Flat Plate Collector - Yearly Energy

And cost savings

To determine the amount of energy produced by a single Solavis Collector we should know the average collector efficiency over the whole year. This can be calculated using a standard formula. However, to use this formula we are required to know the following:

- Insolation Level
- Collector Size
- Average Cold water temperature
- Average Ambient air temperature
- Average Collector Manifold temperature

MELBOURNE:

Insolation Level:

Maximum and Minimum insolation levels as well as the annual average value can be obtained either from the Bureau of Meteorology (BOM) website* or from the NASA Surface meteorology website.

The Average Insolation (10 year average) given for Melbourne (averaged over the full year) is 4.34 kWh/m^2/day

Also from the BOM website we see that the mean daily sunshine hours** averaged over the full year is 6 hours. Dividing the average insolation level by the number of sunshine hours would suggest that Melbourne would receive an average of 723 Watts/m^2 of insulation averaged across the full year.

Average Cold water temperature: 15 ^{o}C*

Average Ambient air temperature:

Solar collectors work during sunshine hours, where temperatures are higher than those at night. For this reason the average air temperature should not include temperature readings from times outside the normal operating conditions of the panel. In this case the average annual ambient temperature at 3pm was used. This is 18.8 ^{o}C*

Collector Size:

In this case it is important to use the collector absorber area; the area in which solar gain can be converted to heat energy. The absorber area of each Solavis FP collector is $1.76m^2$

Average Manifold temperature:

The average manifold temperature is the same as the average annual water temperature flowing through the collector outlet port after heating. A figure of 50 °C is used as a realistic estimate. The difference between the manifold temperature and the ambient temperature is a major factor in determining the heat lost from the collector to the outside, and therefore the efficiency of the collector.

Collector Efficiency – Average over full year:

Solar water heater performance is often presented in an efficiency chart, constructed from a set of three performance variables. Also, using these variables we can calculate the solar conversion efficiency of a panel at a specific point in time and a set of environmental conditions.

The Three performance variables for the Solavis FP collector were discovered in the course of ‘Keymark’ compliance testing in Europe, and are as follows:

Conversion Factor: $\eta 0 = 0.787$
Loss Coefficient: a1 = 5 $W/(m^2K)$
Loss Coefficient: a2 = 0.001 $W/(m^2K^2)$

We plug these values into the standard efficiency formula:

$$\eta(x) = \eta 0 - a1 \text{ x } (X) - a2 \text{ x } G \text{ x } (X)^2$$

Where:
X = *(Tm – Ta)/G*
Tm = Manifold Temperature
Ta = Ambient Temperature
G = Insolation Level in $Watts/m^2$

As calculated earlier, the average annual insolation level is 723 $Watts/m^2$

Therefore:

$$X = (50-18.8)/723$$

$$X = .04315$$

Plugging 'X' into the main equation:

$$\eta(x) = 0.787 – (5 \times .04315) – (.001 \times 723 \times .04315^2)$$

$$\boldsymbol{\eta(x) = 56.9\%}$$

This means that over a year, ***56.9***% of the total energy provided by the sun can be converted to heat energy.

Energy Savings – Average over full year:

To work out the energy output of the collector over one year we need to know:

Average insolation - 4.34 kWh/m2/day
Absorber surface area - 1.76m2
Average efficiency - 56.9%

Each day, a single Solavis FP collector will collect:

Irradiance x collector surface area

4.34kwh x 1.76

= 7.64kWh

Multiplying this value by the average collection effectiveness gives us:

7.64kWh x 56.9

= 4.34 Kwh of energy produced by a single collector each day.

Over the year, one collector will collect **1547.26 kWh** of energy. This will offset the energy previously required from your gas or electric heater.

Assuming the Solavis panel offsets energy previously required by an electric heater, taking an average cost of $.15 per kWh, a single collector can save you **$232** in electric heating bills in Melbourne conditions.

BRISBANE:

Using the same method as described above it was calculated that for Brisbane a single Solavis panel will produce 7.75kWh per day, or 2829kWh per year. Again, using a cost of $0.15 per kWh, a single collector can save **$424** in electric heating bills in Brisbane.

If you currently use gas rather than electricity for your hot water heating, it is still possible to calculate your savings. You need to convert energy savings from kWh to Megajoules and divide by the cost per unit of energy supplied by your gas heater.

Note:

1. *Isolation levels may fluctuate with intermittent cloud cover. More accurate calculations can be derived with a more complete set of environmental data. Ideally performance calculations should be taken hourly throughout the day.*
2. *Energy outputs are approximations and actual energy output and efficiency will depend on many factors including system configurations, installation, orientation of panels and more.*
3. *The values above do not take into account system loses including loses through piping; we must remember that insulation is not 100% efficient.*
4. *Calculations do not take into account costs to run a pump in a split system. This can be nullified with the use of a PV powered pump.*

** Data transcribed from the Bureau of Meteorology webpage at the following link:*
http://www.bom.gov.au/climate/averages/

** Mean daily sunshine (h): *Average number of hours of bright sunshine each day in a calendar month or year, calculated over the period of record. Hours of bright sunshine is measured from midnight to midnight. Within the Bureau of Meteorology network bright sunshine has generally been recorded with a Campbell-Stokes recorder. This device only measures the duration of* “bright” *sunshine, which is less than the amount of* “visible” *sunshine. For example, sunshine immediately after sunrise and just before sunset is visible, but would not be bright enough to register on the Campbell-Stokes recorder. (Courtesy of BOM webpage)*