Solar Solutions

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Solar heating design – computer software

I had the opportunity to attend the annual tradeshow of the Radiant Panel Association (RPA) a few weeks ago and sat in on the "Solar Heating" panel discussion. Based on the depth of knowledge of the people in that room, I would say that these were some of the most experienced solar heating "die-hards" around. When they were asked what solar heating design software they were using, the list was surprisingly short. RETScreen, T*SOL, Polysun and F-Chart were mentioned by satisfied users.

There is no substitute for thorough design analysis and computer software. The solar energy resource can change radically from day to day, month to month and from one location to another, so to accomplish a thorough analysis, the designer must have at least the monthly (if not hourly or daily) solar data for many different locations easily available and in a useful format. This is the essence of what these computer programs provide.

When running design software on the computer, you can evaluate how useful the program is by judging how quickly and/or thoroughly it provides the answers to the following basic design questions:

1. What is the monthly heating load?
2. How much solar energy is available for collectors at a suitable tilt and orientation?
3. How much solar heat is delivered and how much fuel is offset as a result?
4. How do the costs and benefits compare to other alternative design options?

All of the software we are discussing here provides answers to these questions to a greater or lesser degree. Some of the software mentioned here is free and the rest are available as trial or demonstration versions. So, there is no downside to exploring these programs on your own computer as time allows.

Weather data for computer-aided solar design

The most basic computer-aided design tool is the spreadsheet. I use weather data in spreadsheet calculations regularly as a quick way of processing 12 months worth of solar radiation and temperature data for fast comparisons. In this column a couple months ago I showed some sample graphs created on spreadsheets and mentioned that a good resource for this kind of climate data is the National Renewable Energy Laboratory (NREL) website. Their "Solar Radiation Data Manual for Flat-Plate and Concentrating Collectors" contains a summary for each of 239 locations across the U.S. can be obtained free on the Web at http://rredc.nrel.gov/solar/pubs/redbook/ in PDF format as well as ASCII Data Files (comma delimited) that can be copied into spreadsheets.

I suspect that the reason this data manual is now out of print and available only on the Web, is because the world of energy calculations is turning toward software-compatible digital data files. NREL is also a leading provider of such data files which are available as TMY (Typical Meteorological Year) and now EPW (Energy Plus Weather) and other standard formats. There are now thousands of locations where weather files are available in these formats. These are the kind of weather files used by RETScreen and the other programs as inputs to their energy calculations for any of these locations around the world.

If you are wondering what is included in these weather data files, I would like to encourage you to peek inside and see for yourself. One easy way to do this is using the (free) Climate Consultant weather data visualization program. It can be downloaded from the UCLA Energy Design Tools Web page:

http://www2.aud.ucla.edu/energy-design-tools/.

There is a version for Mac OSX and a version for MS Windows. This program allows you to display the contents of EPW files which are available (free) from the EnergyPlus website:

http://apps1.eere.energy.gov/buildings/energyplus/.

Using this program you can easily inspect the latitude, longitude, elevation, Global horizontal and Direct Normal solar radiation, air temperature, dew point, ground temperature, wind speed, sun path, sun hours, and a multitude of other climate variables for over two thousand locations, based entirely on historical weather records. You can choose imperial or metric units to be displayed.

Popular Low-Cost Solar Hot Water Heating Modeling Software

Software	Source	Cost	Platform	Units
F-chart	F-Chart Software Univ. Wisconsin	$400	MSWindows	Imperial or Metric
Polysun5 Light	Vela Solaris	$159	MSWindows MAC OSX	Imperial or Metric
RetScreen	Natural Resources Canada	Free	MS Excel Spreadsheet	Imperial or Metric
SAM	NREL Solar Advisor Model	Free	MSWindows MAC OSX	Metric
T*Sol Express	Valentin Software	$195	MSWindows	Imperial or Metric
CombiSun	European Solar Combisystem Project	Free	MSWindows	Metric

Table 1

Of course, for solar heating design, what you really want is the Solar Climate Data converted into Solar Available on any tilted collector surface and energy col-

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lected day by day or even hour by hour. That capability is built into these solar design software packages using some pretty sophisticated solar radiation conversion routines (e.g. Perez, Hay & Davies, Reindl, etc.). The accuracy of solar conversion routines as well as the solar collector efficiency routines and other calculations would be hard to duplicate on a DIY spreadsheet, which is why the new software, especially the low cost and free versions are so attractive.

A brief sample of popular solar heating software

Let's start by looking at the tip of the software iceberg by focusing on programs that are lower in cost or free, and start with solar hot water analysis. Some programs that cover solar hot water also cross-over into solar combisystems, but not all of them.

Starting with the four programs acclaimed at the RPA solar panel discussion, I have assembled a quick comparison in Table 1 with my own additions of SAM and CombiSun.

F-chart

F-chart is the authoritative solar system analysis and design program written by S.A. Klein and W.A. Beckman, the originators of the F-Chart method developed at the University of Wisconsin. It has provided a high standard in solar heating analysis in the United States for decades. Its capabilities go well beyond solar water heating, and include the flexibility to handle passive solar collectors, pool heating, rock bins and thermal mass in buildings. It comes with 300 weather data locations and more are available. Results are output as monthly tables or line graphs. Life-cycle economics with cash flow are included.

Polysun 5

Polysun comes in three flavors — Light, Professional and Designer, with prices ranging from $159 to $1499. It provides eye-popping graphics that make impressive sales presentations. SRCC collector data is built-in, eliminating manual data entry of collector efficiency parameters. It allows a large customizable component catalog and includes built-in weather data using Meteotest. It is especially good for solar thermal simulation going well beyond solar water heaters, including grid tie PV and heat pump simulation. Outputs include solar fraction, hourly energy usage for system and components, economic analysis.

RETScreen

Software for evaluating energy production and savings, costs, emission reductions, financial viability and risk for various types of renewable energy and energy efficient technologies (RETs). Inputs are in spreadsheet format and vary with the type of project. Product data is included in software as well as climate data, with over 4,000 weather locations available. Default and suggested values for all inputs via manual or project database. This software's capabilities include renewable energy projects, cogeneration and district energy, plus a full array of financially viable clean power, heating and cooling technologies, and energy efficiency measures. All outputs are in Excel and can be copied, printed or saved to PDF format.

SAM

NREL, working in conjunction with Sandia National Laboratory and in partnership with the U.S. Department of Energy (DOE) Solar Energy Technologies Program (SETP), developed the Solar Advisor Model (SAM) starting in 2004 with ongoing efforts today. SAM combines a detailed performance model with several types of financing (from residential to utility-scale) for most solar technologies. The solar technologies currently represented in SAM (besides solar hot water) include concentrating solar power (CSP) parabolic trough, dish-Stirling, and power tower systems, as well as flat plate and concentrating photovoltaic technologies. It has a deceptively friendly user screen that tends to mask the impressive simulation engines under the hood.

T*SOL

T*SOL comes in 3 flavors — Express, Professional and Expert, ranging in cost from $197 to $1581. It is intended for the planning, analysis and simulation of thermal solar heating systems. It is a professional tool for planners, engineers, energy specialists, and educational purposes. A large number of solar water heating systems, including space heating, can be modeled under varying parameters, with the results (temperature, energies, efficiencies and solar fraction) easily saved to file and presented in graph or chart form. Two extra modules are available in addition to the main program: the Swimming Pool module and the SysCat module for large-scale systems. Outputs include pre-formatted reports in graph and chart form, economic efficiency calculations. It is also possible for the user to define custom report formats and also features some stunning color graphics.

CombiSun

CombiSun is a PC tool for performance estimation of solar combisystems. It can estimate the performance of a number of different combisystem designs, under different climates and different loads. It is intended to be quick and simple design tool for architects, planners and engineers, and was developed within the framework of a European task force on Solar Combisystems (IEA-SHC Task 26 and EU Altener Project AL/297). It uses TRNSYS to calculate the load as well as the radiation on a collector for a given house and climate. This data is then used together with the thermal characteristics of the chosen solar combisystem to calculate the final energy savings compared to a reference, non-solar, heating system supplying the same load. It requires the user to be familiar with the generic types of combisystems catalogued by the taskforce which are available in supporting documents. Presently it seems to be limited to locations only in Europe.

Under the tip of the iceberg

The software described above is only the tip of the ice-

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berg when it comes to energy simulation tools for computers. A plethora of Energy Calculators and Software are listed by the U.S. Department of Energy on their Energy Efficiency and Renewable Energy website at: http://www.eere.energy.gov/.

Most of the programs discussed above are described in much greater detail on this website along with a huge collection of others too numerous to mention here. There are more than 60 programs that do "Whole Building" energy modeling that are reported to include Renewable Energy in the analysis. Many of these simulation programs include a solar water heater component. Some include passive solar heating, some allow active solar heating (combisystems), PV electric, natural lighting and many other energy efficiency measures. The one that I have used the most in the past is Energy-10, but lately, Energy Plus seems to be leading the way in the building energy simulation world and seems to include many more modeling capabilities (although it is much more difficult to learn). The direction that the best programs seem to going, is making the inputs easier and more graphical. For example, Energy Plus now has a new "front end" called OpenStudio that allows the user to describe the building by drawing it in Google Sketch-up. Energy Plus, Openstudio and Sketch-up are free so if you have the time, give them a try.

Brand names, organizations, suppliers and manufacturers are mentioned in these articles only to provide examples for illustration and discussion and do not constitute any recommendation or endorsement. ■

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In this series of articles, I have been making the case that the key ingredients for solar/hydronic design and installation can be divided into six categories, listed below, roughly in order of their importance.

1. RELIABILITY
2. EFFECTIVENESS
3. COMPATIBILITY
4. ELEGANCE
5. SERVICEABILITY
6. EFFICIENCY

The success of any solar hydronic home heating installation depends on the often-conflicting balance between any of these six principles. Finding the balance between them defines the art of solar heating design.