# Specifiers: Solar Collector Efficiency

## From RVR

There are several factors which determine the heat output of a solar heating system. These include:

1. intensity of solar radiation
2. location and orientation of the collectors
3. aperture area of solar collectors
4. type of system to which it is connected (size of water heater etc)
5. efficiency of the solar collectors

There are large differences between the efficiency of different types of collector and different manufacturers. A further complication is that the efficiency of a collector varies with the temperature of the collectors, ambient air temperature and some other factors.

## The Efficiency Equation

The efficiency of a solar collector is simply the heat output produced divided by the solar energy incident on the collector.

It can be calculated using the following equation:

$$\%Eff = \eta_0 - a_1 \frac{(T_m - T_a)}{G_k} - a_2 \frac{(T_m - T_a)^2}{G_k}$$

**$\eta_0$ is the optical efficiency of the collector.** This is a measure of how good the collector is at absorbing solar energy. It is affected by the type of materials used in the construction of the collector, especially the glass and absorber material. The optical efficiency can be measured when there is no temperature difference between the collector and the ambient air temperature.

**$a_1$ (sometimes called $k_1$) is usually called the linear loss co-efficient.** It is similar to a U-value and is a measure of how much heat the collector loses (mainly by conduction) as it's temperature rises relative to the surrounding ambient air temperature. Units are $W/m^2K$.

**$a_2$ (sometimes called $k_2$ is usually called the quadratic loss co-efficient.** It is a measure of how much heat the collector loses (mainly by convection and radiation) as it's temperature rises relative to the surrounding ambient air temperature. This type of heat loss becomes more significant at higher absorber temperatures. Units are $W/m^2K$.

**$T_a$ is the surrounding ambient air temperature in °C.**

**$T_m$ is the mean temp of the collector in °C.**

**$G_k$ is the solar irradiation in $W/m^2$**

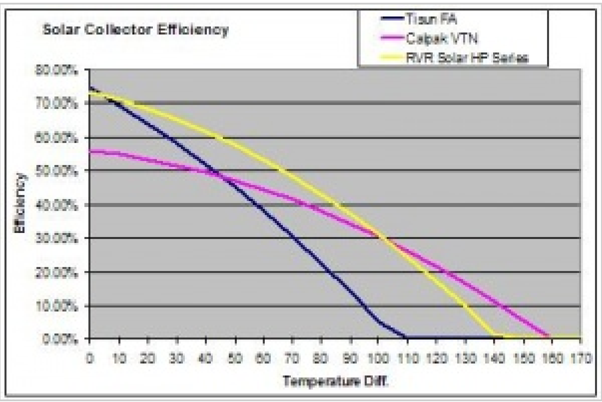
$\eta_0$, $a_1$ and $a_2$ are usually stated for the aperture area of the collector but may sometimes be stated for the gross area. When comparing collector efficiencies, it is important to ensure that the parameters for all collectors are stated for aperture area.

# Differences Between Collector Types

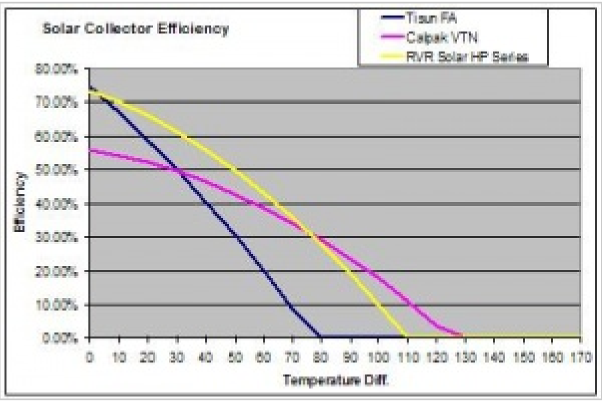
Flat panel collectors tend to have a higher optical efficiency than vacuum tube collectors. However, they also usually have higher heat losses i.e. $a_1$ and $a_2$ loss coefficients.

In practice, this means that flat panel collectors are excellent collectors of solar energy but are not as good as vacuum tube collectors at retaining the energy. Flat panel collectors will have very good summer performance when the high optical efficiency is an advantage. They will also perform well with low temperature systems which help minimise collector heat losses.

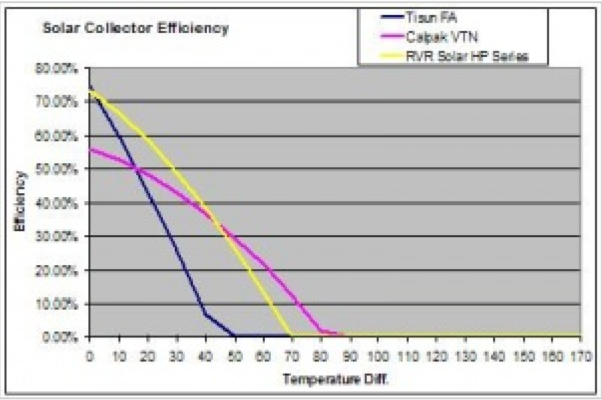
The curves below may be an aid to understanding the efficiencies of different types of collector under varying operating conditions.




Comparision of Solar Efficiencies at Gk = 750W/m$^2$




Comparision of Solar Efficiencies at Gk = 500W/m$^2$




Comparision of Solar Efficiencies at Gk = 250W/m$^2$

# Collector Advantages and Disadvantages

**Advantages of vacuum tube collectors**

- High efficiency even with large temperature difference between collector and surroundings.
- High efficiency with low solar radiation.
- Better for space heating applications.
- Suitable for generation of high temperatures.
- Easily transported due to low weight.

**Disadvantages**

- More expensive than flat plate collector.
- Cannot be used for in roof installations.
- Cannot be used for horizontal installation

# Thermal output of Solar Systems

The thermal output of a solar collector is;

Output = Aperture Area x Efficiency x Solar Irradiation

As the level of solar irradiation cannot be influenced, the key parameters affecting the thermal energy delivered by the solar collector are:

1. Aperture Area
2. $\eta_0$ - optical efficiency
3. $a_1$ - linear loss co-efficient
4. $a_2$ - quadratic loss co-efficient

These parameters will be listed on the Solar Keymark test report for the collector. Once these parameters are known, it is possible to compare different collector types.

**Care should be taken not to compare collectors based on gross area or 'number of tubes'. These may not reflect the true aperture area of the collector. e.g. vacuum tubes are available in several different diameters and lengths.**

Also, some collectors have reflectors which increase the aperture area significantly.

The parameters for solar collectors sold by RVR are listed in the table below:

| Collector | Gross Area | Aperture Area | $\eta_0$ | $a_1$ | $a_2$ |
|---|---|---|---|---|---|
| **RVR Solar HP20** | $3.267m^2$ | $1.861m^2$ | 0.734 | 1.529 | 0.0166 |
| **RVR Solar HP30** | $4.901m^2$ | $2.791m^2$ | 0.734 | 1.529 | 0.0166 |
| **Calpak VTN12** | $2.15m^2$ | $1.95m^2$ | 0.56 | 0.729 | 0.012 |
| **Tisun Flat Panel** | $2.55m^2$ | $2.35m^2$ | 0.744 | 3.59 | 0.016 |