Solar Solutions

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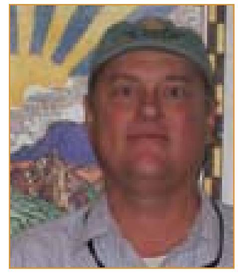


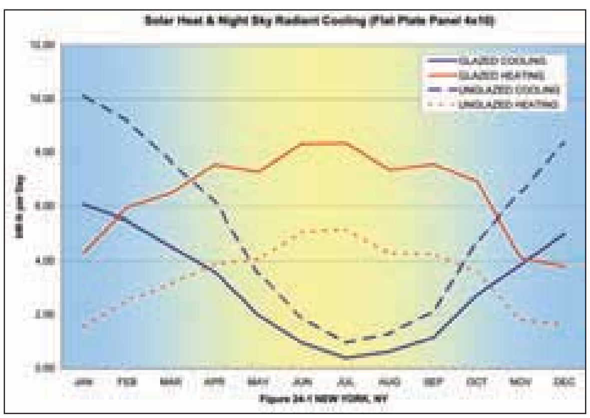
Flat plate collectors – heating vs. cooling by climate

Last month I introduced some of the computer software available to model and analyze solar heating installations in virtually any climate. Using this type of software with its detailed weather data and the ability to export data to supplementary spreadsheets allows the solar heating designer to answer questions and visualize the range of performance like never before. Let me show you what I mean with a practical example.

In the past few months, an increasing number of people have been asking me about using flat plate solar thermal panels for both daytime solar heating and night time radiant cooling. The inevitable design questions come up in nearly every project:

1. Can I use unglazed panels for both heating and cooling all year round?
2. How much better will the glazed panels perform in winter compared to unglazed?
3. If I use glazed panels only, is it worth while to run them at night for summer cooling?
4. How much solar heat and how much night cooling will each type of panel provide?

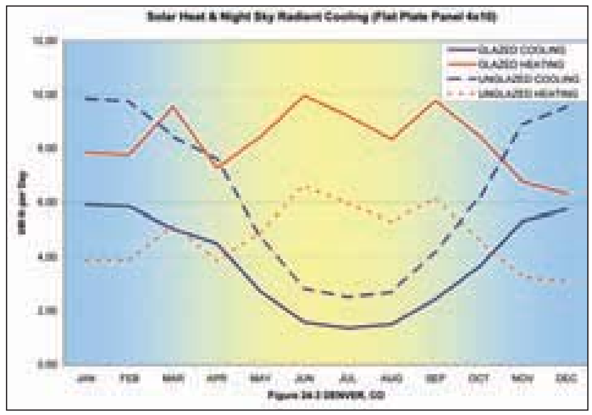
Of course the answers to these questions depend entirely on the climate at each different project, since solar heat



production and radiant cooling availability are driven entirely by local weather and temperature patterns. Since the solar heating computer models give virtually instant access to thousands of climate locations, this seems like an ideal way to answer these questions quickly and thoroughly.

Modeling the temps and solar heat available with SAM

I decided to try the free solar design program from NREL called SAM (Solar Adviser Model). This software allows the user to enter the collector efficiency ratings (available from the SRCC tests) and then calculates the solar heat output hour by hour using TMY or EPW weather data. A built-in routine called Data View (DView) allows you to graph the weather data and the simulation results hourly, daily or monthly. Once you see a graph you like, you can right click on the graph, and a menu allows you to export the data seen on that graph into a text file that is



compatible with the Excel spreadsheet.

My goal was to compare data from various collectors in various climates on a month by month basis. SAM allows the user to keep the same collector configuration and instantly change climates, so building a spreadsheet using several different collectors in a number of different climates proved to be a rapid process.

My method was to enter one glazed collector and one unglazed panel of the same size into the program at a fixed tilt and orientation. Then change the climate location and plot the results on a graph using Excel. Since SAM does not include the capability to analyze Night Sky Radiant Cooling (NSRC), I plan to use the climate data provided by SAM and some additional spreadsheet calculations to accomplish that.

The following conditions were assumed in these collector simulation models:

Panel Size — 4x 10 , 40 ft2, (3.7 m2)

Tilt – 45 degrees

Orientation — South (within 5 degrees)

Net heating & cooling energy will be used (pump energy is deducted)

Solar heating temperatures are assumed to be within the normal DHW range.

Comfort cooling for mass floors uses 75F fluid provided to the cooling panel.

Glazed panels use selective surface black absorbers with single glass.

Unglazed panels are black plastic non-selective rectangular tube plates.

Estimating NSRC using the "Dew Point Method"

The dew point method for estimating NSRC heat loss

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rates is based on an original study that I completed in 2006 along with co-researchers Mark Chalom and Kate Snyder

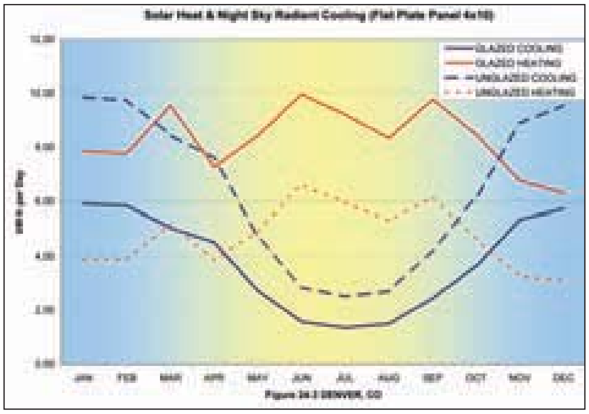

Figure 24-2 DENVER, CO

and support from the State of New Mexico. One of the findings from this study was that the following formula (Equation 24-1) provides a reasonably simple way of estimating the cooling potential for NSRC in various climates using Dew Point and Air Temperature.

$Q=U*A*[Tin-(Tdew+(Tair-Tdew)/2)]$ {Equation 24-1}

The terms in Equation 24-1 are defined as follows:

Q - Btu/hr - Heat Loss (Cooling) available per Hour from a radiator plate
(Multiply times 10 hours for typical Heat Loss per Night.)
(Divide by 3413 to convert to Heat Loss per night in units of kilo-Watt Hours.)

U - Btu/hr-ft2-°F - Heat Loss Coefficient for a collec tor/radiator panel.
(Determined by the author by field measurement.)
e.g. glazed=1.22, unglazed = 1.98
(The most common radiator plates typically fit into a range from 1 to 2. Radiator plates with glazing, selec tive surfaces, widely spaced tubing and poor thermal contact between the fluid and the plate surface will have lower values. Plates that are 'fully wetted', closely spaced tubes, no selective surface and good thermal contact between the fluid and the surface will have higher values.)
A - ft2 - Area of the cooling panel. e.g. 40 ft2
Tin - °F ¬- Fluid inlet temperature entering the panel e.g. 75F for direct floor cooling. Higher temperatures for cooling jobs.
Tair -°F - Ambient (dry bulb) outdoor air temperature.
Tdew -°F - Dew Point outdoor air temperature.

Using the temperatures provided by SAM, (Tair and Tdew), this equation can be used to estimate the cooling available very quickly using a spreadsheet.

Annual heating and cooling graphs

The results of this series of computer models are shown in the graphs, Figure 24-1 through Figure 24-4. Four sample climate locations are shown month by month with the solar heat available and the NSRC cooling potential for both a glazed and an unglazed collector panel. With these results, we can begin to answer the questions posed at the top of this article for each of these climate locations.

Looking at these graphs, we can observe some interesting general trends, some obvious some not so obvious.

- Glazed panels tend to produce twice as much heat as unglazed panels.
- Unglazed panels tend to produce twice as much cooling as glazed panels.
- Unglazed panels don't heat very well in winter in climates like New York.
- Unglazed panels heat surprisingly consistently in climates like LA and Miami.
- NSRC cooling is an energy resource that mirrors the solar heating resource.
- NSRC comfort cooling does not work in high humidity (like Miami in summer).
- A couple of panels may be enough to cool a single room in drier climates.
- Plenty of 'free' cooling is available through the year in the non-summer months.

Keep in mind that these graphs were constructed for home heating and cooling applications were comfort cooling fluid from hydronic floors is typically around 75F.

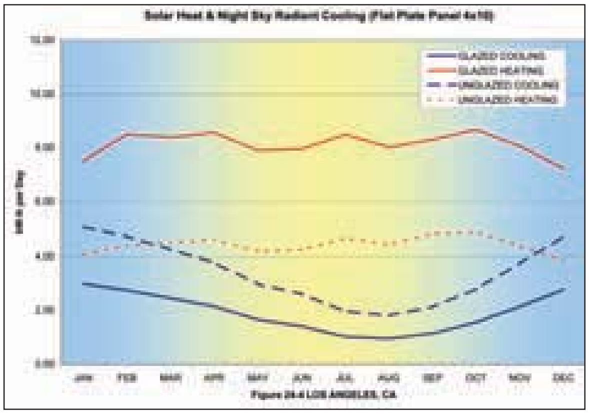

Figure 24-4 LOS ANGELES, CA

Much more radiant cooling can be accomplished at higher fluid temperatures. So for example, if some process required cooling fluid at 100F, twice as much NSRC heat loss can be achieved at this higher temperature. For commercial buildings and industrial processes, NSRC cooling even in winter is not such a crazy idea.

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. Calculations and estimates are for example only, and not for intended for any particular design application. ■

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