A solar water heater reduces household energy use, reliance on the grid and greenhouse gas emissions by making use of the sun. A solar hot water heater unlike household consumer goods comes with a payback.

It’s unlikely you’ll make a good decision when puddling in the water from the failed tank of your conventional system. You need to take time to consider what is available and what you might reasonably expect to save. It’s sensible to make your plumbing system and lifestyle, energy and water efficient before installation. It’s the sort of system you need to “keep a weather eye on” rather than plug in and forget.

Remember that the past way of doing things may contribute to present problems and is probably not the way of the future.
PERFORMANCE

Expectations. A well installed solar hot water system in Tasmania should be able to meet 50 - 75% of hot water needs in winter and all hot water needs in summer.

- Systems need to work at the top end of expectations to make them a good proposition both for owners and the subsidising authorities.
- Unfortunately there is no published performance data and little reliable information available. Agencies selling solar systems are not likely to give unbiased comparisons. Remember, people selling something may be more focused on the sale than your best interests. Caveat Emptor

Actual Performance. In 2008, a detailed study of solar hot water systems in New Zealand showed, on average, the solar system only offset 37% of electricity usage. The south island of New Zealand straddles Lat 42½° and has a cool temperate climate similar to Tasmania, so the results of the NZ study are more relevant than studies done in the warm temperate climates of places straddling Lat 32½° such as Perth, Adelaide and Sydney.

The study found only 15% of NZ owners were satisfied. Installation problems seem to dominate: Most of the NZ houses only got about 20% - 50% contribution from solar for one or more of the following reasons:
- Collectors mounted at too low an angle – all were less than the latitude and a few did not face north.
- Standing losses were high, especially for thermosyphon systems with the tank on the roof. About 1/3 of the losses were standing losses.
- Automatic boost heating resulted in reduced solar contribution.
- Installers failed to notice how poorly systems were operating with over 20% performing worse than the standard system they replaced.

- Owners were not aware of how their systems were operating
- These results led the NZ government to require:
- All systems participating in its grants and loans schemes to have their energy performance calculated and published. This led very quickly to 80% of manufacturers using timers to improve the system control strategies.
- Installers to undertake a short course training certificate
- An auditing process to provide feedback to the industry and the training programmes.

None of these are required in Australia. Several of the recommendations and suggestions in this pamphlet are based on the results of the NZ report.

ECONOMICS

The economics of solar water heaters vary from house to house depending on hot water use, system type and local climate. System costs, electricity prices and government rebates are also factors that change over time. As at June 2014, a typical Tasmanian household might reduce their electricity use by 6kWh/day, saving $350/year, by installing a solar hot water heater at a cost of about $4,500 above that of a conventional inefficient electric hot water cylinder.

SOLAR COLLECTOR

The collector should ideally face north in a position where it is not shaded for the major part of the day. Fig 4. shows the decline in efficiency as orientation deviates from north. Collectors in common use are:

- Strip collectors, suitable only for low temperature use such as pool heating.
- Flat plate collectors – a sheet of metal, treated to make it a good absorber and poor emitter of solar radiation, with water pipes bonded to the surface, enclosed in an insulated metal box with a sheet of low iron toughened glass over the top. Water is heated by conduction from the plate and rises to the top of the panel then through to the storage tank. (eg Rinnai, Somer, Edwards, Solarhart)

It is essential in a cool temperate climate to have a frost protection system protecting the water pipes from freezing.

Evacuated Tubes comprising a series of single (Greenland, Thermomax) or double (Apricus, Solar Energy Direct, Edson) wall glass tubes with a vacuum between the inner and outer wall. As heat is not convected through a vacuum this provides both frost protection and insulation. Inside the glass tube is a heat pipe, containing a liquid (usually water) which, when heated, evaporates. The heat is transferred by conduction to water circulated through a small manifold across the top of the tubes then returned to the storage tank.

A Comparative Study. Without research or comparative studies of any systems in a cool temperate climate, it is not possible to unequivocally claim better performance for either system. Figs 1, 6 & 7, found on the internet, provide a comparative study performed in a warm temperate climate and show:

- In low radiation conditions the evacuated tubes produce more than the flat plate. A thermosyphon only transfers heat when the temperature difference between the collector and the cylinder is enough to overcome the friction. A heat pipe transfers heat whenever there is a temperature difference.
- The flat plate collector cooks down during overcast and rainy weather whereas the evacuated tube continues to deliver energy.
- In high radiation conditions the performance of both collectors is similar

These findings lead you to expect the evacuated tube to be the better performer in a cool temperate climate with its periods of overcast and frosty weather.
SIZE OF COLLECTORS

Useful heat supplied by collectors is not proportional to panel area as an increase leads to the system operating, on average, at a higher temperature and therefore at a lower collection efficiency.

- Collector sizes vary between manufacturers but a typical flat plate or 15-tube array is approximately 2m long by 1m wide. A minimum of two panels or 30 tubes is required in a cool temperate climate.

SLOPE OF COLLECTORS

- A solar hot water system will provide almost all hot water needs in summer, so it is preferable to optimise the collector slope for winter, i.e. 60º to 70º. (Figs 2, 3 & 5).
- The NZ study discussed above, concluded: never mount the collector at an angle less than the latitude. Lower angles mean very little solar hot water in winter. For Tasmania this means at least 42º, but 60º is better. So whenever a lesser slope and/or orientation away from north is suggested, whether for cost, aesthetic or heritage considerations, the performance will be significantly undermined.

STORAGE

It is sensible to avoid waste of water and energy. Too much storage, particularly in cool temperate climates, leads to overuse of boosting with increased heating costs and consequent erosion of the solar advantage.

Circulation. Solar heated water is stored in a tank. If the tank is above the collector then circulation through the collector is by thermosiphon and no electricity is required; if the tank is below the collector then a pump is required which, of course, uses electricity.

Storage tanks are made from steel with a vitreous enamel lining (5 yr guarantee), or copper (20+ yr guarantee) or stainless steel (10+ yr). The guarantee is a good indicator of the life expectancy of the tank.

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**Fig 4** Average winter incident solar radiation vs collector deviation from north for collector at 60º. (Computer modelling: Todd Houstein)

**Fig 5** Incident solar radiation by month for north facing collectors at various slopes in Hobart. (Computer modelling: Todd Houstein)

**Fig 6** Rainy day – Flat plate collector and evacuated tubes – low and fluctuating solar radiation levels. (Source: its – solar division. www.its-solar.com)

**Fig 7** Hot summers day – Flat plate collector and evacuated tubes – high peak solar radiation levels. (Source: its – solar division. www.its-solar.com)
<table>
<thead>
<tr>
<th>Household hot water usage</th>
<th>Low or conserving household (litres)</th>
<th>Medium household (litres)</th>
<th>High or wasteful household (litres)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 person</td>
<td>50L (40L hw/day)</td>
<td>90L (52L hw/day)</td>
<td>120L (122L hw/day)</td>
</tr>
<tr>
<td>2 person</td>
<td>90L (76L hw/day)</td>
<td>120L (110L hw/day)</td>
<td>200L (214L hw/day)</td>
</tr>
<tr>
<td>3 person</td>
<td>120L (108L hw/day)</td>
<td>160L (165L hw/day)</td>
<td>300L (294L hw/day)</td>
</tr>
<tr>
<td>4 person</td>
<td>160L (148L hw/day)</td>
<td>250L (235L hw/day)</td>
<td>400L (386L hw/day)</td>
</tr>
<tr>
<td>5 person</td>
<td>200L (184L hw/day)</td>
<td>300L (294L hw/day)</td>
<td>400L (485L hw/day)</td>
</tr>
<tr>
<td>6 person</td>
<td>200L (210L hw/day)</td>
<td>315L (343L hw/day)</td>
<td>400L (563L hw/day)</td>
</tr>
</tbody>
</table>

Fig 8 Hot water tank capacity. (Source: R.J.McGregor Architecture Solar Design 2012)

Insulation. Tanks are also insulated, usually with 50mm of polyurethane foam which has an insulation value of R1.5. Considering the water is stored at 60°C this is a very minimal amount, particularly in a cool temperate climate during a stretch of cold cloudy weather. Some manufacturers use phenolic foam insulation which gives a higher value of R2.5 for 50mm thickness. Wrapping the tank with additional layers of insulation makes an appreciable difference but it is important to ensure electrical connections and wiring won’t overheat.

Tank Location. Putting the tank inside the building means that the heat lost by the tank, guaranteed by the laws of thermodynamics, contributes to your home heating and not outside air warming. Storage tanks that sit on top of the roof (or outside) are obviously going to have much higher heat losses due to the greater temperature differentials as well as wind speeds over the tank. These systems are not very suitable for cool temperate climates.

Water temperature. The plumbing regulations require the water to be stored at 60°C or more to prevent bacteria growth such as Legionella (note that incidence of legionnaires disease is no greater in countries without this regulation). Regulations also require a limiting valve in the pipe-work, set at 50°C, to prevent scalding at the bathroom taps.

Boosting. A thermostat connected to a heating element controls supplementary boosting which can be either automatic or manual. If boosting is continuous the best position for the thermostat is towards the top of the tank with about 70 litres above the thermostat. Most standard tanks have the thermostat and heating element at the bottom so other locations may only be available on special order. With manual and automatic boosting a timer limits the quantity of water boosted.

- Setting the timer to come on at 5am and boost for 30 minutes is a popular option for conserving household.
- A 3kW element will heat 50 litres in 30min

Storage capacity. The less hot water stored, the lower the energy losses and the more efficient the service. Australia and household sizes have changed considerably since most of the recommended storage sizes were developed. E.g. the average Australian household is now 2.5 persons; water usage is influenced by water pressure (a 10 min shower at very low pressure uses less water than a 3 min shower at high pressure), as well as metering (which has a much stronger influence on consumption than moral hindrance) and the availability of more efficient appliances that usually heat their own water. Fig 8 has been developed to better reflect contemporary needs.

- Anyone brought up on tank water will have no trouble fitting in the low or conserving category whereas contemporary urban dwellers may find it difficult to fit in the medium category without adjusting household habits.
- Too much storage, particularly in cool temperate climates, leads to overuse of boosting and consequent erosion of the solar advantage.

Storage tanks are available in the following sizes: 50L, 63L, 90L, 120L, 160L, 180L, 200L, 250L, 270L, 300L, 315L, 400L, 500L. No manufacturer has the complete range; some won’t have connections for solar, some won’t be in stainless steel or copper, most won’t have been submitted for government subsidies. As you work through these variables you will be surprised at how few options are available in stock. Stock sizes are obviously made for a different climate and aimed at large &/or wasteful households. The most desirable combination of features often requires a special order.

DISTRIBUTION

Heat losses from the reticulation of hot water add considerably to the “standing losses” of a solar water system. To minimise these losses:

- Keep pipes to the shortest practicable run to reduce hot water wasted by lying in pipes and losing heat.
- Insulate pipes (prelagged piping may not be sufficient). All plumbing joints should be lagged to prevent spot losses (cold bridges). Inlet temperatures can get over 90°C in summer so use a heat resistant insulation.
- Provide heat traps in inlet and outlet pipes from the storage tank to reduce conduction losses from the tank through the pipework. (fig 9)

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Further Information

Home Energy Audit Toolkit (HEAT), shows how to measure water used by a shower as well as the electricity used in your home. Contact your local council.

3.6MJ = 1kWh

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Copies may be downloaded from:
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