Echo™ Solar System Energy Modeling Using Department Of Energy Standard TRNSYS

This paper summarizes the key modeling tool and analytical approach used to accurately forecast the energy production of the **Echo™** solar system.

Modeling utilizes Department of Energy (DOE) standard TRNSYS software engine

All energy production forecasts are based on TRNSYS (TRaNsient SYstem Simulation Program). TRNSYS grew out of the work of the Solar Energy Laboratory, at the University of Wisconsin, which has been the premier center for solar energy research for well over three decades. TRNSYS has been used for more than 30 years for heating, ventilation, and air conditioning (HVAC) analysis and sizing, multi-zone airflow analyses, electric power simulation, solar design, building thermal performance, and analysis of home control schemes. It has been peer reviewed and cited in more than 100 academic articles. TRNSYS is maintained by TESS (Thermal Energy Systems Specialists) through an international collaboration with institutions in France, Germany and Sweden.

Other organizations that utilize TRNSYS include:

- DOE and National Renewable Energy Labs (NREL)
  - uses TRNSYS for all its solar systems models such as SAM (Solar Advisor Model),
- Solar Ratings and Certifications Corporation (SRCC)
  - uses TRNSYS for rating all solar systems
- California Solar Initiative (CSI)
  - uses TRNSYS for rebate calculations for both the PV and the upcoming thermal program

Additional details about TRNSYS are available at:
(http://apps1.eere.energy.gov/buildings/tools_directory/software.cfm/ID=58/pagename=alpha_list

Modeling utilizes 20 year averaged DOE databases and California Energy Commission PV module data
The modeling tool uses standard libraries from TRNSYS for modeling the performance of both the building and the solar energy system. The building is modeled as a Type 56, which is the standard building type. The PV system is modeled using Type 180, which uses the rated data from the CEC/CSI program for every module. The thermal models are based on data from the SRCC for the OG-100 ratings. Each location is modeled using a weather file. The weather files are developed by the Department of Energy and NOAA (National Oceanic and Atmospheric Administration), using 20 year weather averages as maintained by NOAA. Almost all locations in the US have weather files within 50 miles.

Accurate energy offset forecasts
To get an accurate representation of energy savings, the modeling tool compares two different houses simultaneously. In the base case, a home without an **Echo** solar system (or basic PV system) is modeled to establish a baseline. The solar system is then added to the same house to calculate the reduction in gas and electric use.

This methodology is much more rigorous and more accurate than most other modeling tools. *Most other modeling tools do not run a base case, and they must therefore extrapolate the energy generation to the reduction in home energy use.* While standard tools for PV system energy production use a straight derivation from incident energy to electrical energy production, solar thermal systems displace building energy use and as

a result, *models have to accurately account for not just energy use, but the time of energy use.* This requires recursive algorithms that cannot be easily modeled by hand or with spreadsheets. **Echo** solar system energy estimates are based on actual energy offsets, because what matters to the consumer is not how much energy was generated using the solar system, but how much less gas or electricity they consumed.

By utilizing TRNSYS coupled with simultaneous simulations run through we can accurately model energy savings for:

- Electrical production
- Water Heating
- Space Heating
- Space Cooling and Ventilation

Building energy compliance codes and modeling software

Residential building construction is regulated by most states and municipalities according to standards of construction as laid out in codes like the International Residential Code (IRC). One component of these codes deals with energy use in buildings. One code widely adopted in the US is the International Energy Conservation Code (IECC). Some states have more stringent state specific codes, such as California's Title 24. These codes lay out minimum requirements for building features such as insulation, and building devices such as air conditioners, all of which influence the energy used by the building to provide comfort.

A building energy compliance tool is designed to a specific code and is used to calculate building energy use using built-in algorithms. These tools are based on simulation engines like TRNSYS and DOE 2 (similar to TRNSYS), but contain artificial "constraints" which 1) limit choice of measures (e.g., minimum insulation for ducting) and 2) limit the way they are applied (e.g., thermostat set-points). All compliance tools compare the building "as designed" with a "base case" building as defined in the code. Examples of building compliance software tools include MicroPAS and EnergyPro for compliance with California Title 24 and REM/Rate and EnergyGauge for compliance with IECC (used in about 35 states).

HERS ratings vs. TRNSYS

A HERS rating is a rating of building's energy efficiency on a scale of 0 to 100. A score of 100 represents a base building as defined by the prevailing version of the IECC energy code in the state. A score of 0 represents a net zero energy building. Most green building codes use the HERS rating to provide credits and incentives.

The TRNSYS tool is a more comprehensive simulation of a building's energy performance which includes the effects of solar home cooling, more accurately models home heating, and more accurately represents projected building energy consumption. A HERS rating is based only on the energy efficiency and generation features that are already a part of the prevailing code and thus it does not include **Echo** solar system specific features like space cooling nor does it accurately model waste heat recovery. Even the models of solar collectors for HERS ratings as set in REM/Rate are generic. This means that all solar thermal collectors are treated as being the same and differences between individual products or models are not recognized. As a result, the reduction in HERS rating using a **Echo** solar system will always be less than the actual reduction in energy use, particularly so in predominantly cooling climates.