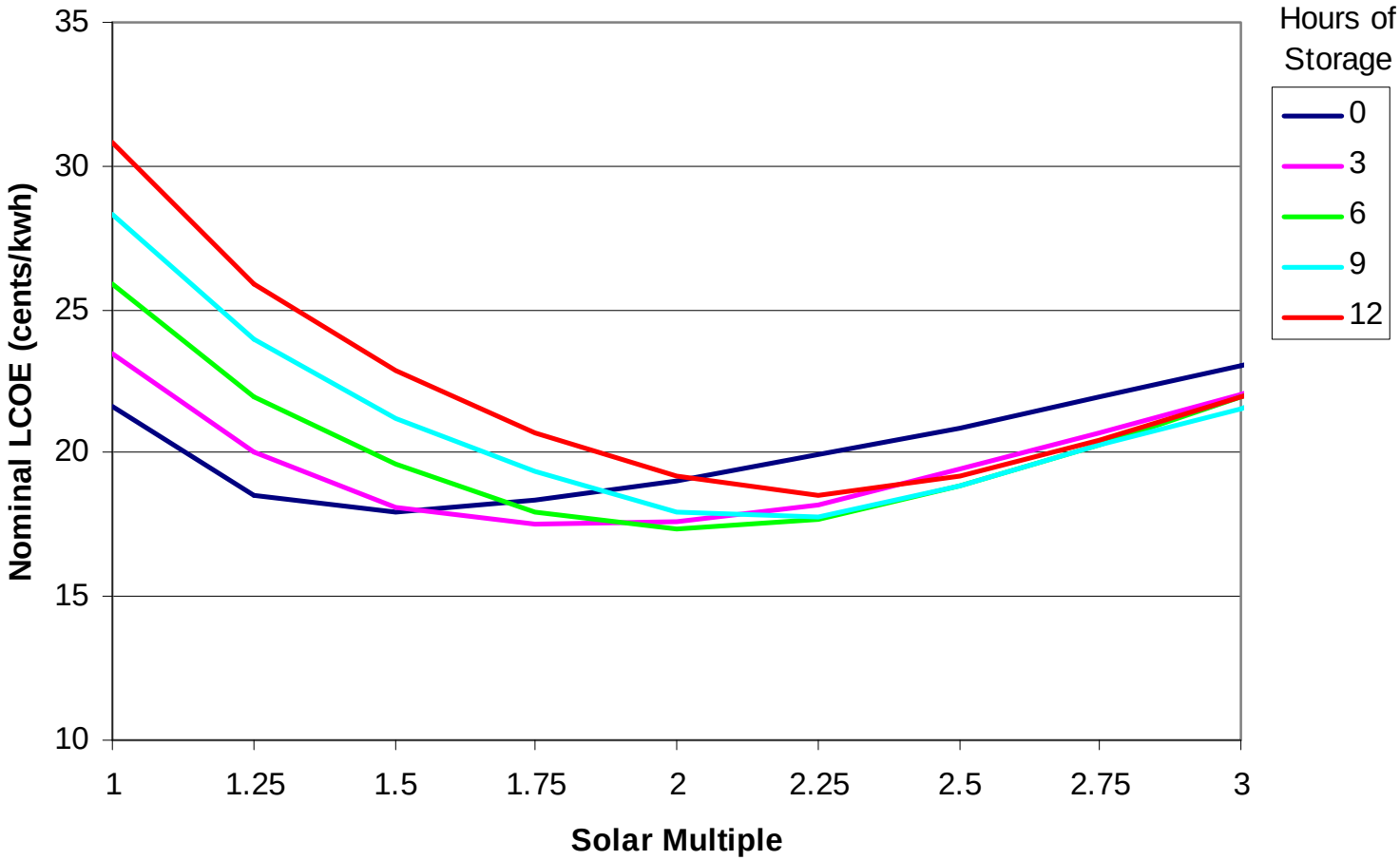


Monthly PV System Output

Policy Impacts
Federal Investment Tax Credit



CSP Plant & Storage Optimized to Minimize LCOE



- Solar Multiple is non-dimensional solar field term (1 = solar-only design point)
- 6-hours TES and solar multiple of 2.0 results in minimum LCOE

Project Update

	Planned Work Since Last Program Review	Expected date (mm/yy)
Past	Release SAM version with additional weather file type support	12/07
Past	User forum and user interactivity	2/08 (delayed to 5/08)
Past	Release SAM version with: •major update of user manual with perf model documentation •improved PV performance algorithms •capability of using latest CEC and Sandia module and inverter databases •detailed yearly O&M inputs (annual $, $/MW, $/MWh options)	4/08
Future	First Modeling Workshop Held concurrent with ASES	5/08
Future	Publish subcontractor report on financial model validation	6/08 (delayed to 7/08)
Future	Release SAM version with: •dish Stirling CSP models included •enhanced GUI and greater graphical output capability •time-of-use rates	8/08

Obstacle Discussion

- Keeping up with addition of new components and technologies
- Estimating PV derate factors
- Credible, current cost data for general users
- Difficulty in hiring junior staff member to help with coding and support of SAM as funded.
- Due to lack of hiring, programming support still main bottleneck
- Varying customer base (including lab analysts, DOE, industry developers, investors, …) and how to tailor the program to each