



## Flat Plate Collectors v. Evacuated tubes – a brief overview

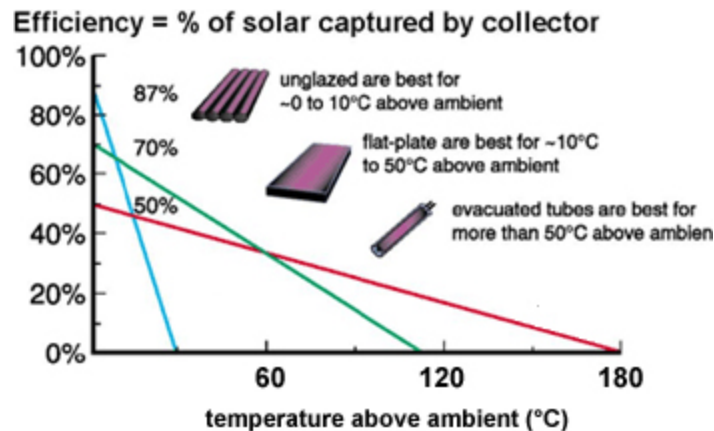
Since their conception, the evacuated tube collector has been commonly heralded around the solar industry as the more efficient collector. This idea has been perpetuated mainly by manufacturers of evacuated tube collectors, but unfortunately their claims are often not backed up by any scientific data or independent testing results.

Efficiency in hot water collectors is predominantly influenced by Newton's Law of cooling which states that a hot object transfers heat to its surroundings (cools) at a rate proportional to the difference in temperature between the two – with hotter objects cooling faster than colder objects, given the same surrounding temperature. Applying this theory to a solar collector, when the difference in temperature between the heated water within the collector and outside temperature (delta T) is large, heat losses will be proportionally larger than when the delta T is lower. In domestic water heating, these heat losses can be high and degrade the efficiency of a collector significantly. Cooling cannot be prevented, but it can be retarded by insulating the body, either by glazing the collector or utilising a vacuum such as in evacuated tubes.

For example, unglazed polymer collectors are used for swimming pool heating over glazed designs because a collector in this environment will often be operating under ambient temperatures. That is, it will only be required to heat the water up to air temperatures or slightly above. In these cases, when the temperature of the water is the same as the outside air temperature, there will be no heat loss – nullifying the need for insulation. Polymer collectors actually have a higher efficiency than both flat plate and evacuated tube collectors for the delta T range they are employed in. Introducing glazing in this case would actually decrease their efficiency as the layer of glass will reduce light transmission to the collector plate.

As our needs move up the temperature scale, heat losses to air become an important consideration. For domestic hot water applications, water at up to 30-40 °C above ambient is required, and even more demanding are the thermal requirements of certain commercial processes and space heating systems. In such systems insulating the solar collectors against heat losses is very important. Glazing in flat plate collectors achieves good results in the mid range of temperatures, while the vacuum present in evacuated tube collectors does indeed prove to be superior in systems where the ambient temperature is very low (very cold climates) or where it is necessary to heat the water significantly higher than normally required for domestic hot water requirements.

It is for this reason, being that each collector design has its own merits, that no collector has dominated the solar hot water market.



Source: Alternative energy store; [www.learn.altenergystore.com](http://www.learn.altenergystore.com)

### Notes on efficiency data:

When comparing efficiency data for different collectors it is important to check whether the efficiency stated is based on the collector total area, or the absorber area (area in which solar gain can be converted to heat energy). In the USA and Europe efficiency testing is mostly based on total collector area which is the space taken up on your roof. As we know, there is a significant area between the evacuated tubes which produces no energy, and drags down efficiency results.

Tests carried out on over 160 solar panels by the internationally acclaimed research organisation Solartechnik Prufung Forschung (SPF) found that in low to medium delta T conditions (temperature difference between the collector and air) evacuated tube collectors are actually less efficient than their flat plate cousins.

*"The average gross efficiency of the 120+ flat plate collectors tested was about 70%, while the average efficiency of the 42 models of evacuated tubes was only 49%. In terms of range, the flat plates varied from 51% to 79% while the evacuated tubes varied from 31% to 62%. All but five of the flat plate collectors tested had a gross efficiency greater than 60%."*

Source: <http://www.sustainability.ie/solar.html>

### Collector Efficiency and cost

Of course, efficiency is not the only characteristic that should be looked at when purchasing a solar collector. The durability of a collector and the price are also very important aspects to consider. Apart from feeling good about the positive environmental benefits, most people are mainly interested in the financial savings they get on the money invested in a collector. This is where price comes into play. A collector that is 10% more efficient but 50% more expensive makes very little economic sense. Maximizing economic return is more about getting more collectors for less money than getting highly efficient, but more expensive, collectors.

Often it is easy to compare the energy output of one collector to another. Data is freely available from both the SFP webpage and from The Solar Rating and Certification Corporation (SRCC)<sup>1</sup> webpage. However, sometimes it may be difficult to take into account the price variations for different collectors and compare them on their economic return. One method to do this is to compare the energy output for each dollar spent on different collectors. That is, how much energy in Megajoules per day a dollar will buy if spent on collector #1 compared to collector #2.

Below is a table offering a comparison between two popular retrofit kits available in Australia. The Apricus 30 tube collector costing \$1999 was compared to a Rheem two panel kit costing \$1470. Both prices are not inclusive of any rebates which might be available. Performance data for the two panels was sourced directly from testing results published in the Directory of SRCC Certified Solar Collector Ratings document\*\*. The Solar Rating and Certification Corporation (SRCC) is the most common and reliable source in the USA for independent information about solar collectors – testing not only for efficiency but also durability and reliability.

In Table 1.1 the cost-effectiveness between the two collectors was compared in a variety of climatic conditions; Warm climates with a 20°C Delta T, Cold climates with a 50°C Delta T and a category for very hot water requirements with an 80°C Delta T. Each category was further divided into the three main sunlight conditions; clear, partly cloudy and cloudy.

Calculations are quite simple. Take for example the Apricus collector on a clear day in a warm climate. In these conditions 23 Megajoules of energy is received from the sun per square metre of area. From this, the Apricus collector manages to produce 37 Megajoules of energy per day. The output per dollar spent is:

$$\begin{aligned} & \text{Energy produced / Price} \\ & 37 \text{ MJ} / \$1999 \\ & .0185 \text{ MJ per dollar spent} \end{aligned}$$

The higher the number of MJs (Megajoules) per dollar, the more cost-effective the collector is – all other things being equal. It is important to remember though that the design and quality of the rest of the hot water system are critical when considering overall system efficiency – not just the collector.

<b>Table 1.1 Warm Climate ( 20 Delta T)</b>								
Make and Model*	Size	Collector Cost*	Clear Day		Mildly Cloudy		Cloudy Day	
			23MJ/ m <sup>2</sup> .d Solar energy Produced		17MJ/ m <sup>2</sup> .d Solar energy Produced		11MJ/ m <sup>2</sup> .d Solar energy Produced	
			Energy output of panel	Output per Dollar spent	Energy output of panel	Output per Dollar spent	Energy output of panel	Output per Dollar spent
Apricus AP-30 Retrofit Evacuated Tube Collector Kit	4.053 m <sup>2</sup> Gross Collector Area	\$1999	37 MJ/panel/day Total = 37 MJ.D	<b>.0185 MJ / \$</b>	27 MJ/panel/day Total = 27 MJ.D	<b>.0135 MJ / \$</b>	17 MJ/panel/day Total = 17 MJ.D	<b>.0085 MJ / \$</b>
Rheem 2RTF Retrofit Flat Plate Collector Kit	1.98 m <sup>2</sup> x 2 panels in Kit = 3.96m <sup>2</sup> Gross collector Area	\$1470	24 MJ/panel/day X2 panels Total = 48 MJ.D	<b>.0326 MJ / \$</b> 76% more cost effective	17 MJ/panel/day X2 panels Total = 34 MJ.D	<b>.0231 MJ / \$</b> 71% more cost effective	9 MJ/panel/day X2 panels Total = 18 MJ.D	<b>.0122 MJ / \$</b> 44 % more cost effective
<b>Cold Climate ( 50 Delta T)</b>								
Make and Model	Size	Collector Cost	Clear Day		Mildly Cloudy		Cloudy Day	
			23MJ/ m <sup>2</sup> .d Solar energy Produced		17MJ/ m <sup>2</sup> .d Solar energy Produced		11MJ/ m <sup>2</sup> .d Solar energy Produced	
			Energy output of panel	Output per Dollar spent	Energy output of panel	Output per Dollar spent	Energy output of panel	Output per Dollar spent
Apricus AP-30 Retrofit Evacuated Tube Collector	4.053 m <sup>2</sup> Gross Collector Area	\$1999	32 MJ/panel/day Total = 32 MJ.D	<b>.016 MJ / \$</b>	22 MJ/panel/day Total =22 MJ.D	<b>.011 MJ / \$</b> 2 % more cost effective	12 MJ/panel/day Total = 12 MJ.D	<b>.006 MJ / \$</b> 222 % more cost effective
Rheem 2RTF retrofit Flat Plate Collector	1.98 m <sup>2</sup> x 2 panels in Kit = 3.96m <sup>2</sup> Gross collector Area	\$1470	15 MJ/panel/day X2 panels Total = 30 MJ.D	<b>.0204 MJ / \$</b> 26 % more cost effective	8 MJ/panel/day X2 panels Total = 16 MJ.D	<b>.0108 MJ / \$</b>	2 MJ/panel/day X2 panels Total = 4 MJ.D	<b>.0027 MJ / \$</b>
<b>Industrial applications/space heating (Very high 80 Delta T)</b>								
Make and Model	Size	Collector Cost	Clear Day		Mildly Cloudy		Cloudy Day	
			23MJ/ m <sup>2</sup> .d Solar energy Produced		17MJ/ m <sup>2</sup> .d Solar energy Produced		11MJ/ m <sup>2</sup> .d Solar energy Produced	
			Energy output of panel	Output per Dollar spent	Energy output of panel	Output per Dollar spent	Energy output of panel	Output per Dollar spent
Apricus AP-30 Retrofit Evacuated Tube Collector	4.053 m <sup>2</sup> Gross Collector Area	\$1999	27 MJ/panel/day Total = 27 MJ.D	<b>.0185 MJ / \$</b> 70 % more cost effective	17 MJ/panel/day Total = 17 MJ.D	<b>.0185 MJ / \$</b> 685 % more cost effective	8 MJ/panel/day Total = 8 MJ.D	<b>.0185 MJ / \$</b>
Rheem 2RTF retrofit Flat Plate Collector	1.98 m <sup>2</sup> x 2 panels in Kit = 3.96m <sup>2</sup> Gross collector Area	\$1470	8 MJ/panel/day X2 panels Total = 16 MJ.D	<b>.0109 MJ / \$</b>	2 MJ/panel/day X2 panels Total = 4 MJ.D	<b>.0027 MJ / \$</b>	N/A	N/A

We can see that for warm conditions, flat plate collectors are more cost effective in all sunlight conditions, up to 76% on clear days. In colder conditions Flat plates win out in clear skies, just about break even with evacuated tubes in mildly cloudy conditions, but are significantly less efficient in cloudy weather. For systems that require very a very high temperature rise evacuated tubes outperform flat plates in all conditions.

The final step is to determine which climate best describes your location. If you often have cloudy or overcast days, especially in winter, evacuated tubes might be worth considering. However to maximise cost-effectiveness evacuated tubes should only be chosen if they can offset the savings you give up by not using Flat plates in summer conditions. If winters are mostly sunny, flat plate collectors tend to be the most cost effective overall.

Some Flat plate systems do have frost protection using a frost dump valve as well as smart controllers which will circulate some hot water through the collector when it senses the water temperature approach freezing. This might work well where mild frosts are observed, but is not sufficient in locations prone to more severe frost or freezing conditions. In these conditions evacuated tubes provide an advantage in that they don't require a closed-loop system with glycerol to cope. This saves money in initial installation costs compared to Flat plate systems, as well as maintenance costs every few years.

\*Retrofit Kit model names and prices were sourced from the solar hot water section of the Sustainability Victoria webpage: [www.sv.sustainability.vic.gov.au](http://www.sv.sustainability.vic.gov.au)

\*\*Data using in the comparison was taken directly from the Directory of SRCC Certified Solar Collector Ratings document accessible on the SRCC webpage; [www.solar-rating.org](http://www.solar-rating.org)

\*\*\*Please note: Solavis does not guarantee the accuracy of these calculations and will not be held liable or responsible for any activities relating to their use or any inaccuracies present.