Evacuated Tube Collectors Compared with the Thermo Dynamics Liquid-Flat-Plate Collector

There are two competing technologies for solar domestic hot water systems – the evacuated tube collector (ETC) and the liquid flat plate (LFP) collector. The ETC consists of an absorber plate inside an evacuated glass tube. The evacuated glass tube reduces the heat loss from the absorber plate. The glass tubes are usually 50-75 mm in diameter. Typically, twenty to thirty tubes packaged together form a single solar collector. The LFP collector consists of a flat metal plate, typically 4' x 8', placed behind a sheet of glass in an aluminum frame. The solar heat absorbed by the plate is removed by a liquid that circulates within copper tubes attached to the absorber plate. The space between the absorber plate and glass cover is not evacuated, hence there are convective heat losses to the environment from the heated absorber plate.

There are claims that the ETC solar collectors are more efficient than the LFP collectors. This is true under certain conditions. At collector inlet temperatures above 45°C, and at low levels of solar radiation, the ETC is more efficient. However, the solar collector in a solar domestic hot water system only operates at 45°C when the solar storage tank is already hot. Furthermore, at low levels of solar radiation there is not much solar energy available, regardless of the efficiency of the solar collector.

To compare the two technologies, consider an ETC, the Apricus AP-30, and the Thermo Dynamics G32P LFP solar collector. The retail price of the Apricus AP-30 is $1725 CAD[1]. This ETC has a gross area of 4.4 m^2 and an absorber area of 2.4 m^2. The thermal performance of the Apricus AP-30 has been determined by the *Institut für Thermodynamik and Wärmetechnik* (ITW) at the University of Stuttgart in Germany. The retail price of the Thermo Dynamics G32P is $864 CAD[2], half the cost of the Apricus AP-30. The G32P solar collector has a gross area of 3.0 m^2, and an absorber area of 2.7 m^2. The thermal performance of the G32P has been determined by the Canadian National Solar Test facility (NSTF) and by the Swiss *Solartechnik Prüfung Forschung* (SPF). The results from the NSTF and the SPF for the G32P solar collector are virtually identical.

Using data from the ITW for the Apricus AP-30 and data from the NSTF for the G32P, the heat output from the two solar collectors was calculated for four sets of weather conditions. The results are shown in the graph below. The orange lines are for the G32P solar collector; the blue lines are for the Apricus AP-30. In bright sunshine, but cool air (1000 W/m^2; 10°C), the G32P outperforms the AP-30 until the collector inlet temperatures reaches 45°C. In sunny conditions, with warm air (800 W/m^2; 20°C), the G32P outperforms the AP-30 until the collector inlet temperatures reaches 47°C. When collector inlet temperatures reach 45°C, or more, the bottom of the storage tank will be warm, meaning that the tank is almost filled to capacity with heat.

In sunny but cold air (800 W/m^2; 0°C), the G32P outperforms the AP-30 while collector inlet temperatures are less than 30°C. In cloudy, cold weather (400 W/m^2; 0°C) the AP-30 outperforms the G32P for inlet temperatures greater than 18°C. However, with cloudy conditions the collector inlet temperature will not be high with either solar collector because there simply is not enough solar radiation on a cloudy day to raise the bottom tank

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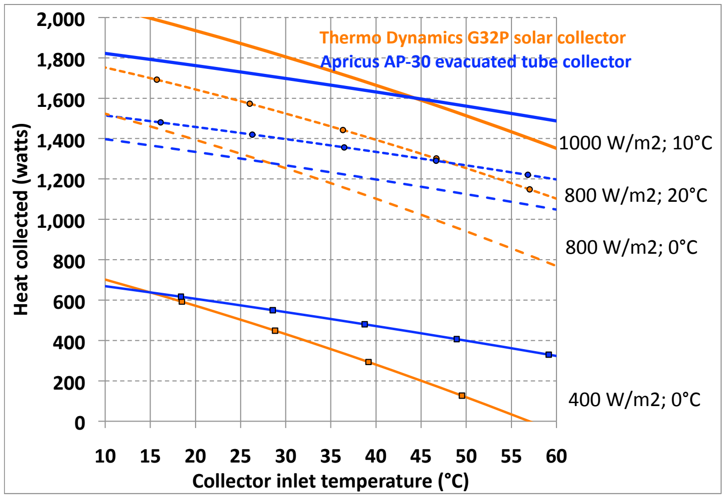
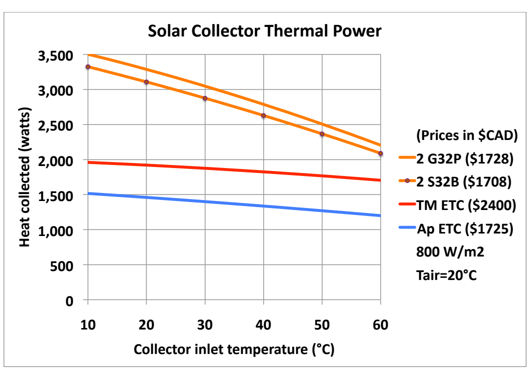
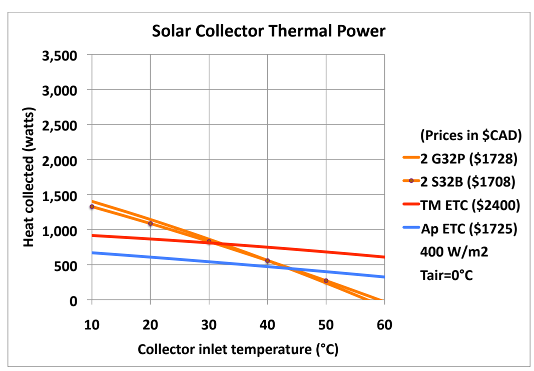
[1] http://www.theresourcestore.ca/proddetail.php?prod=AP-30-KIT
[2] http://www.thermo-dynamics.com/products.html

temperature much above 20°C. For half the cost of the AP-30, the G32P solar collector delivers more heat most of the time in a typical solar water heater.



Another comparison of the ETC and LFP can be made by considering the thermal power provided by the Apricus AP-30, which costs $1725 (line Ap ETC below) and two Thermo Dynamics G32P solar collectors, which cost $1728 (line 2 G32P). At all collector inlet temperatures the two G32P's deliver 80% to 120% more heat. Also shown on the graph is a plot of the thermal power from another ETC, the Thermomax TDS300, which costs $2400[3]. In many 2-collector systems the Thermo Dynamics S32B solar collector is used. A pair costs $1708 and the thermal power is 5 to 10% lower than that from two G32P solar collectors.



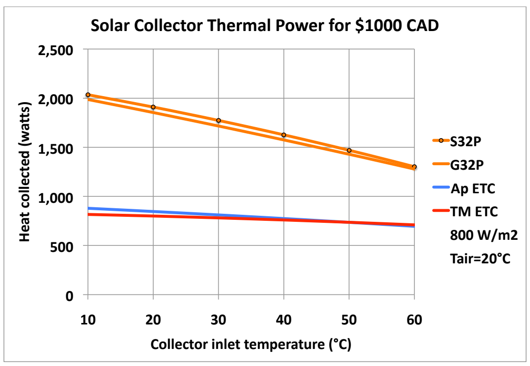


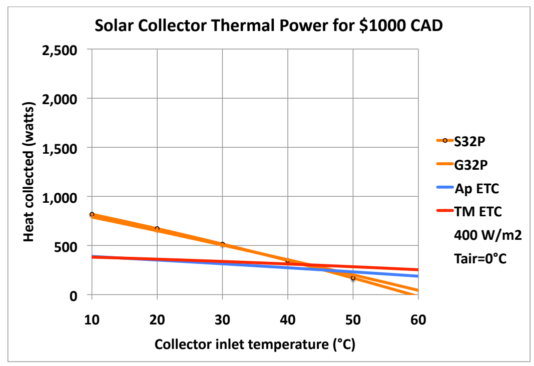
One graph is for solar radiation of 800 W/m², a sunny day, and 20°C air. The same information has been plotted also for poor solar conditions: solar radiation of 400 W/m², which is somewhat cloudy, and 0°C. The Thermo Dynamics G32P and S32B, outperform the AP-30 for

[3] http://www.greenshop.co.uk/solar/documents/Consolar-prices.pdf (The price quoted is 1220 UK pound sterling, and is from a 2004 price list.)

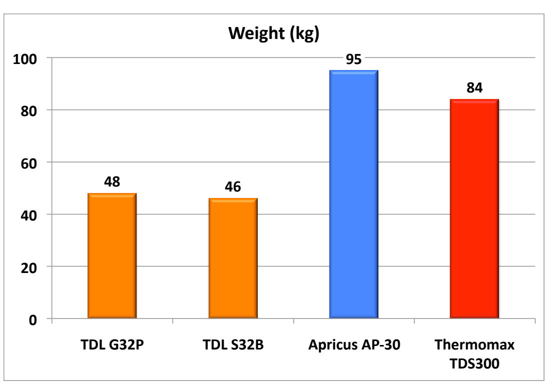
collector inlet temperatures less than 45°C. The Thermo Dynamics collectors outperform the Thermomax TDS300 for inlet temperatures less than 32°C, however, the Thermomax collector costs $2400, compared with $1700 for 2 Thermo Dynamics solar collectors.

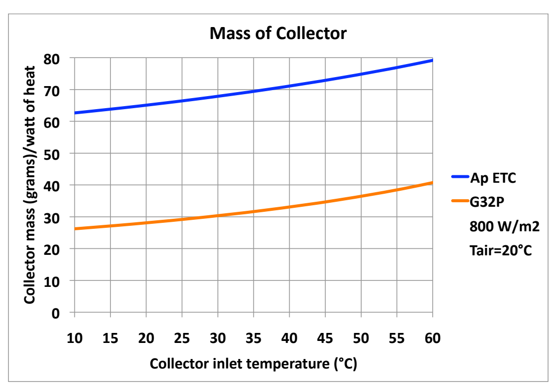
The best comparison is to consider the thermal power delivered for an investment of $1000. In good solar conditions the Thermo Dynamics solar collectors outperform the ETC's by a factor of two to one. In poor solar conditions the LFP collectors again outperform the ETC's, for collector inlet temperatures less than 40°C. However, with solar radiation of 400 W/m^2, the collector inlet temperatures will be less than 40°C. In both weather scenarios the $1000 of Apricus and Thermomax ETC provide almost the same thermal power.



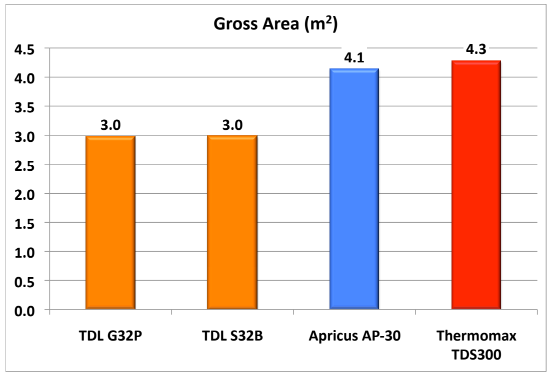


The ETC modules are twice the weight of a Thermo Dynamics solar collector. The ETC's, weighing in at 84 to 95 kg, are difficult to handle relative to the lightweight Thermo Dynamics solar collectors. It is also important to consider the collector mass required to deliver one watt of heat. The mass of a solar collector is indicative of the energy consumed in the production of the solar collector. The lower the mass, the lower the energy embodied in the solar collector. In the graph below the mass of collector required to deliver one watt of heat is plotted against the collector inlet temperature. The mass of ETC required per watt is twice the mass of G32P solar collector required to deliver one watt. The LFP solar collector provides a more effective manner in which to employ materials to capture the energy of the sun.

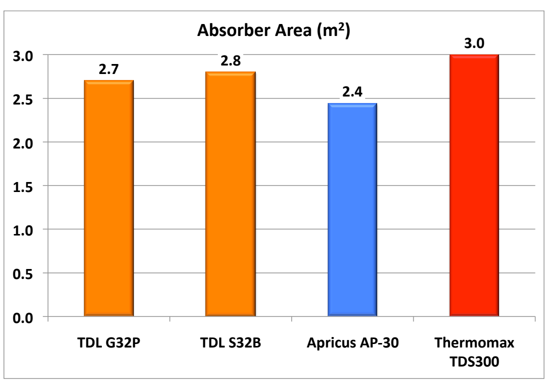


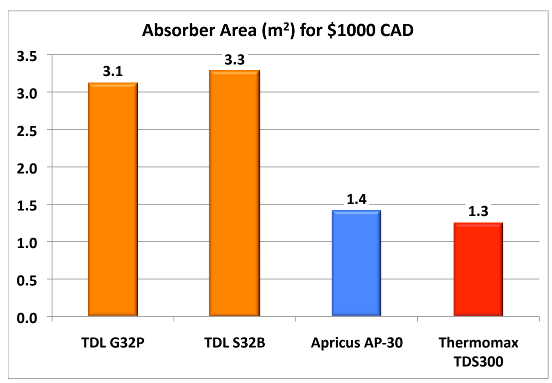


Gross area is also an important parameter. In many situations there is a limited space in which to locate solar collectors. The gross area of the ETC's is considerably higher than that of the Thermo Dynamics solar collector



The heart of a solar collector is the absorber plate. Below are shown the absorber areas of the four solar collectors under consideration, in absolute terms, and in terms of the purchase of $1000 worth of solar collector. The Thermo Dynamics solar collectors offer twice the absorber surface for a $1000 investment. The instantaneous efficiency of the ETC is sometimes greater than that of the LFP solar collector, however, the increase in efficiency is rarely more than twice that of the LFP collector.





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