NZ PLUMBERS' JOURNAL – AUGUST/SEPTEMBER 2008

Solar Water Heating – It's time to upskill #12
Overheating Systems

By Ian Sumner

Ian Sumner's solar upskilling series continues in this issue. In the previous article, he looked at why solar water heating systems overheat. Now he looks at how to manage over-heating and includes three case-studies to examine.

To summarise our last article (April/May 2008), overheating occurs when the heat supplied to the water is greater than the heat demand being drawn off, this can occur for numerous reasons:

- Oversized solar water heating system
- Reduced heating demand
- Low collector pitch
- Backup heating system switched on too often or is left on continuously

Overheating is also more of a problem with modern solar water heating systems which are more efficient than traditional systems. Therefore, good design is key to the reliability and performance of the system. A one size fits all approach should be avoided.

There are several methods that can be adopted to limit the potential for a solar water heating system to overheat. These are highlighted below.

Heat dumps and heat exchangers - There are various ways a heat dump can be incorporated in to an installation to reject excess heat, for instance, to swimming pools, or with external heat exchangers, to the environment. These circuits can either draw hot water from the cylinder to reject heat or, the heat from the solar collectors can be redirected to another heat sink such as shown in Figure 1 below.

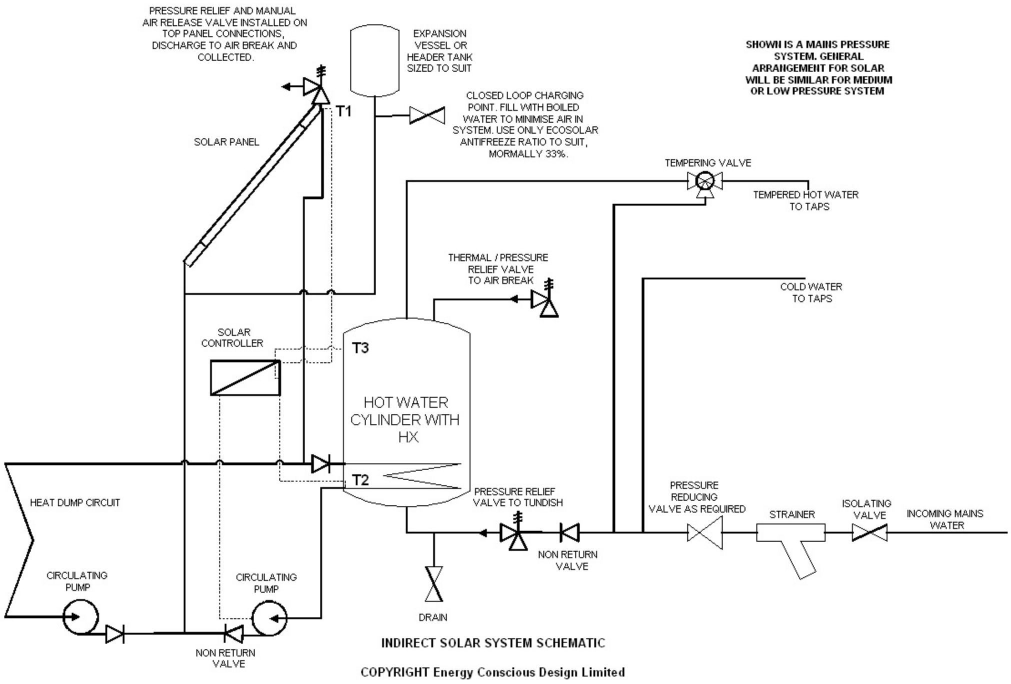

Figure 1 Mains pressure indirect solar system c/w heat dump circuit

Installers need to be wary when installing indirect solar systems that utilise a glycol solution within the solar circuit. Glycols break down and become corrosive when subjected to air, sunlight, copper, and heat. So if a glycol based system overheats, the glycol will become corrosive and will require additional maintenance to ensure the long term relibility of the system. We at EcoSolar have tested one of the common glycols available in New Zealand, the glycol became concerningly corrosive in less than one year. Best practice now states that glycols should either be checked or replaced annually, which is one reason why installers are moving away from Glycol based systems or are installing heat dump circuits on glycol based systems.

Drainback Systems – There are numerous forms of drainback systems. Such a system is based upon the methodolgy that there is only water in the collectors when the pump is operating. When there is no heat to gain from the collectors or when the cylinder has reached its maximum set point storage temperature, the pump is switched off and the water drains from the collectors back into a receiver which is located a safe distance from the collectors.

Such systems are very dependent upon the resiliance of the solar collectors to reliably manage high temperatures and the installer ensuring that the system is free draining. If the system does not drain, any water remaining in the collectors will be heated and quickly turn in to steam.

Two forms of drainback system are shown below;

1. A low pressure system, as shown in Figure 2, where the collectors are placed above the cold water header tank feeding the hot water cylinder. This is a reliable and cost effective system, however the number of header tank based systems are reducing.

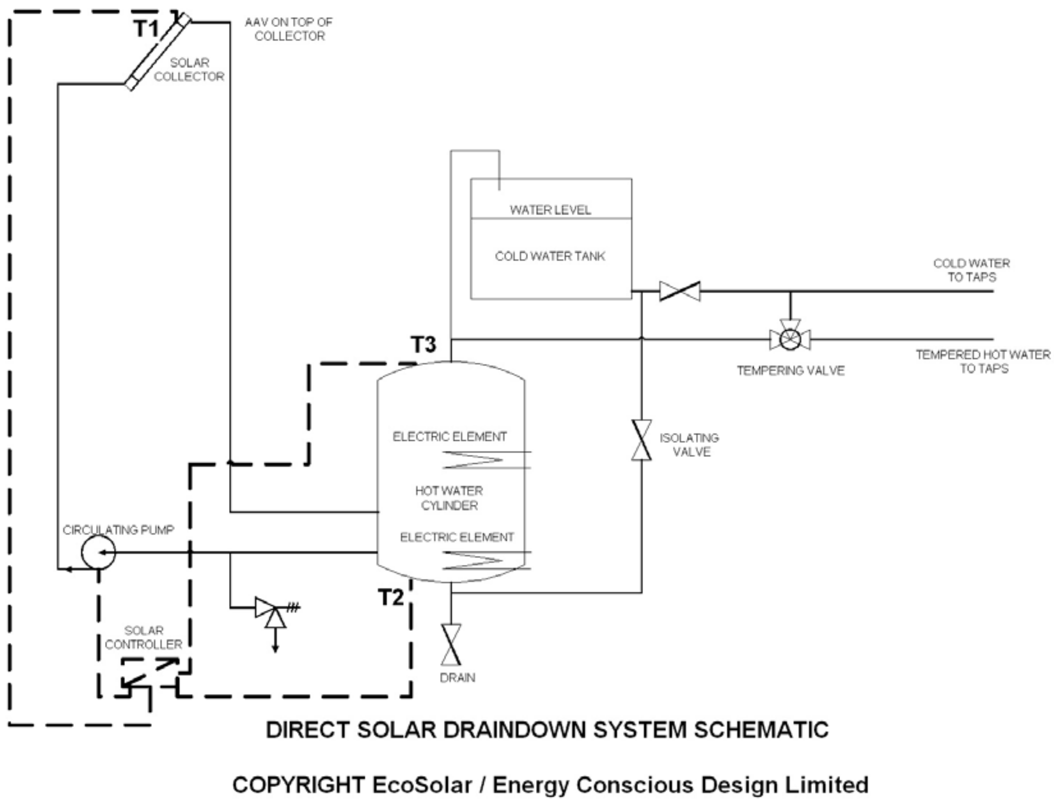

Figure 2: Low pressure drainback system, with the hot water cylinder being fed from a cold water header tank.

2. An indirect drainback system, as shown in Figure 3 below, which has separate stored hot water from the solar circuit, the solar circuit heats the stored water using a heat exchanger. A purpose built drainback receiver is placed in the solar circuit, when the pump turns off, the water within the solar circuit above the receiver, drains back into the receiver. Figure 4 shows a large collector area mounted on an Auckland house, an indirect drainback system was installed which eliminates over heating and ensures maximum system performance.

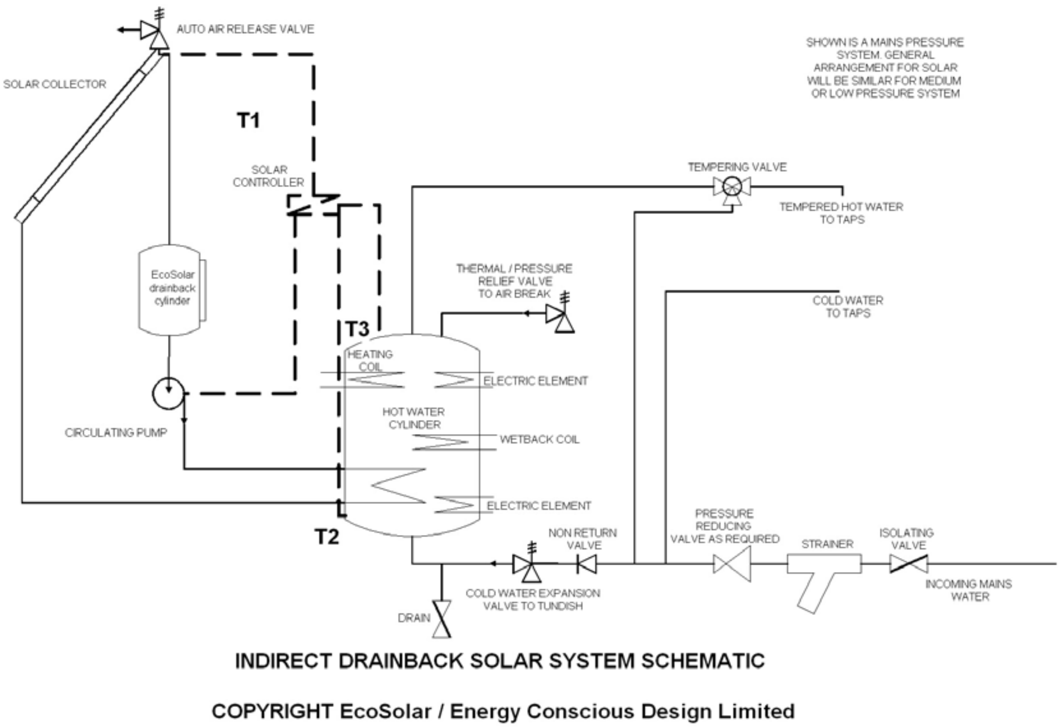

Figure 3 Indirect drainback system utilising a special receiver in the solar circuit.

Figure 4 Large collector area installed on an indirect drainback system which manages overheating whilst maximising system performance.

Shades – Shades can be installed on the collectors which close and shade the collector when the cylinder has reached its maximum temperature. These shades are commercially available however, the shades will be exposed to New Zealand's harsh environmental conditions and so whilst they are seen as an option in other countries, such installations here in New Zealand would require significant periodic maintenance.

Tracking systems – These are fairly common on photovoltaic solar installations, photovoltaic systems generate electricity rather than heat, where they are used to maximise the area of collector "seen" by the sun, thereby maximising their efficiency. However, whilst the technology is available it is expensive and is rarely used in thermal solar systems.

Heat rejection - Some solar controllers, such as the modern one shown in Figure 5 below is able to utilise some solar collectors to reject heat back to the environment during cooler times of the day or at night. This is often the most cost effective method of limiting the effects of over heating and is a fairly common form of retrofit to homes where the occupants go away on holiday especially at cooler times of the year. This option does have its limitations, as during the summer when systems can over heat from solar raditation collected in a single day, the system may not be able to reject excessive heat. However, it will limit the buildup of heat over several days or weeks such as when occupants go on long holidays especially in the cooler months of the year.

Figure 5. Modern solar controller able to operate heat rejection cycles during cooler periods of the day.

Below are three case studies of over heating solar water heating systems, we provide cost effective and reliable solutions for each to manage over heating and optimise system performance.

Case Study 1 – Bed & Breakfast
Large new build home intended to be used as a bed and breakfast
The home in question had two retired occupants throughout the year and occasionally had up to 4 guests mostly for weekends.

The indirect solar water heating system included a 300 litre storage cylinder with over $9m^2$ of collector area, approximately double that normally installed, operating using a glycol mixture in the solar circuit. Although it was intended to have paying guests, there were rarely guests and so the solar system overheated during the Summer months. During the cooler months the oversized system provided a high proportion of hot water demand and the clients wanted to maintain the collector area installed.

The solution to this over heating was to install a heat rejection system which operated similar to that shown above in Figure 1. Once the hot water cylinder reached its maximum temperature, its solar pump was turned off and the heat dump pump switched on to reject the excess heat via a heat exchanger to a heat sink. The clients were pleased with the solution as it allowed them to cater for guests and maximise the solar contribution to the system during the cooler months.

Case Study 2 - A holiday home
The holiday home in question was generally used only at weekends, on average every other weekend through the year, by a nearly retired couple. The house was generally continually occupied through late Spring, Summer and early Autumn with 4 or more occupants.

The system had a 300 litre hot water storage cylinder with around $5m^2$ of collector area. A thermal pressure relief (TPR) valve that was mounted on the collector had repeatedly failed, damaging the plastic gutter and draining the cold water storage tank. TPR valves are not suitable for installation on the solar circuits of solar water heating systems, this valve was replaced with a suitable pressure relief valve located adjacent to the hot water storage cylinder.

As the house was occupied during the warmer months, the system only over heated during the cooler months when left unoccupied for long periods. Therefore a controller was installed, as per Figure 5, the controller utilised the flat plate collectors to reject heat at night or cooler times of the day limiting the ongoing heat buildup. These modifications were successful in managing the over heating of the system. However had the home been unoccupied for long periods during the Summer months a heat rejection system would have been required.

Case Study 3 - Solar system retrofitted to an existing hot water cylinder
A solar water heating system was installed on to an existing low pressure 180 litre cylinder serving a family of four. As the the cylinder was undersized for the four occupants, the electric element was often switched on. However as the backup heating was often required and the only way of turning the element on was by switching the isolator on in the cylinder cupboard, the element was often left switched on and this

allowed the cylinder to over heat the following day when the solar system heated the cylinder.

A cost effective solution was required, two of the occupants were expected to leave home in the next two years and so significant and expensive changes to the system would not be cost effective. It was decided to install a “One Shot” element controller as shown in Figure 6 below, this simple to use controller, which is easily and cheaply installed, ensures that the element was not left switched on. Not only did this solution manage the over heating but also significantly reduced the power bill as the element was only utilised when the solar system could not satisfy the hot water demand.

Figure 6: “One Shot” Backup heating controller, allows manual control of the backup heating. The heating is manually turned on and will be automatically turned off, ensuring the element is not left on unintentionally.

Energy Conscious Design and EcoSolar, in conjunction with several trade and professional industry associations is in the final stages of preparing training sessions that will tour New Zealand, these training sessions are suitable for both specifiers, designers and installers, please contact Energy Conscious Design for dates and seminar locations.

- *Ian Sumner of Energy Conscious Design Limited and EcoSolar previously worked as a plumber. He subsequently completed a degree in building services design and has completed a thesis on trying to get solar hot water to be cost effective in the UK. He has local experience in solar system design and installation and is currently the only solar water heating system engineer accredited bu the Solar Industries Association in New Zealand. Ian says, “This series of articles is intended to be an introduction to solar water heating only and I do not intend to provide specific design advice.”*

For more information, ask for a free copy of the latest EcoSolar solar hot water installation guide, or send questions or requests for topics to be covered to ian@ecosolar.co.nz or 0800 ECOSOLAR (0800 32676527).