Solar Hot Water System Installation Guide

ECOSOLAR

Solar Hot Water Heating Installation Guide

© Energy Conscious Design Limited / EcoSolar
15B Saturn Place, Albany, Auckland,
Postal PO Box 81049 • Whenuapai • Auckland • New Zealand
Phone 09 442 0996 • Fax 09 442 0997
E info@ecosolar.co.nz • Web. www.ecosolar.co.nz

Revision Date 29 May 2009

Table of Contents

Thank you

Thank you for choosing an EcoSolar hot water system. You may look forward to many years of monetary savings as well as knowing that you are helping provide a sustainable future for generations to come.

Please ensure you read these instructions carefully and complete the installation to these guidelines, the New Zealand Building Code, AS/NZS3500 and The Code of Practice (COP) for Manufacture and Installation of Solar Water Heating Systems in New Zealand, this COP is available for download from www.solarindustries.org.nz.

Where there is a conflicting requirement, either within this or, between documents, suitable professional guidance should be sought.

This guide is not intended to be exhaustive and there are many types of system and variations there of, that are not intended to be covered here. For instance, there are systems that incorporate a second hot water cylinder acting as a preheater and it is possible to incorporate a wetback system for heating water in winter and the solar system for heating water in summer.

Prior to proceeding with the installation the installer should discuss the requirements with the end user to ensure an appropriate system is installed. The EcoSolar check sheets should be completed, guidance sought and complied with where required, and the installer should understand the type of system most suited to the particular installation.

Selling the benefits of solar water heating

Selling the system and in particular informing the customer what they can expect from the solar water heating system and selecting the right system for a particular client are key to the success of the installation. If the system and its benefits are over inflated by the person selling the system to the customer, then the customer will have unrealistic expectations and is unlikely to be satisfied with the installation.

A correctly designed, installed and maintained solar water heating system will provide effective savings on the energy consumption of a household, of around 70% of the electricity consumed for water heating. As a rule of thumb delivering around 90% of the hot water in Summer, 50 to 75% in Spring and Autumn and 25 to 40% in Winter.

There are many levels of efficiency being promoted to customers however, the bottom line is that a correctly designed, installed and operated system will have an annual efficiency in the order of 30 to 40%, this is the percentage of the solar gain that the sun delivers compared to the amount of heat supplied to the hot water cylinder. The efficiency of a system is often overstated or misinterpreted, two of the most common overstated efficiency levels are outlined below;

- **97% efficiency** – we have heard salespersons promoting that a system is 97% efficient. This level of efficiency is only for the absorber within the collector i.e. the absorber within a collector, which historically was a matt black high temperature paint is often now a selective coating which is able to receive high levels of solar gain and only reflects back a very low percentage.
- **70% efficiency** – this level of efficiency is often the peak collector efficiency and will certainly not be delivered and maintained in practice. This collector efficiency reduces as the water is heated above the ambient (outside) temperature.

Selecting the most appropriate system

Selecting the right system for a customer can be split into three;

- **Type of system** – the type of system is key to ensure system reliability and is dependent upon the climatic conditions of the site and how the customer will use the system.
- **Size of system** – this is key to the performance of the system and delivering acceptable energy savings
- **System operation and control** – there are several levels of system operation and control, the selection of these is dependent upon how much the customer is willing or able to manually intervene and control the system.

Type of system

The types of solar hot water system include, thermosyphon systems, pumped systems, drainback systems, indirect and direct systems. Each of these systems has advantages and disadvantages that should be understood so that by the most appropriate system is recommended to the customer. For instance a remote site without reliable power could have a thermosyphon system installed, see Figure 1 below, which requires no power but will probably have a lower efficiency and may require increased maintenance, alternatively a pumped drainback system could be installed, see Figure 2 below, that would potentially utilise a 12Volt controller (see Figure 3) and pump, the system would be more efficient, would address the issues of freezing and overheating but may be more expensive to install than a thermosyphon system.

A batch with an intermittent hot water demand or a house with a variable hot water demand would probably have a drainback system installed, as this system is able to manage overheating in a fail-safe manner

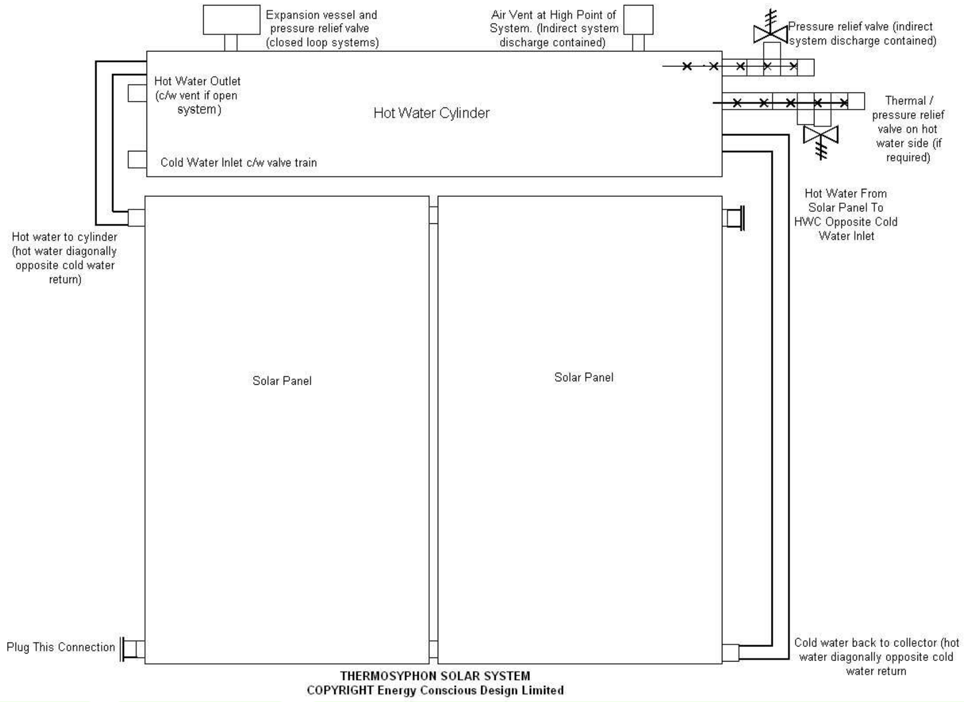


Figure 1 Thermosyphon system

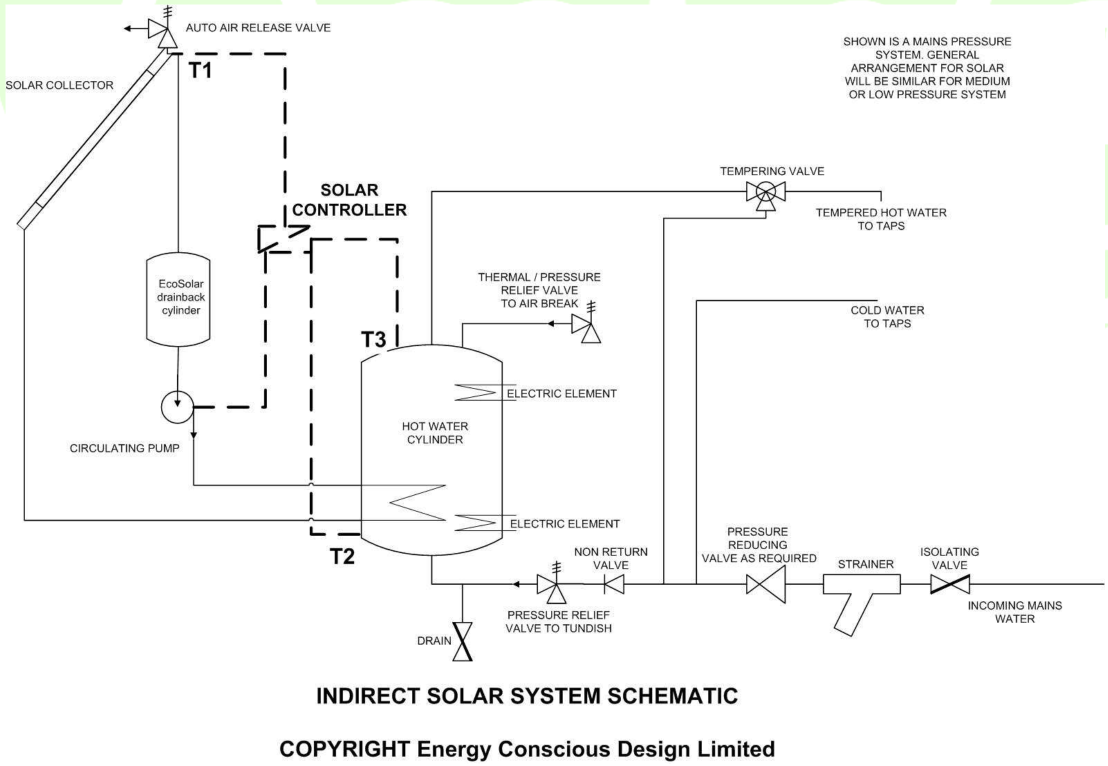


Figure 2 Indirect pumped drainback system

Figure 3. EcoSolar 12Volt UVR61 controller

Basics of system sizing

As a rule of thumb solar hot water systems are often sized on the basis of 1m2 of collector area per 50 to 75 litres of water storage or per person. For instance, based upon 75litres of water storage per person a two person house hold should be able to comfortably utilise an existing 135 or 180 litre cylinder. In many cases solar collectors are able to be retrofitted on to an existing cylinder and providing the issues associated with frost protection, backup heating, excessive temperatures and volume of water storage are effectively managed, can provide the most cost effective solution with very favourable returns for the consumer. Such retrofitted systems should be installed such that they can be extended and the cylinder replaced with a larger one once hot water usage increases i.e. the couple start a family. A four person household would require a larger system with a 300 litre hot water cylinder and multiple collectors.

The sizing of solar water heating systems for conventional housing is fairly well known however, sizing of commercial or larger scale multiple residential sites requires extensive engineering. The engineering of such systems would require computer simulation of hot water loads and solar gain to refine the system design. Energy Conscious Design have completed many engineering, feasibility reports and system designs for high rise multi tenancy dwellings, hotels, retirement villages, offices, schools, as well as other commercial applications and swimming pools. This engineering utilises computer software, this together with our historical experience are able to determine if solar is suitable and deliver well engineered designs for each application.

System operation and control

System operation and control was discussed in previous articles last year. The solar water heating system will operate automatically by recovering heat from the solar collector to the hot water cylinder. However, all solar water heating systems need a backup heating system, this needs to be adequately managed to maximise energy savings and to ensure that excess heat is not provided to the cylinder increasing the risk of overheating.

There are numerous methods of providing backup heating

1. electric elements in the cylinder
2. boiler or other heat source heating the water in the cylinder
3. wetback
4. an instantaneous water heater with the solar system acting as a preheater
5. a boosting cylinder with the solar system acting as a preheater

The first two options highlighted above are usually controlled through a time clock or manual intervention by the customer, these options are commonly used in domestic systems and will not suffice in the commercial environment where the solar water heating system has to act as a preheater as highlighted in items 4 and 5 above.

Electric elements or boiler heated cylinder

These are by far the most common methods of providing backup water heating but its use is rarely optimised. Solar cylinders often have multiple electric elements, one at the bottom to be used for Legionella control and one in the upper half of the cylinder for boosting the water temperature. The use of the electric elements, the boiler or other heat source should be minimised and ideally should only be switched on at the end of the day if the sun was unable to heat the water to the desired temperature. There are several methods of controlling the backup heating system.

User intervention – i.e. the customer determines if the water is up to temperature, modern controllers, such as the one shown above in Figure 3, display the water temperature in the cylinder, if below a predetermined temperature, the customer manually switches the element or boiler on and switches it off once the water is up to temperature. Historically. this has been a manual process for instance using the main element isolator and the problem has been that the customer forgets to turn the element off thereby leading to increased energy usage. The installation of the EcoSolar "One shot" controller makes this control method much more user friendly and eliminates the problem of the electric element being left on. The "One Shot" controller as shown below in Figure 4 allows the customer to press a button to switch on the backup heating and once the water is up to temperature the heating is automatically switched off.

Figure 4 "One Shot" Backup heating controller, allows manual control of the backup heating. The heating is manually turned on and will be automatically turned off, maximising the savings from the solar system

Timeclock – the electric elements or boiler are switched on at a predetermined time towards the end of the day, once the cylinder has been heated by the sun, and only in the event that the water is not up to the desired temperature. The modern solar controller as shown in Figure 3 above, is able to determine cylinder temperatures and turn the electric elements or boiler on if required.

Wetback

Combined solar and wetback heated installations are becoming increasingly common. The solar system heats the cylinder in the normal way either as a direct or indirect circuit and the wetback heating is provided directly in an open vented cylinder, or via a heat exchanger in a valve vented cylinder.

If the wetback is some distance from the cylinder and unable to operate as a thermosyphon system, the water is able to be pumped between the wetback and cylinder. Some solar controllers, such as the one shown in Figure 3 above, are able to not only control the solar system, but are also able to control the wetback circulating pump. The solar controller monitors the temperatures in the wetback system and automatically switches the wetback pump on only when there is heat available in the wetback.

Solar water heating as a preheater

In most cases a solar system installed in either a commercial or higher specification domestic system will have to act as a preheater. A solar preheated system ensures that there is hot water on demand, the temperature of the hot water drawn off at the taps is not dependent upon the amount of solar gain available, in this type of system the customers see a seamless supply of hot water delivered to the points of use.

The solar preheated water can be supplied to the following boosting systems,

1. an instantaneous gas water heater as shown in Figure 5 below. If the water being heated by the solar system is up to temperature, the bypass valve in the hot water supply diverts the water around the instantaneous gas heater, if the water is not up to temperature the bypass valve directs the water through the instantaneous heater to be heated.

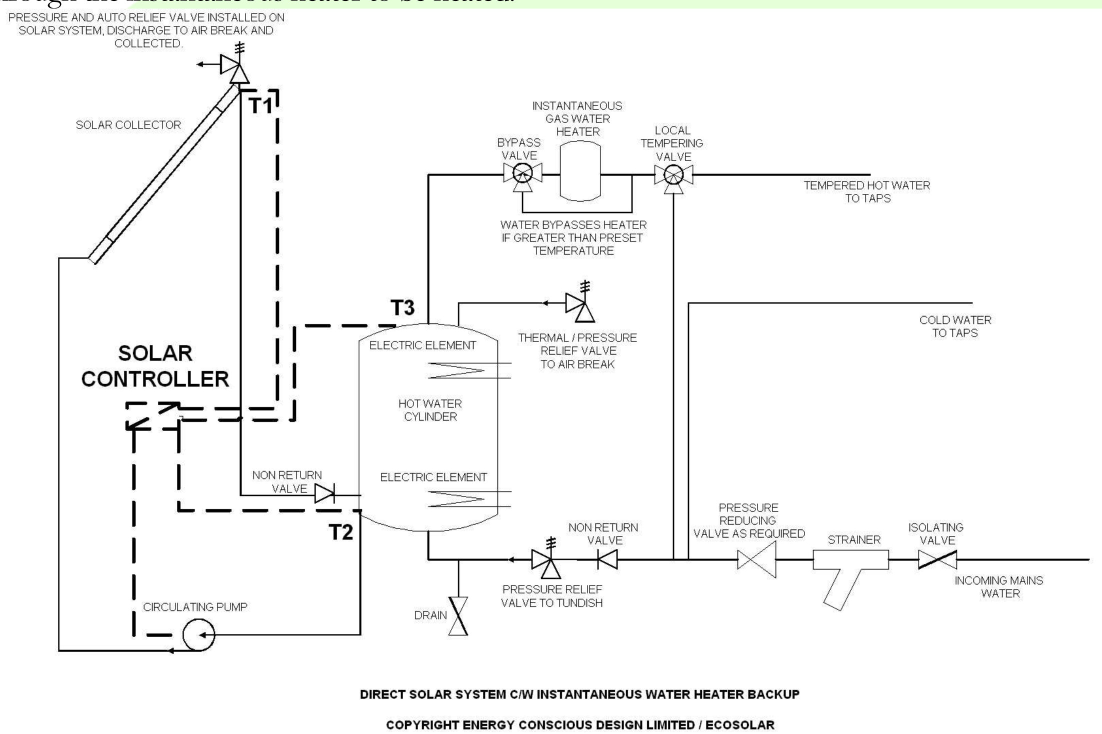


Figure 5. Direct solar water heating system being used as a preheater to an instantaneous gas heater

2. a backup heated cylinder as shown in Figure 6 below. The solar heated water is supplied from the preheat cylinder to the boosting cylinder as its cold water supply. The boosting cylinder may be heated by electric elements, gas boiler or another heat source. Figure 6 below shows an EcoSolar drainback system operating as a solar preheating system with a boiler heated booster cylinder.

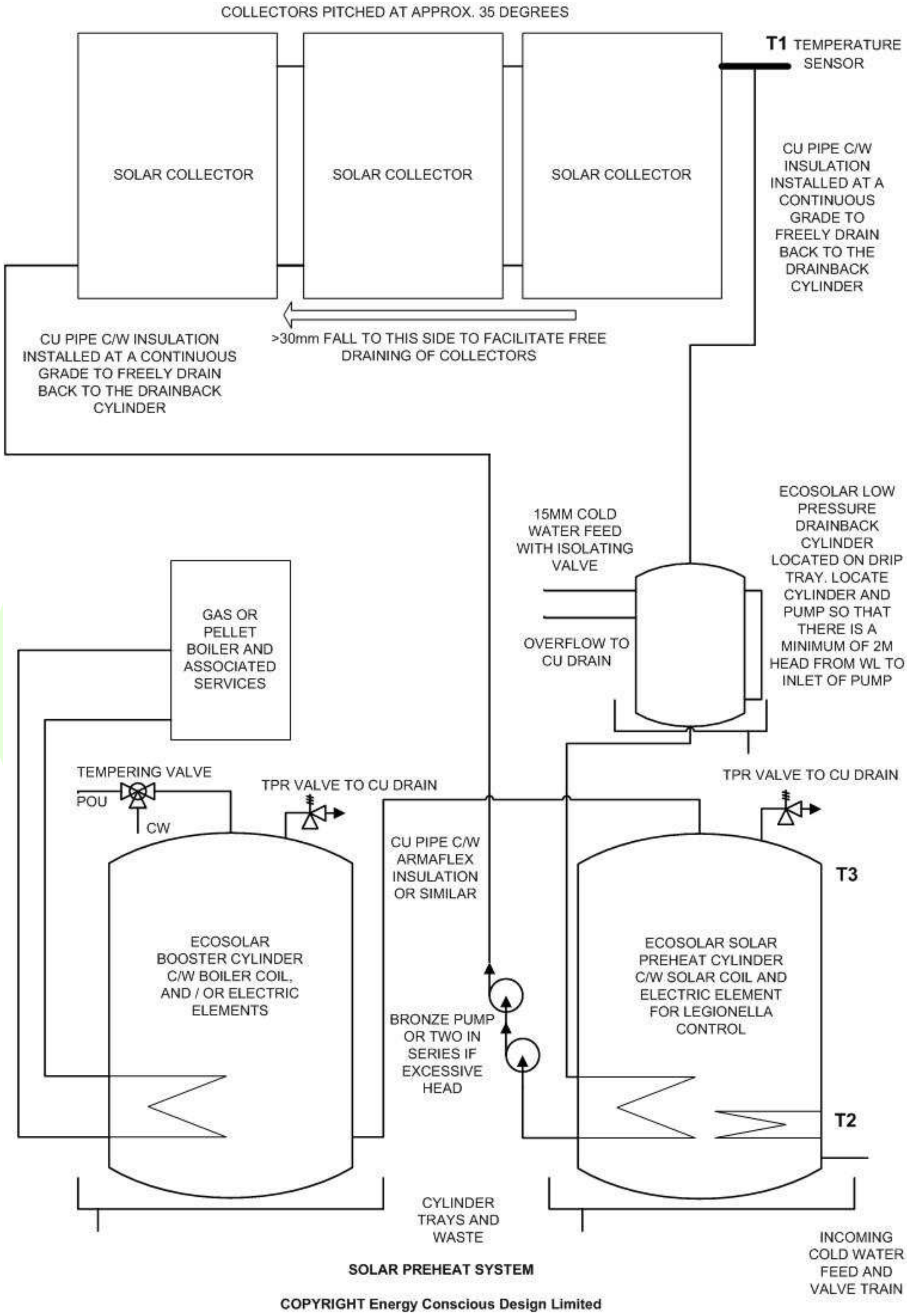


Figure 6. EcoSolar drainback solar preheat system c/w boiler heated booster cylinder

In summary the solar water heating system must be promoted with the correct level of savings else, it is unlikely that the customer will be satisfied with the system. The type of system is key to the reliability of the system and the sizing and control of the system are key to the performance of the system and energy savings achieved.

Caution

There are several issues that you should be aware of and manage prior to installing a solar hot water system.

Building consent and Code Compliance

You will be required to submit a building consent for the installation of a solar hot water system. An owner occupier can undertake some of the installation however, in order for the building consent application to be signed off and a Code of Compliance Certificate granted, a registered plumber will need to check, complete the installation including connecting in to the existing hot water system or potable water reticulation and sign off the installation.

Heat Rejection

All solar hot water systems must have a method of discharging heat in event of a control or power failure. Without a suitably sized method of rejecting heat, in the event of a thermostat or control system failure or excessive heat being supplied by the solar collector, the hot water cylinder could explode causing serious injury / death and or damage. There have been many such cases and the results can and often have been, catastrophic. It is therefore imperative that adequate heat rejection be maintained.

As a general rule, each $1m^2$ of solar collector should have at least 1.5kW of heat rejection capacity, if in any doubt please consult a suitably qualified and competent Engineer. These systems of relief must not have isolation valves installed between the heat source and the relief discharge point. Also take precautions to prevent the hot water discharge from causing damage to building elements or scalding persons. These discharge points must not be long enough to allow freezing and therefore allowing pipe blockages to occur. This requires a tundish or air gap to be present at the discharge point of the relief valve and the relief valve piped away safely. The relief may be hot and therefore the relief drain from a solar water heating system shall be of copper, not of plastic.

System Temperatures

Solar systems are able to heat the water to very high temperatures this leads to the following concerns,

- **temperature of water delivered from taps.** A tempering valve must be installed to limit the water temperature delivered at the taps. If there is already one installed, its correct operation should be confirmed and the valve replaced if there is any doubt over its operation and correct function. The function of this valve shall be regularly checked and be appropriately maintained. The tempering valve must be suitable for the high temperatures experienced in solar systems

- **damage to system components.** Some components installed in conventional hot water systems are not compatible with the high temperatures experienced in solar hot water systems. Of particular concern are;
- mains pressure hot water cylinders which, unless manufactured specifically for use in high temperature systems, have a recommended temperature limit. In many cases this will be between 70^{O}C to 80^{O}C. The specification of the installed cylinder should be checked and a temperature limitation device installed to limit the temperature within the cylinder to within acceptable limits. The solar controller has this function and should be programmed to suit.
- Pipework. All hot water pipework upstream of the tempering valve should be completed in copper. Please be aware that many other alternatives have unacceptable temperature limitations and are not suitable for the high temperatures associated with solar hot water systems.

Frost Protection

Many areas of New Zealand are prone to collectors freezing and subsequent damage, including areas which are not renowned for heavy frosts or pipes freezing. By their very nature solar collectors are good at absorbing heat, they are also good at absorbing coolth. The collector temperature is raised mainly by thermal radiation from the sun, in the same way its temperature is lowered at night by the cold night sky. A night sky can, especially on a cold clear night, freeze the water within the solar collector even if the ambient temperatures are above 0^{O}C.

The water in the collector generally freezes within the pipe risers, the smaller copper tubes that run the length of the collector, see Figure 2 below. Once the water in the collector freezes, it generally results in the riser splitting and a subsequent leak once the ice has thawed. This split in the pipework can generally be repaired by removing the absorber from the collector and brazing.

Antifreeze

A reliable system of frost protection, indirect systems circulate water with predetermined concentrations of a suitable Propylene Glycol antifreeze through the collectors and through a heat exchanger to transfer heat to the hot water cylinder.

Being a chemical, the handling and use of Propylene Glycol should be strictly in accordance with the manufacturer's recommendations. The Propylene Glycol should also contain:

- a dye to help identify leaks and system failure. If a customer observes dye in the hot water from the cylinder they should suspect a leak in the solar system and immediately contact their local EcoSolar solar installer for guidance.
- a corrosion inhibitor to prevent corrosion in systems containing dissimilar metals.

The PH of the Propylene Glycol mixture should be periodically tested and the mixture replaced as necessary usually every year. The discharge of Propylene Glycol should be contained and not left to enter the environment or rainwater tanks. If Propylene Glycol does enter a rainwater tank used for drinking water, it will have an adverse effect upon the taste of the water and it may be necessary to drain the contents of the tank to solve the problem. If the glycol is replaced, it should be drained from the system, contained and disposed of in a suitable manner.

Another commonly found problem is that of incorrectly sized expansion vessels. Any thermal expansion of the antifreeze mixture is taken up within the expansion vessel, this vessel is often undersized and the excess expansion results in discharge from the pressure relief valve. To ensure effective long term system performance the expansion vessel should be suitably sized, most systems will have an expansion vessel installed with a volume of 18 to 35 litres or more.

NOTE Do not use Ethylene Glycol, as used in vehicle coolant systems, in solar systems as it is toxic, use only proprietary Propylene Glycol as recommended by the solar water heating supplier.

Drainback

Indirect and direct drainback systems can be designed to be the most reliable and appropriate solar water heating system. The systems incorporate a solar controller which only turns the pump on when there is heat available to be recovered from the collector. When the pump is off, i.e. there is no heat to be recovered from the solar collector, the solar collectors are empty. When the controller detects a greater temperature in the collector, it starts the pump, forcing water up in to the collector and circulates it through to the cylinder. During times of cold weather the pump will not be operating, therefore there will be no water in the collector and thus, providing the water level is suitable, no risk of the collector freezing. This system effectively manages the risks of freezing and overheating.

Controller

The EcoSolar solar controllers have functions to start the pump and allow warm water to enter the collector when low temperatures are recorded by its sensor in the collector, thereby reducing the risk of the water in the collector freezing. The controller monitors the water temperature in the collector using a sensor located in the solar collector. For effective control this sensor should be installed within a dry pocket with heat transfer paste and adequately insulated from the ambient temperatures. Under normal conditions the controller uses this temperature sensor to determine when the collector is warmer than the bottom of the cylinder and turns the pump on and off to recover this heat.

If the collector temperature sensor detects that the water temperature within the collector has fallen below a predetermined temperature, the controller will turn on the pump for a short period of time to circulate some warm water from the cylinder to the collector to increase the collector temperature and prevent it from freezing. This is not a fully reliable method of frost control as it relies upon power being available to the controller and pump, so in the event of a power failure there will be no frost protection. The accuracy of the temperature sensors also needs to be monitored during maintenance to ensure they are recording an accurate water temperature.

Frost Valves

These mechanical valves open, when they are subjected to low temperatures, discharging water from the collector which is replaced by water from the cylinder. This relies upon the correct flow patterns through the system and collector and water being supplied to the collector being warm. These valves should be installed at the top and bottom of collectors on direct heating systems. Please note this is not a fully reliable method of freeze protection, are prone to going out of calibration and are slow to close after the water has warmed up, this results in excess water usage. The valves are susceptible to damage and go out of calibration if exposed to high temperatures. Increased reliability can be obtained if the frost valves are installed on a 300mm length of uninsulated copper tube with a heat trap, thereby limiting the heat from the valve. These valves are useful as a back up to the controller frost protection and also on thermosyphon systems where no controllers are installed.

Figure 7 Mechanical frost valves

Frost valves rely upon the warm water in the cylinder heating the collectors, this therefore results in cooling of the hot water cylinder and thus increased energy consumption.

Water Quality

Water that contains a high percentage of foreign matter, is of poor or unacceptable quality or contains low chlorine concentrations can lead to blockages, corrosion or premature failure of the systems. Such failures are out of acceptable limits and are not covered by the warranty. Systems operating under such conditions should have their periodic maintenance increased to suit.

Collectors

For reference the collector specifications are available from the EcoSolar website.

Cylinders

There are many options for hot water cylinders.

Low pressure

Low pressure copper cylinders offer a good resilience to high water temperatures as experienced in solar water heating systems and are historically proven for most areas. There are several areas in New Zealand that suffer from poor water quality and this can result in a significantly reduced life expectancy.

Many households now insist on higher water pressures and this limits the number of low pressure cylinders being installed.

Medium pressure

Medium pressure copper cylinders offer a good resilience to high water temperatures as experienced in solar water heating systems and offer increased resilience to poor quality water than low pressure cylinders. Medium pressure cylinders provide a good reliable cylinder at a lower price than mains pressure cylinders whilst offering increased water pressures over low pressure cylinders. In many case a good compromise. However, again many households now insist on higher water pressures and this limits the number of medium pressure cylinders being installed.

The low and medium pressure cylinders often offer a reduction in water usage, which is becoming increasingly important.

Mains pressure

There are now more and more options available for purchasers of mains pressure cylinders, including steel lined and stainless steel cylinders.

Lined steel cylinders are often the lower cost option for mains pressure cylinders however care should be taken in their selection for solar water heating systems as many have a relatively low maximum recommended storage temperature. Temperature limitations of between 70 to 85^{O}C are common. Care should be taken in moving steel cylinders as the internal lining can easily be damaged, which then exposes the steel cylinder to the stored water.

Stainless steel cylinders, especially duplex stainless steel cylinders appear to have a good resilience to poor water quality and to the higher water temperatures experienced in solar water heating systems. However their quality and thus life expectancy is very dependent upon the quality and cleanliness of the manufacturing process.

Cylinders with / without heat exchangers

Cylinders can be fabricated with or without internal heat exchangers and there are several configurations available. Unless a heat exchanger is installed, the solar water heating system will operate as a direct (open loop) system, that is, the water contained within the cylinder that is drawn off at the taps is also the water that circulates through the solar collector.

Most existing cylinders do not have an internal heat exchanger and therefore if a solar system is being retrofitted on to an existing cylinder, the solar heating system will generally need to operate as a direct system, that is unless an external or retrofit heat exchanger is installed.

If a new cylinder is being specified it is cost effective to manufacture it with a heat exchanger and these cylinders are available from several manufacturers in New Zealand.

Cylinder capacity

Domestic solar heated cylinders are generally sized on the basis of 75litres of water storage per occupant. This commonly results in the installed cylinder being of a greater capacity than would otherwise be installed. This results in several issues;

- Space allocation and structural loading for the cylinder, although many cylinder manufactures can produce cylinders to suit the space available
- Existing cylinder storage capacity is often only suitable for two to three people and therefore retrofit solar systems, where the solar system utilises the existing hot water cylinder, are only suitable for smaller households. Retrofit systems will be covered in more detail in a future article.

Horizontal versus vertical cylinders

Vertical cylinders are invariably more efficient than horizontal cylinders. However, site limitations may dictate that a horizontal cylinder be installed.

Most thermosyphon systems are designed as a close coupled package of collector and storage container with the storage container invariably horizontal for aesthetic reasons as it will be installed on a roof where a horizontal cylinder blends in better than a vertical cylinder would.

Pumped / Thermosyphon systems

Solar systems can utilise two forms of circulation system;

Pumped systems

These rely upon a small circulating pump to circulate water between the collectors and the hot water cylinder. These pumps are usually mains operated and are initiated by a controller that only turns the pump on when the collector is warmer than the bottom of the hot water cylinder. These pumps are very quiet offering no noise disturbance and only draw between 50 and 100 Watts.

We can also offer 12 volt pumps and controllers which are coupled to a photovoltaic cell of approximately up to approximately 20 to 30 Watts depending upon system characteristics. These systems offer increased reliability on sites susceptible to mains power failure. These systems are often installed in remote sites where thermosyphon systems cannot be suitably installed.

Thermosyphon systems

Thermosyphon systems do not have pumps and operate on the principle of warm water rising from the solar collector into the hot water cylinder. Thermosyphon systems can either have the cylinder close coupled to the collectors or have a remote mounted cylinder. The systems with horizontal cylinders, such as the case with close coupled systems, have reduced efficiency due to thermal mixing within the cylinder.

System Types

There are two overall types of thermal hot water systems;

- Direct System
- Indirect System

In a direct system the hot water that is heated as it passes through the solar collector is supplied to the taps.

An indirect system has a heat exchanger, generally within the hot water cylinder which transfers heat between the liquid being heated in the solar collector and the hot water that is drawn off at the taps. This system has the advantage that a suitable antifreeze mixture can be used in place of water in the solar collector thus limiting the potential of the collector freezing.

All direct and indirect heating solar systems shall incorporate additional suitable relief valves on the solar circuit such to ensure adequate relief of heat or pressure. These will be in addition to other relief valves on the cylinder or in the system. Direct systems will usually have pressure relief valves installed, no isolation valves shall be installed between the cylinder and collectors or relief valve. Indirect systems will usually have pressure relief valves installed which will be suitably rated for the installed expansion vessel, if installed. If the system installed is a drainback system there will be an overflow from the system.

If the hot water cylinder is valve vented, the existing relief valves should be checked for correct operation and adequate sizing. This needs to be completed by a competent and trained plumber. If the relief valves sizing or function is in doubt then it should be replaced with a correctly sized relief valve. The open vent should be checked to ensure that it is not blocked and not becoming blocked.

Mains Pressure Systems

If a high pressure system is installed, it is important to determine the material the hot water cylinder is made from and to obtain guidance from the manufacturer as to the cylinder's maximum allowable temperature. Many high pressure cylinders have a vitreous or glass internal surface that is damaged at the high temperatures, as experienced in solar hot water heating systems. It is important to limit the storage temperature within these recommended limits, this can be done by programming the solar controller and installing three sensors, the third sensor being at the top of the cylinder. At EcoSolar we tend to specify duplex grade stainless steel cylinders, due to their resilience to temperatures and pressures and have found them to be a reliable option.

The solar system may have a pressure reducing valve on the inlet to the cylinder and will be vented in one of two ways either;

- open vented, a vent pipe will extend from the cylinder through the roof and terminate some distance above the roof with an open end.

- valve vented, a thermal / pressure and / or pressure relief valves will be installed to relief any excess pressure or heat from the cylinder.

Low Pressure Systems

Low pressure hot water cylinders are generally fabricated from copper, insulated and have a specification stamped on the cladding over the insulation providing details of pressure rating etc. Copper cylinders are historically proven and have a good resilience to temperature, however they are generally only available as low (7.6m head) or medium pressure (12.2m head).

Connection to an existing hot water cylinder, with no solar system connections

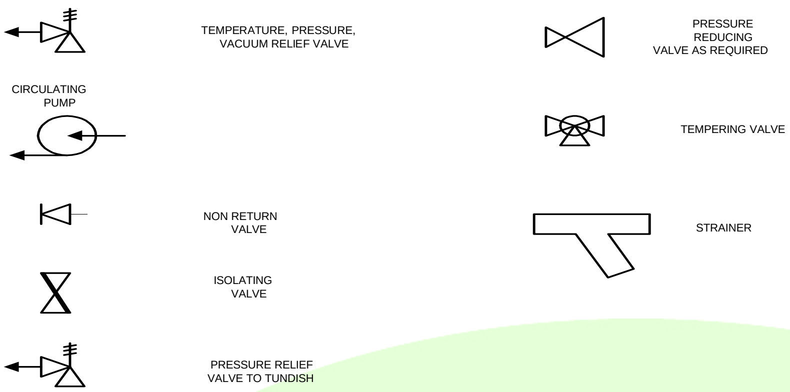
In many retrofit installations the solar system will be installed on to a cylinder that has no spare cylinder connections. Most of these will require the installation of a four way inlet which allows the cold water supply and warm water returns from the collector to be installed in to the existing cold water connection. Alternatively spare lower connections can be utilised.

Where the four-way inlet is required, reference should be made to the existing hot water cylinder to determine any limitations. Some cylinders have a bottom entry cold feed and have no solar connections. Many hot water cylinders have a dispersion plate located above the bottom entry inlet thereby not allowing the 10mm dispersion tube, which is connected on the 4 way inlet, to be inserted in to the cylinder from the bottom. This dispersion plate may, in some cases, be drilled, to allow the dispersion tube to pass through. Reference should be made to the cylinder manufacturer to confirm that this is acceptable.

Connection to a hot water cylinder with solar system connections

These cylinders will either have connections just made into the hot water cylinder and allow the stored water to circulate through the solar collector, direct system, or have a heat exchanger installed within or encompassing the cylinder, indirect system.

Symbols



Solar water heating system types and schematics

Direct or open loop systems

Many direct systems are the retrofitting of a solar system on to an existing hot water cylinder as shown in Figure 8 and 8.

A direct system as highlighted previously is where the water passing through the collectors is drawn off by the taps.

A direct or open loop system generally has a lower installed cost than other types of system and generally have a higher maximum efficiency as they have no heat exchanger losses. However, they are prone to overheating and freezing and so these need to be effectively managed to ensure a cost effective and resilient system.

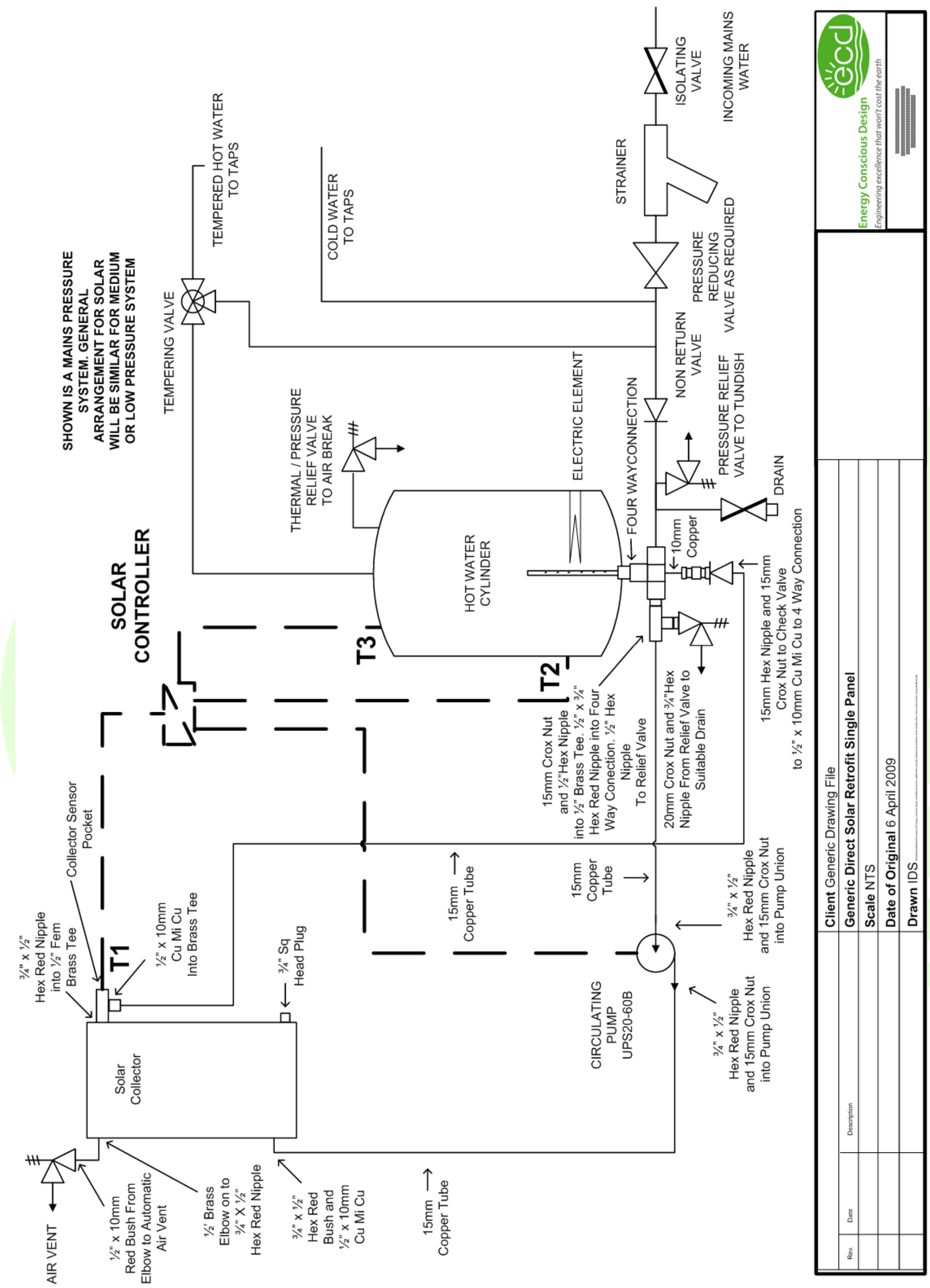


Figure 8 above shows an open loop solar hot water installation retrofitted on to a cylinder with only bottom entry fittings, no bottom dispersion plate. This installation uses the 4 way inlet fitting.

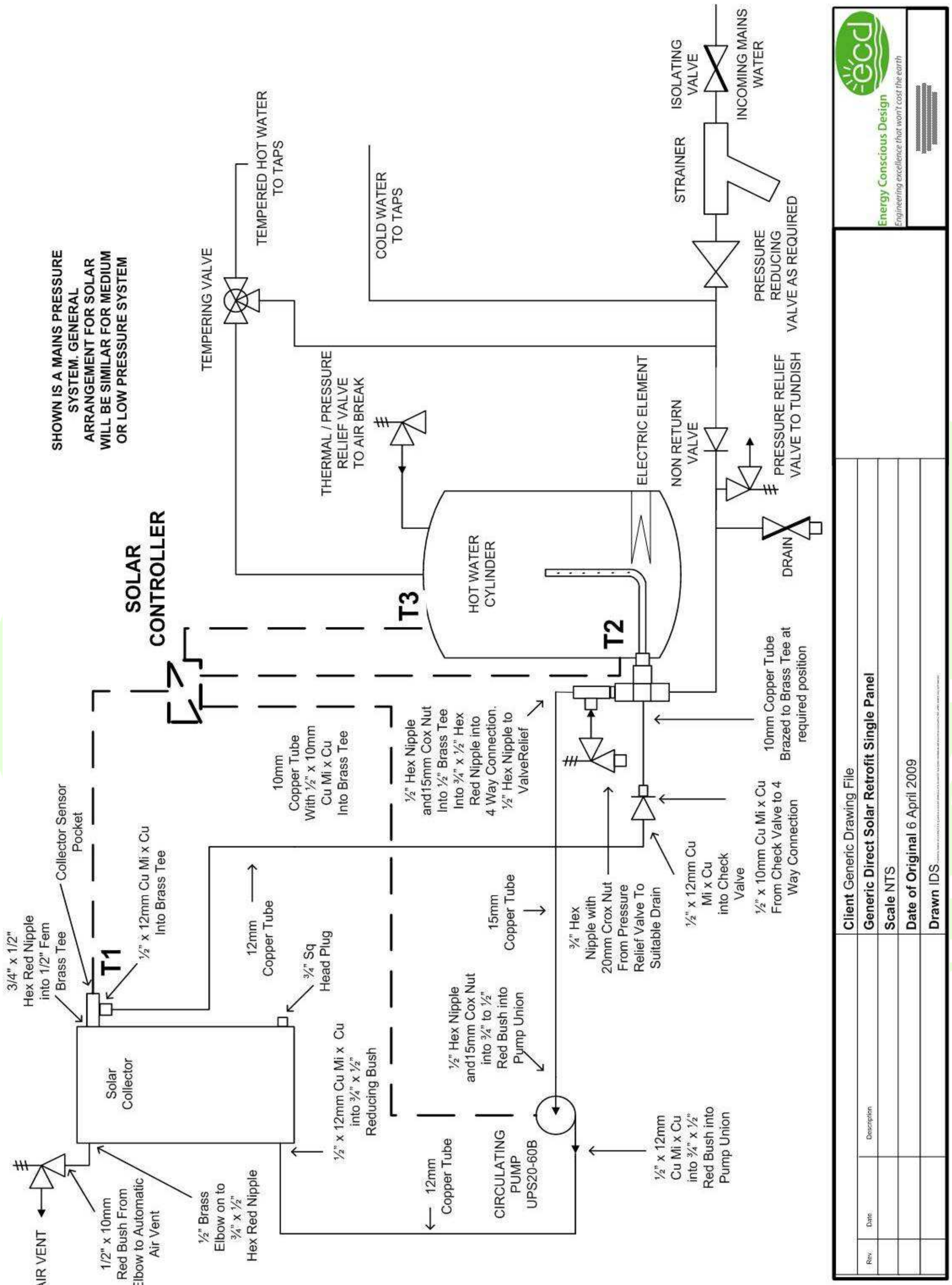


Figure 9 Mains pressure open loop solar hot water installation, using side entry connections and retrofit 4-way connection.

Indirect or closed loop systems

Many indirect or closed loop systems have historically been systems using a Propylene Glycol and corrosion inhibitor, however these system are becoming less favourable as the deficiencies of Propylene glycol are becoming understood. An indirect Glycol based system is shown in Figure 10 below.

These systems are resilient to frost however they have a higher installed cost than direct systems, can be exposed to overheating and have increased levels of maintenance.

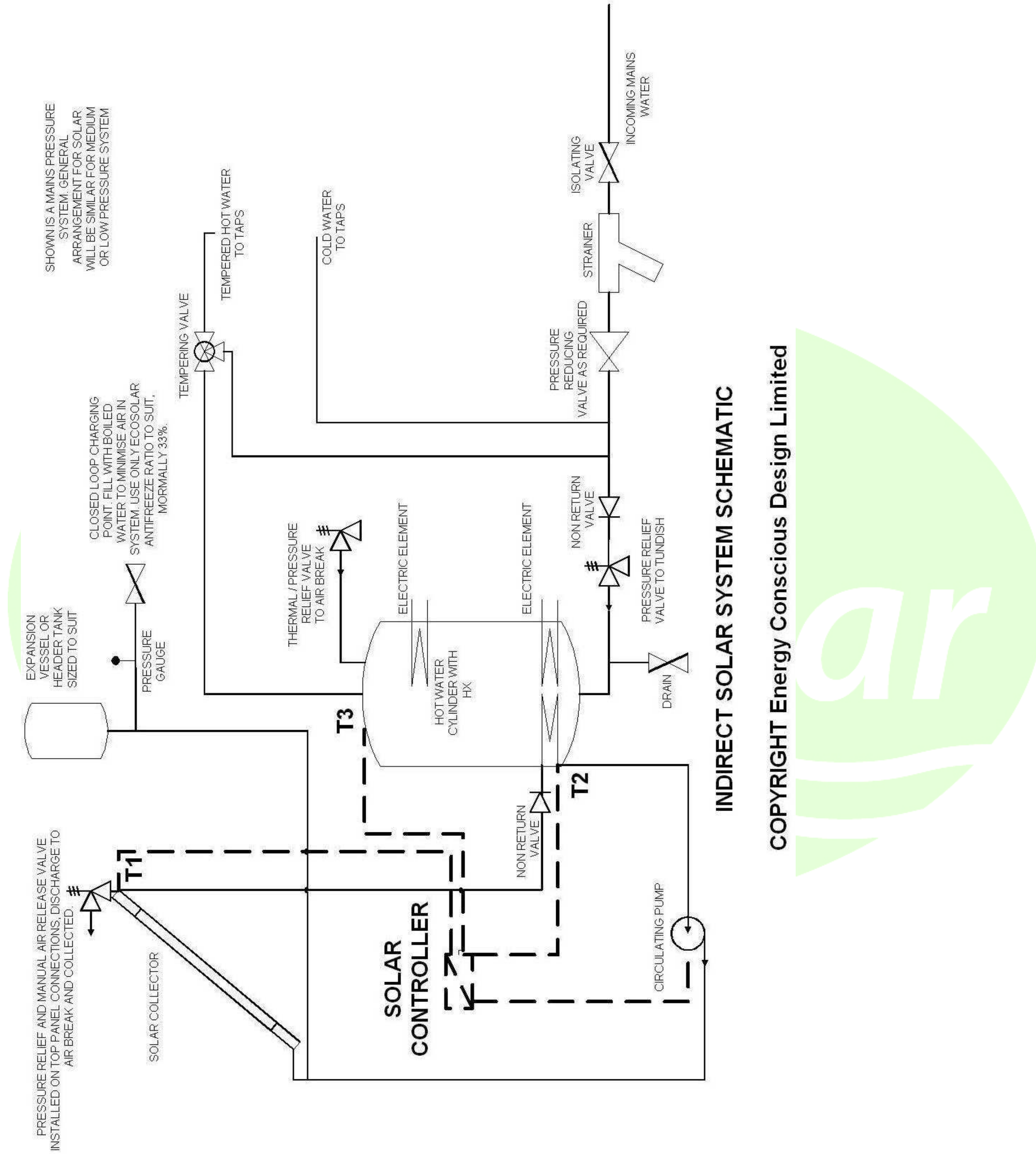


Figure10 Closed loop glycol based system with single pump and heat exchanger in the DHW cylinder.

Indirect drainback system

Drainback systems are often seen to be the most flexible and reliable system and are becoming more commonly installed in NZ. As well as the conventional drainback system as shown in Figure 11 below, options are available to retrofit a drainback system on to an existing cylinder or a cylinder without an internal heat exchange coil, see Figure 12.

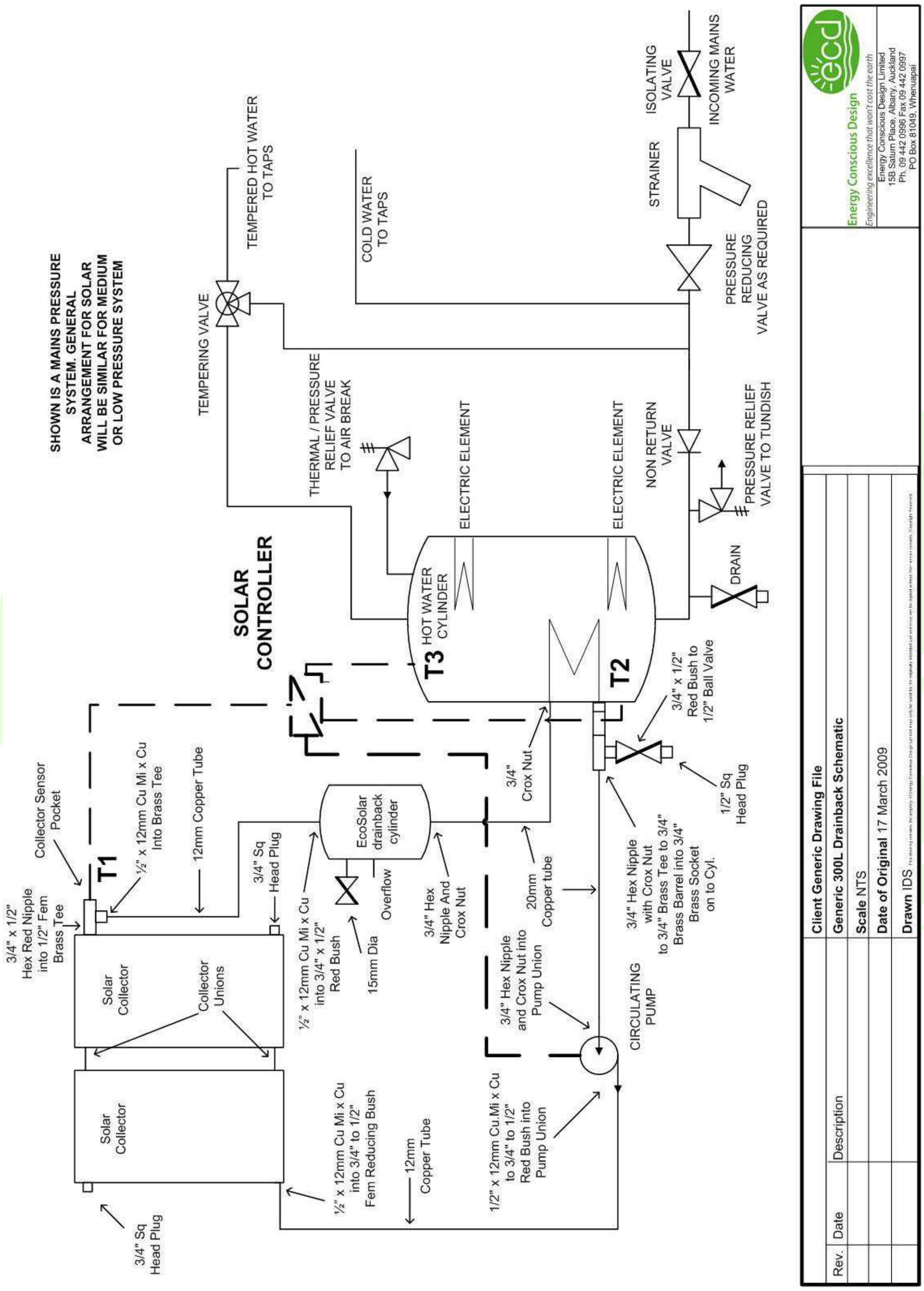


Figure 11 Closed loop drainback system with single pump and heat exchanger in the DHW cylinder.

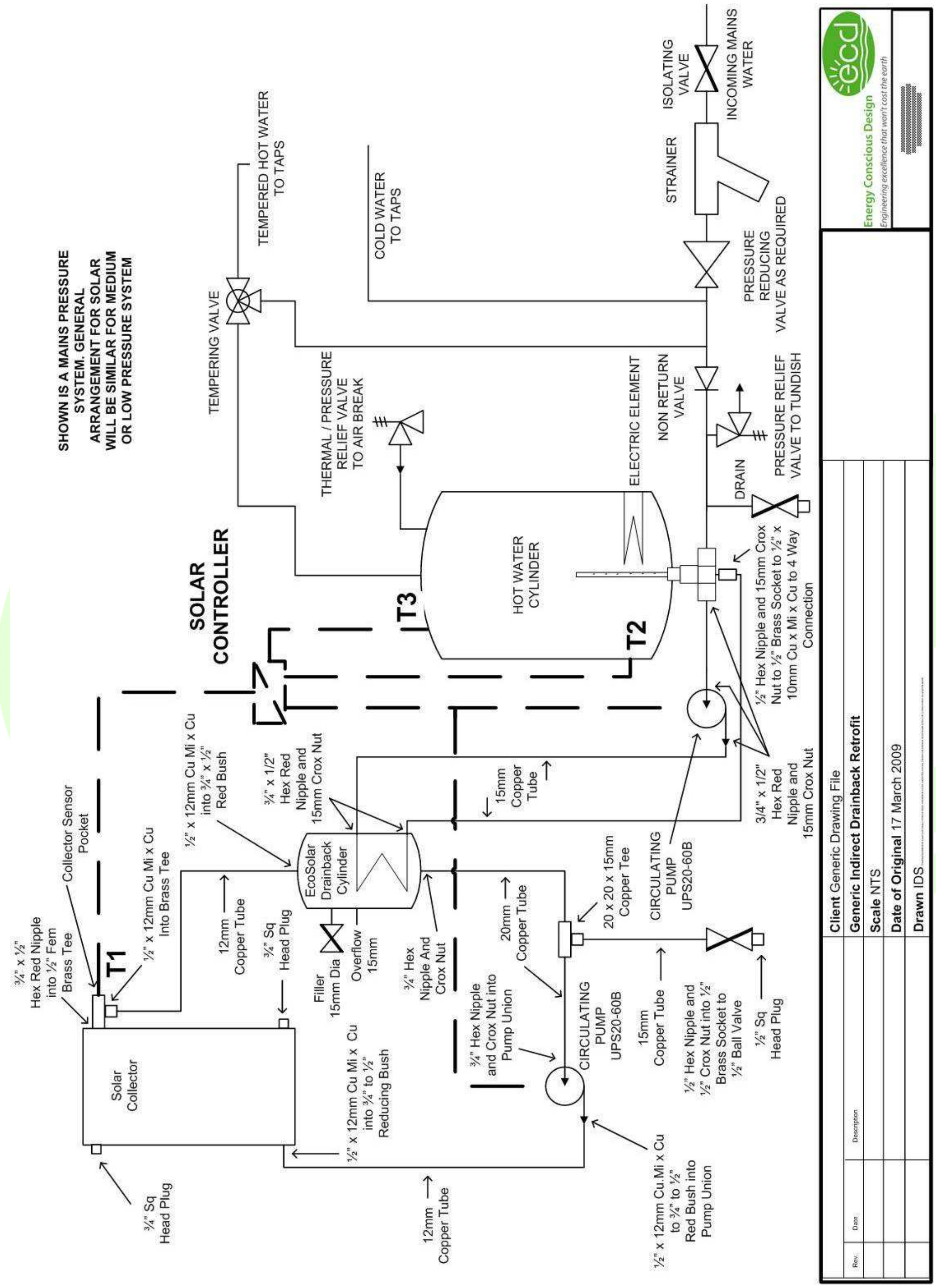


Figure 12 Retrofit indirect drainback system with twin pumps.

Thermosyphon systems

Thermosyphon systems do not have pumps and operate on the principle of warm water rising from the solar collector into the hot water cylinder. Thermosyphon solar heating systems can be either direct or indirect systems depending upon site requirements. There are several forms of thermosyphon system as follows;

Close coupled

The cylinder is mounted directly above the collectors on the roof. This system although generally cheaper to install does have aesthetic and potential structural disadvantages. The cylinder is also mounted horizontally, which increases mixing within the cylinder, which reduces the efficiency of the system. See Figure below.

Remote Mounted Cylinder

These systems have the collectors on the roof and the cylinder located above and some distance from the collectors. The greater the separation distances between the collectors and the cylinder, the less efficient the system. Pipes should be installed inclined up to the cylinder at a grade greater than 1 in 7 and have minimal restriction to water flow by installing swept bends and no sharp changes in direction such as elbows. As the separation distance increases so the resistance to flow also increases and it is advantageous to increase the pipe size from ¾" as per many close coupled systems to 1" and greater to increase the system performance.

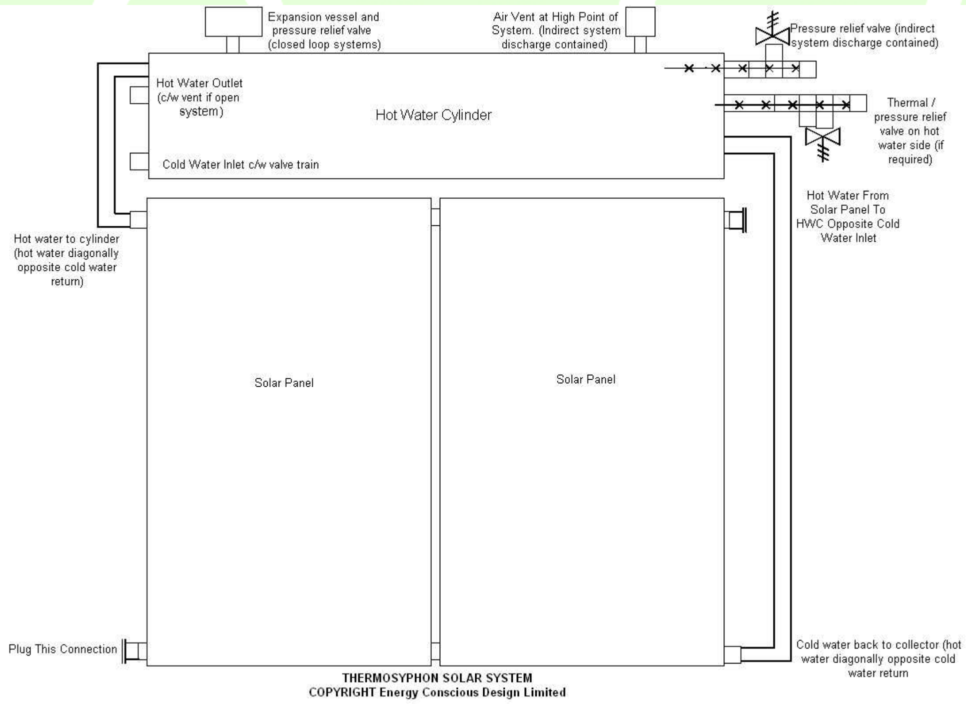


Figure 13. Close coupled thermosyphon system

General Installation

Pipework

All pipework shall be copper and completed in a neat and economical layout, using long radius bends and minimising the use of fittings to ensure that the resistance to flow rate through the pipework is minimised. Pipework shall run straight and true, at a constant grade and parallel to adjacent surfaces. Pipework joints shall be located a minimum of 75mm from walls, beams and floors.

For single and two solar collector installations the flow and return pipework between the solar collectors and hot water cylinder shall be a minimum of 10mm diameter. Systems consisting of three to four solar collectors shall be piped up with 15mm copper pipework. Solar collectors shall not be piped up together in more than banks of four.

Thermosyphon systems shall be a minimum of 20mm diameter only if the solar collector is within a couple of meters of the cylinder and locations are optimal for thermosyphon action else, 25mm pipework shall be installed. All pipework shall be adequately supported, supports shall also be installed immediately either side of pumps, valves and changes in direction. All hot water pipework is to be insulated using Armstrong Armaflex or similar.

Pipework shall be flushed out to ensure no foreign matter remains in the system.

The pipework shall be pressure tested to 1.5 times the working pressure of the system or 1000kPa which ever is greater.

The pipework shall be filled with the air release valves open to ensure all air is removed from the system.

The solar collector shall be located as close as possible to the hot water cylinder to minimise pipework lengths.

NOTE Use PTFE tape to seal the fittings, do not use hemp as this can exert extreme stresses on the fittings which are not covered by any guarantee and can dry out causing leaks.

Long pipe runs shall incorporate expansion loops or bends to allow for thermal expansion. These shall be installed horizontally to avoid forming air locks.

The pipework should be installed such that;

- The flow, colder water, to the solar collector is connected from the bottom of the hot water cylinder to the bottom of the solar collector.

- The return, warmer water, from the solar collector is connected from the top of the solar collector to the top of the hot water cylinder or dispersion tube.

- The pump shall be installed in the flow to the solar collector pipework, i.e. colder pipework.

- A non return valve shall be installed about 0.5m from the hot water cylinder on the hot return to the cylinder to eliminate back circulation, (thermosiphon action using warm water from the hot water cylinder to heat the solar collector)

Roof penetrations

There will invariably be a requirement for both pipes and electrical cables to penetrate the roof. Care shall be taken to ensure the integrity of the roof is not compromised. These shall be in compliance with G12 AS2.

Relief Valve

The relief valve or relief path shall be sized for the total power output of the system at 99^{O}C and 1500W/m^2 and 45^{O}C ambient temperature and any additional heating source. See also Heat Rejection, Page 2 of this guide.

Safe Tray

A safe tray c/w drain to a suitable drain shall be installed on all new and if at all possible under existing hot water cylinders to capture water from leaks.

Controller

Please reference the controller installation manual included with the kitset for details including installing the sensors and programming of the controller.

Solar collector location

NOTE The solar collector is to be installed with the vent holes at the bottom or with the new slot vents on the side. The vents shall not be orientated to allow moisture ingress.

Orientation

The solar collector should be orientated to geographic north for optimum solar gain. Geographic north is between 17 and 24degrees west of magnetic north as shown by a compass. See table below.

Shadows

The location for the solar collector should be carefully chosen to ensure that the surroundings do not cast shadows on to the collector for excessive periods during the day. Remember that shadows are considerably longer in winter than summer and that vegetation may grow to cast shadows therefore, the vegetation may have to be pruned to prevent shadows.

Inclination

The ideal inclination of the solar collector is at an angle equal to the latitude of the site. Deviations greater than 20^{O} will have a significant effect on the annual solar gain. An inclination less than the latitude will result in increased summer performance and inclinations greater than the latitude of the site will increase solar gain during winter. The inclination of the collector is often dependent upon the surface it is being mounted on to and aesthetics. However, if the collector is being mounted on a frame the inclination can often be optimised based upon winter and summer hot water loads and whether a wet back or other winter heat recovery system is installed. The latitudes for New Zealand are shown below;

The collector shall be installed with a slight (10mm) slope upwards to the air vent. This will allow the air to automatically vent rather than airlock.

Location	Geographic north is (X) degrees west of magnetic north, as shown by a compass (X for locations in NZ are shown below)	Latitude
Cape Reinga	17	34
Kaitia	17.5	35
Whangerei	18	36
Auckland	18.5	37
Hamilton	19	38
Taupo	19.5	39
Palmerston North	20	40
Wellington and Nelson	20.5	41
Kaikoura	21.5	43
Christchurch	22	44
Duneden	23	45
Invercargil	23	46
Stewart Island	24	47

Solar collector mounting

The collector fixings shall be mad in accordance with the NZBC, G12, AS2 or shall be specifically designed by a structural engineer. The details below are generic, however specific design is required in high / extreme wind zone areas, such as above a height of 8m above ground level.

Corrugated / Iron sheet roofing

Attach collector to roof inclination

There are several methods of installing the collectors flat on to an iron roof, Figure 14 shows the EcoSolar aluminium profile system. Short lengths of aluminium angle are used to bolt into the roof and the aluminium profile to maintain a separation between the collector and the roof.

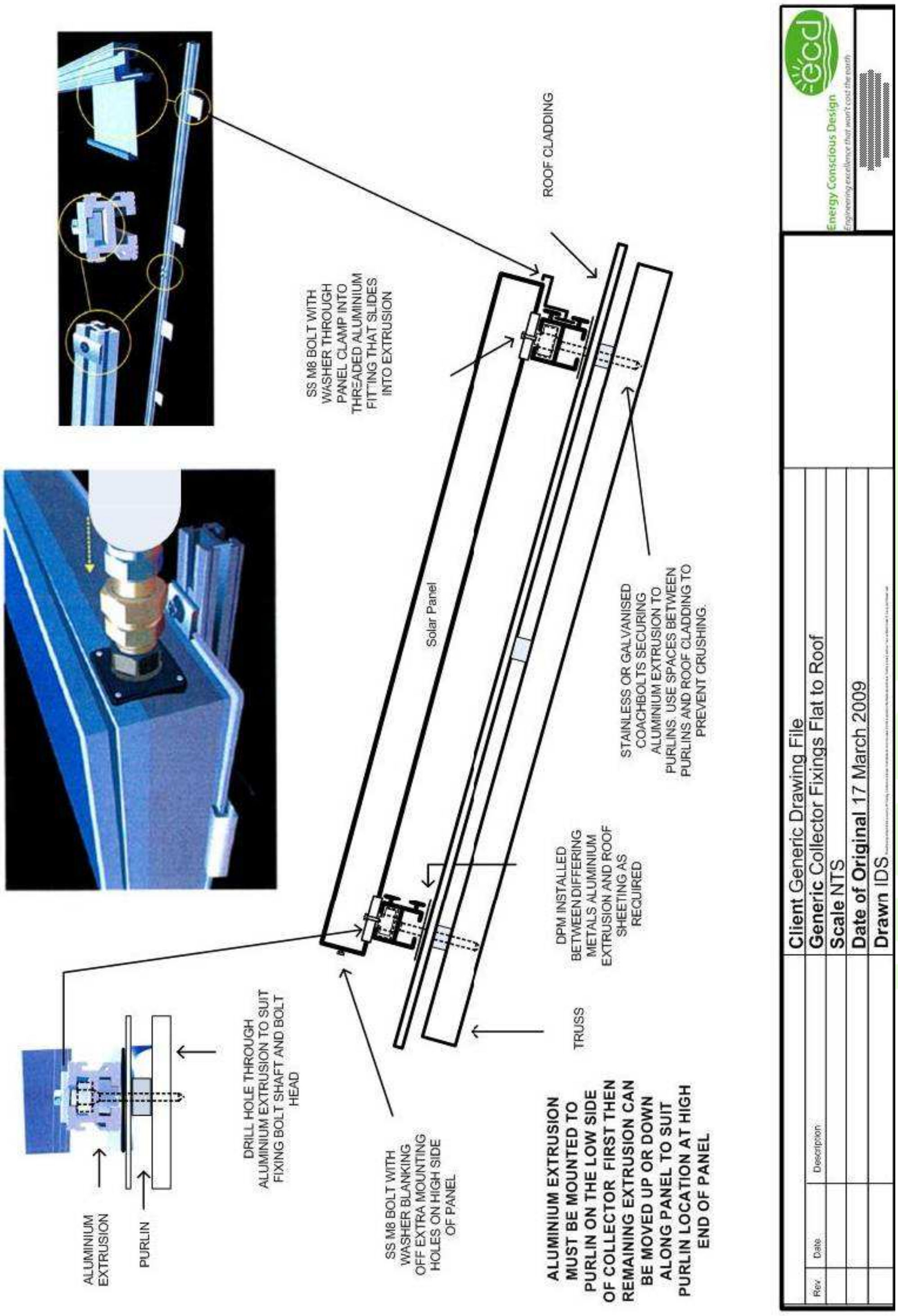


Figure 14 Fixing method to corrugated iron and long run, pan or deep trough roofing.

Tiled roofing

For tiled roofs, install the kitset collector fixings. This kitset consists of 4 lengths of predrilled galvanised strap, 2 lengths of channel, 4 angle brackets and various fixings.

The 4 angle brackets are secured in to the channel and temporarily bolted in to the top and bottom of the collector. The collector is then sited in the required location and the positions of the channel marked out on the roof. The collector is then unbolted from the angle brackets. The channels are laid horizontally across the roof in the required location. The straps are bolted on the channel and fed under the tiles, being formed into the required shape as required to prevent any conflict with the weather proofing of the roof or tile pitch. The straps are then coach screwed in to the battens, twisted and coach bolted in to the trusses.

The collector is then bolted on to the angle brackets using M8 bolts. Rubber separators are to be installed between the angle brackets and the solar collector. See Figure 15 below.

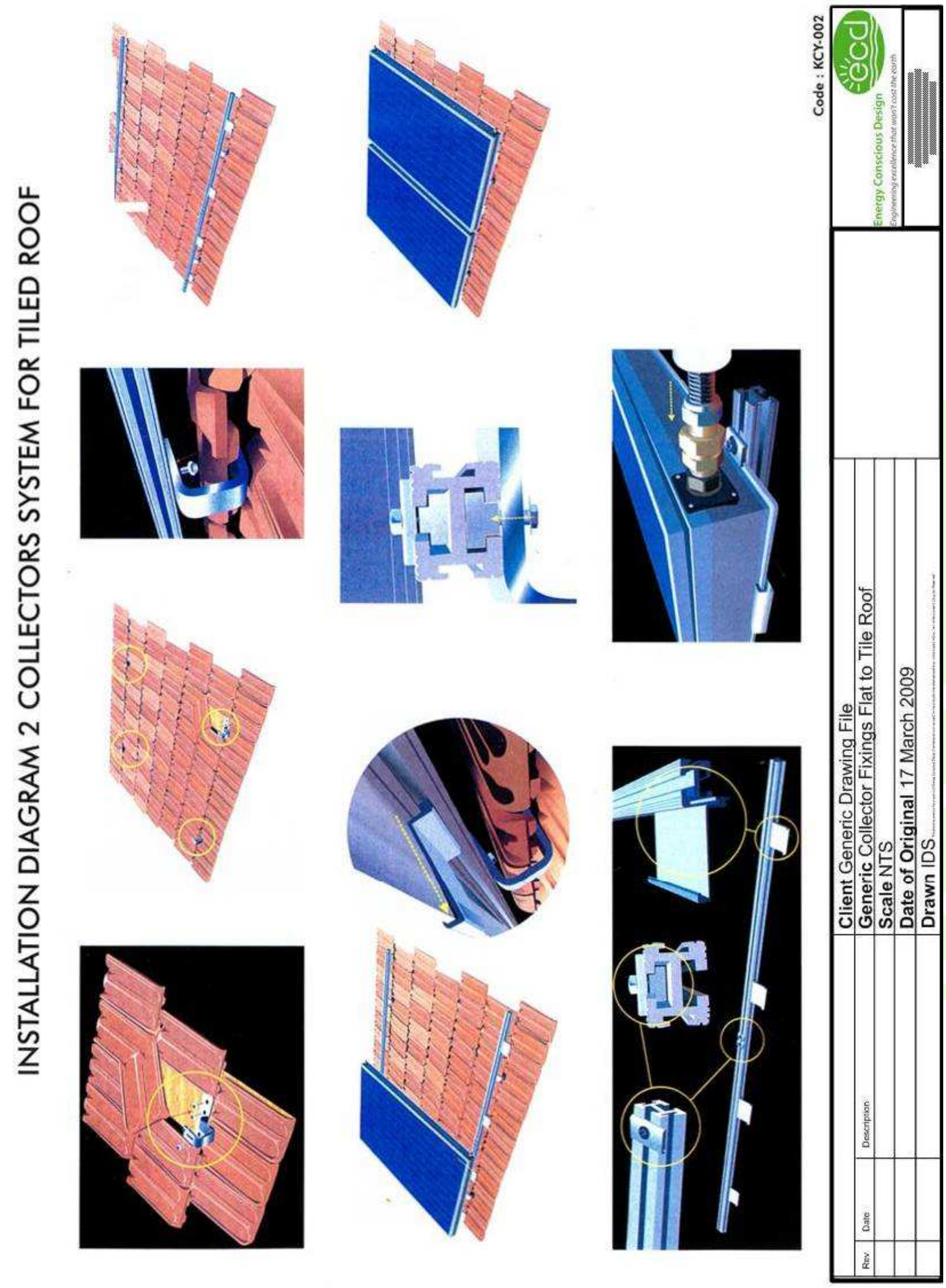


Figure 15 Fixing method to tiled roofing

Flat roof or to increase or decrease collector inclination from roof pitch

The concept for increasing the collector pitch off of a pitched roof is shown below. The pitch required shall be stated when ordering the fixing kits from EcoSolar.

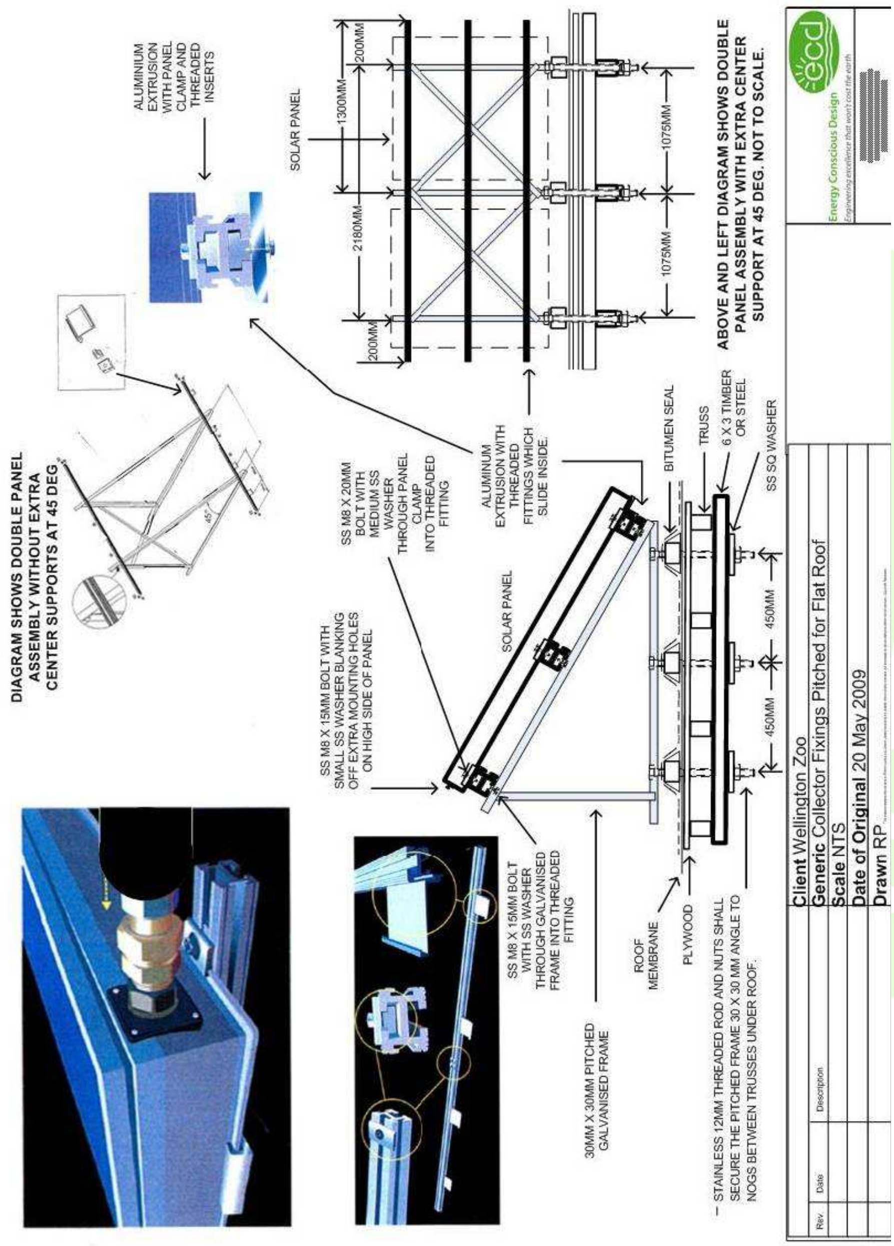


Figure 16 Fixing method pitching collector off of a flat, corrugated iron or shallow trough roof

Collector inclined across roof pitch

This type of installation requires specific design for the design of the collector mounting frame, however the concept is similar to that shown in Figure 16 above. Figure 17 presents a potential system. Please contact us for details.

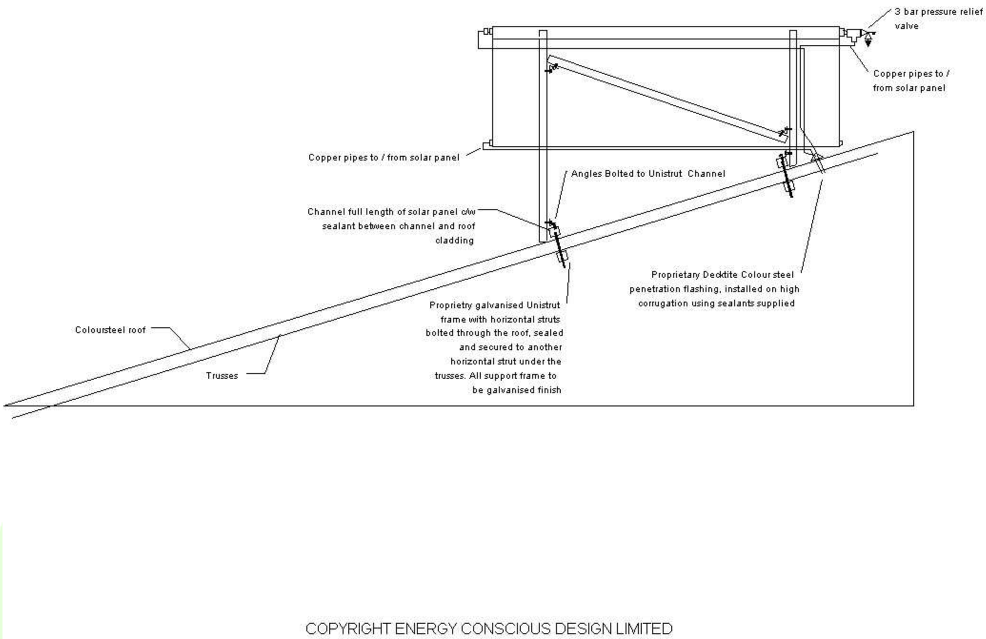


Figure 17 Fixing method pitching collector off of a corrugated iron or shallow trough roof

Maximising the benefit from solar hot water

Following these recommendations will further enhance the benefit from your solar hot water system.

- Install low flow shower heads, taps, install flow restrictors and generally conserve water
- Heavy washing or hot water consumption maximised during the middle of the day
- Showers to be taken in the evening
- If showers are to be taken in the morning, you may need to utilise the electric booster however this should be minimised

System control

System Control Overview

A well designed system will incorporate a level of control that maximises energy savings whilst allowing the end user to manage the system, supply hot water on demand and minimises the risks associated with legionella forming in the cylinder. The level of control is dependent upon the user requirements and the type of system installed. In summary a solar water heating system should be controlled as follows;

- If the solar systems is pumped, the solar heating pump is generally switched off and is only switched on when the solar collector is warmer than the bottom of the cylinder, i.e. there is heat to recover and the cylinder temperature is below its maximum temperature.
- The system will often have a backup heating system such as an electric immersion heater. To maximise savings these backup heating systems should be left off during the day until the solar system has heated the water as high as it can, then the backup heating can be switched on to top up the water temperature to the desired temperature.
- The backup heating is used to control the risk of Legionella.
- Ecosolar contollers automate the solar water heating system. The most commonly installed controllers are the EcoSolar ESR21-R3 and the UVR61. These are described below;
- ESR21-R3, a multi function controller which automates the solar water heating system. Temperatures within the collector, the bottom of the cylinder and the top of the cylinder are monitored and displayed on the clear LCD screen. The solar heating pump is turned on when the collector is warmer than the bottom of the cylinder, i.e. there is heat to recover. It also has a defrost function, turning on the pump to circulate water from the cylinder to the collector to raise the collector temperature if the collector temperature has dropped to a point where there is a potential of freezing. See also earlier section on frost control. There is also the capability for the controller to data log the heat being recovered from the collector, this requires the optional flow meter to be installed.

The monitoring of the water temperature in the top of the cylinder is a beneficial feature as it allows the user to more closely manage the water temperature in the cylinder, being more informed about how much hot water is available and whether the backup heating should be initiated, see section below on "Existing hot water cylinder heating source". This controller is installed in cylinders that must have their maximum temperature limited, such as lined steel mains pressure cylinders.

Figure 18 EcoSolar ESR21 R3 controller

- UVR-61R3, having all the functions of the ESR21-R3, this controller is able to monitor 6 temperature sensors and can also monitor an EcoSolar solar radiation sensor. This controller can control up to 3 solar systems allowing the solar collectors to heat up to 3 hot water cylinders, swimming or spa pools. Multiple arrays of solar collectors in different locations can also be controlled, such as when collectors cannot be installed facing North and are instead installed facing East and West. The controller has an internal daily timer which is able to control 3 outputs, this function is often used to automate the backup heating. The controller will determine if there is sufficient hot water available at a predetermined time of day and automatically turn on and off the heating as required. The 6 sensors are able to be data logged via the optional D-Logg which can download through a USB port to a computer, providing daily graphs of the data and system performance and can also be exported in to Microsoft Excel.

Figure 19 EcoSolar UVR61R3 controller

- Ecosolar "OneShot", this backup heating controller is installed with the above controllers. The user is able to manually turn on the backup heating and the controller will automatically turn the heating off once the water is up to temperature. The user can choose if the heating should only be turned on once, i.e. it will turn off once the water is up to temperature and will not turn on again if the water temperature drops, or to have the backup heating on continually. This cost effective backup heating controller will save considerable energy as, in the past if a solar system was unable to provide sufficient hot water the backup heating was manually turned on but often the user forgot to turn it back off again, resulting in considerable energy usage. This controller automates this function by automatically turning the backup heating off once the water is up to temperature.

There are also more sophisticated controllers that can satisfy even more demanding situations such as the UVR1611 which is IP addressable and able to display graphics, schematics, realtime and data logged data over a local area network (LAN) or the internet and can be accessed remotely over the internet.

Thermosyphon systems

Thermosyphon systems by their very nature require less control than pumped systems. If there is sufficient solar gain to heat the water contained in the solar collector, the water will rise into the cylinder to be replaced by colder water from the cylinder. Thermosyphon systems should incorporate a control system that is able to inform the user of the cylinder temperature, both at the top and bottom of the cylinder and allow the backup heating, such as the electric element, to be easily managed.

Pumped Systems

In addition to the control requirements of the thermosyphon systems, pumped solar systems also need a differential temperature controller to only turn on the circulating pump when there is heat to be recovered from the collector, i.e. when the water temperature in the collector is warmer than that of the water in the bottom of the cylinder.

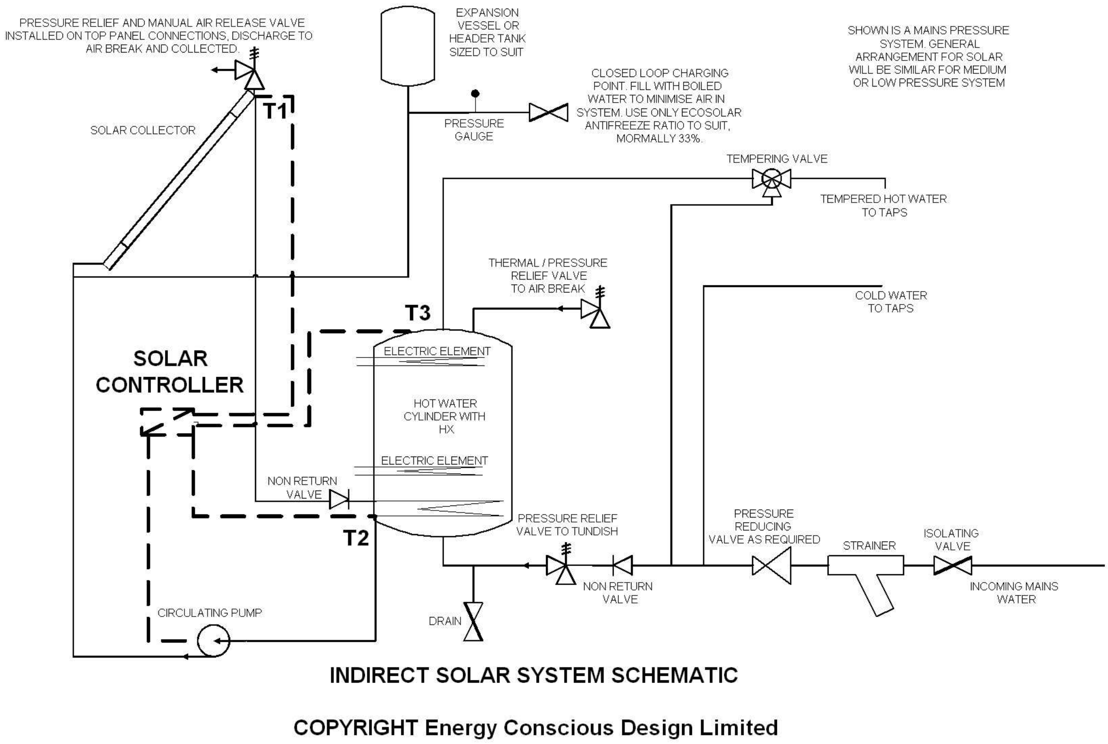


Figure 20. Closed loop solar system showing the placement of the temperature sensors, T1, T2 and T3, in the top of the collector, bottom and top of the cylinder respectively.

Temperature sensor installation

Temperature sensors should be installed such that they monitor the water temperature and are not influenced too greatly by their surroundings. Sensors are often installed in dry pockets and attached to the surface of the actual water cylinder vessel. A heat transfer paste should be used to improve heat transfer between the surface being measured and the temperature sensor. The sensor should also be adequately insulated from the ambient conditions.

Variable speed drives

The EcoSolar ESR21D and UVR61R3 controllers both come standard with a variable speed drive. Utilising this speed drive will considerably increase the system performance and its reliability.

The pumps are installed and set to the high speed (3 on Grundfos) setting. The pump will then always start on the high speed thereby providing the maximum torque to start the pump. Many solar system failures have been due to the pump being unable to start, they are often set to low speed to minimise mixing in the cylinder but this low speed reduces the amount of torque that the pump has to start, this is especially a problem in direct or open loop systems as there could be a build-up of particulates which restrict the starting of the pump. Once the pump has started the controller reduces the pump speed to maintain a constant temperature differential between the collector and the bottom of the cylinder. The pump will rotate faster with an increase in solar gain and slow down with less solar gain. As the pump slows to maintain the temperature differential the pump will also slow down if there is mixing in the cylinder, thereby minimising the mixing and increasing system performance. Currently the slowest pump speed should be set at 40% of the maximum speed.

Overheating

Over heating within solar water heating systems is a significant issue that needs to be carefully managed in order to ensure the system's long term reliability. Over heating puts excessive stresses upon all of the components within the system. Lets look at some of these issues,

Cylinders

Cylinders generally have a maximum design temperature that should not be exceeded. Many of the hot water cylinders sold in New Zealand are lined steel cylinders, these generally have a lower maximum design temperature than the copper or stainless steel cylinders. Particular attention should be paid to retrofitting solar water heating on to existing mains pressure lined steel cylinders, as this often results in the cylinder experiencing excessive stresses that can void any warranty on the cylinder and potentially lead to premature failure.

Collectors

One aspect to choosing a collector should be their resilience to the maximum temperatures that are likely to be experienced in the system, some collectors are more at risk than others and this is a key question to ask any solar supplier.

Valves

Many systems are installed reliant upon valves managing the risks associated with overheating and excessive pressure. These valves discharge water from the system, resulting in excessive water consumption and wear and tear on the valves. New Zealand and Australian Standards will require another solution to managing the problem. Tempering valves will also have maximum hot water temperatures and an uncontrolled heat source will heat water above these maximum temperatures. All the valves should be correctly selected and maintained.

Pumps

Pumps also have maximum design temperatures that should not be exceeded, however another issue that needs to be managed is the boiling of water at the inlet of a pump. Water boils at lower temperatures as the pressure decreases, at the inlet of the pump, there is potential, depending upon the water pressure and the temperature, for the water to boil and lead to cavitation which can damage the pump.

Expansion vessels

Expansion vessels will have maximum temperatures that should not be exceeded, this can often be managed with correct location of the expansion vessel. The sizing of expansion vessels is critical for the reliability of the system.

Propylene Glycol

Heat leads to the premature break down of propylene glycol in to various acids. In systems that experience excessive temperatures, glycols have been found to break down and become concerningly acidic after just one Summer.

The factors leading to overheating of the solar systems are generally, poor system design and insufficient hot water draw off. The following issues need to be managed to prevent overheating;

System design and overheating

The collector area should be sized for the expected hot water draw off, excessive collector area will provide too much heat in to the system and lead to overheating unless correctly managed. Many installations will experience intermittent hot water draw off such as, baches or commercial installations and / or are sized to heat several end uses, such as domestic hot water, swimming pools and under floor heating.

There are several ways of managing the excess heat to limit the effects of overheating, these are outlined below;

Heat dumping

Once the hot water cylinder or other hot water demands are up to temperature, excess heat is supplied to a circuit that is able to safely dump this excess heat. This can be completed automatically with a solar controller such as the one shown below in Figure 1. This controller is able to prioritise heat to the domestic hot water cylinder and another hot water demand such as a swimming pool and then automatically control the system to discharge excess heat to the heat dump circuit. Once the hot water cylinder temperature reduces or there is another heating demand, the solar heated water is redirected back to the hot water cylinder or other heating demand until again satisfied.

Figure 21 Latest generation EcoSolar controller is able to automatically control a solar system to prioritise heat to several heating demands and then dump excess heat so to avoid system overheating.

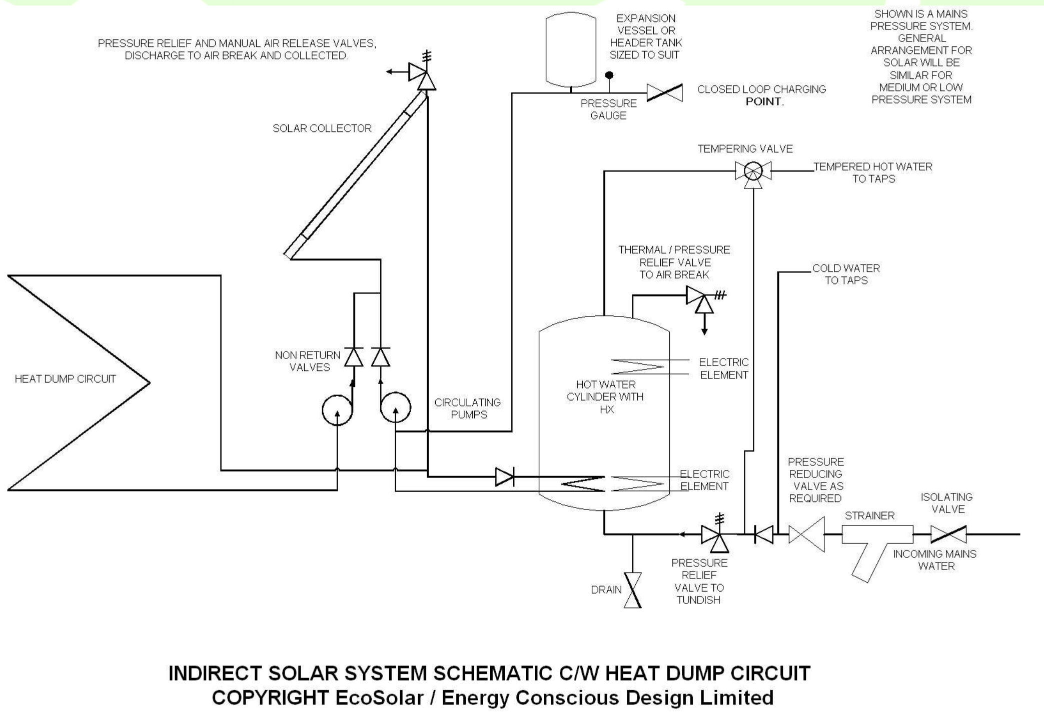


Figure 22 Closed loop solar water heating system with automated heat dump system

A heat dump may be an external heat exchanger, such as a fin and tube located under the South facing eaves or shaded under the solar collectors, hot water passes through the heat exchanger transferring the heat to the surrounding air. Another option, especially suited when a hydronic underfloor heating system is being installed, is to install a circuit in an outdoor area, such as under a patio area. The excess heat is then provided to the underfloor heating system which directs it to the heat dump circuit.

Drain back

These systems are common in Europe and many overseas markets whereby they provide an excellent solution to both the overheating and freezing issues. The collectors selected for these systems must be able to be exposed to these high temperatures without suffering damage. Many collectors are therefore not able to be installed in such systems.

Solutions are available for installing a drainback system for low or mains pressure cylinders, these are outlined below. One common factor to each installation is that the collectors and any pipework that could be exposed to low or high temperatures should be fully free draining. Whilst the pump is turned off there is no water in the collectors, there is then no risk of freezing in cold weather and no risk of the system over heating in warm weather or during periods of low hot water demand. The collector, as stated above, has to be selected to be able to cope with these high temperatures.

Low pressure drainback with header tank - although becoming less common, there are still installations where the hot water system is fed from a header tank located in a loft area. Provided the solar collectors can be installed above the water level in the header tank and the system is installed and commissioned properly the system should operate as follows. When there is a heat demand and there is heat to gain from the collector, the pump is switched on, this draws water out of the cylinder, which is replaced by water from the header tank, and pumped through the solar collector. When the heat demand is satisfied or when there is no longer heat in the collector, the pump is switched off and the water drains back to the cylinder. Care should be taken when selecting pumps for these systems to ensure, sufficient pump head to prime the circuit and not too much flow that could result in mixing within the cylinder.

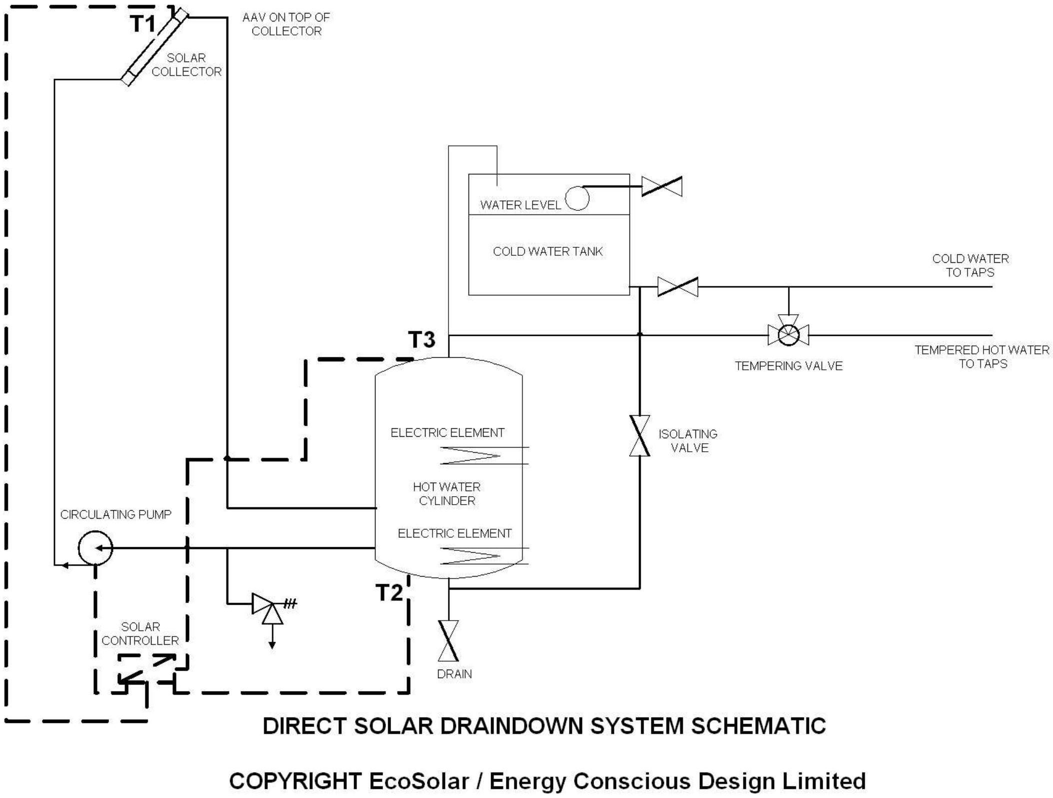
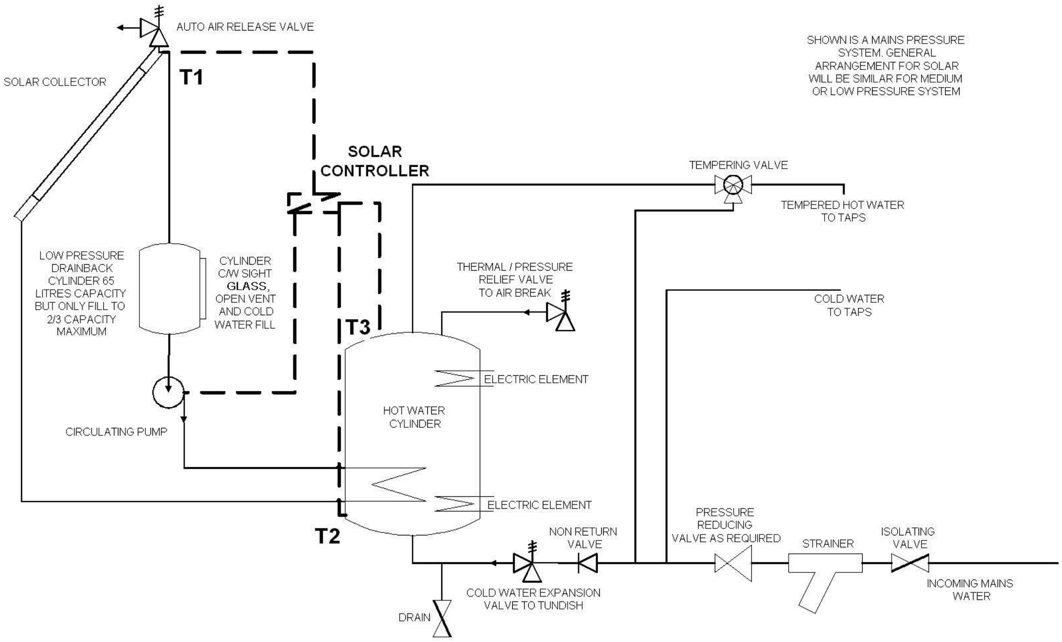


Figure 23. Low pressure drainback system with header tank.

Mains pressure drainback with receiver – these systems are uncommon in New Zealand but offer many more advantages than conventional closed loop circuits with propylene glycol whilst costing about the same to install.

The closed loop is charged with water so that the receiver is a maximum of about two thirds full of water. Provided the system is installed properly the system should operate as follows. When there is a heat demand and there is heat to gain from the collector, the pump is switched on, this draws water out of the receiver, pumping it through the heat exchanger and through the solar collector. When the heat demand is satisfied or when there is no longer heat in the collector, the pump is switched off and the water drains back to the receiver. A sightglass on the outside of the cylinder indicates the water level which should be periodically checked.



INDIRECT DRAINBACK SOLAR SYSTEM SCHEMATIC

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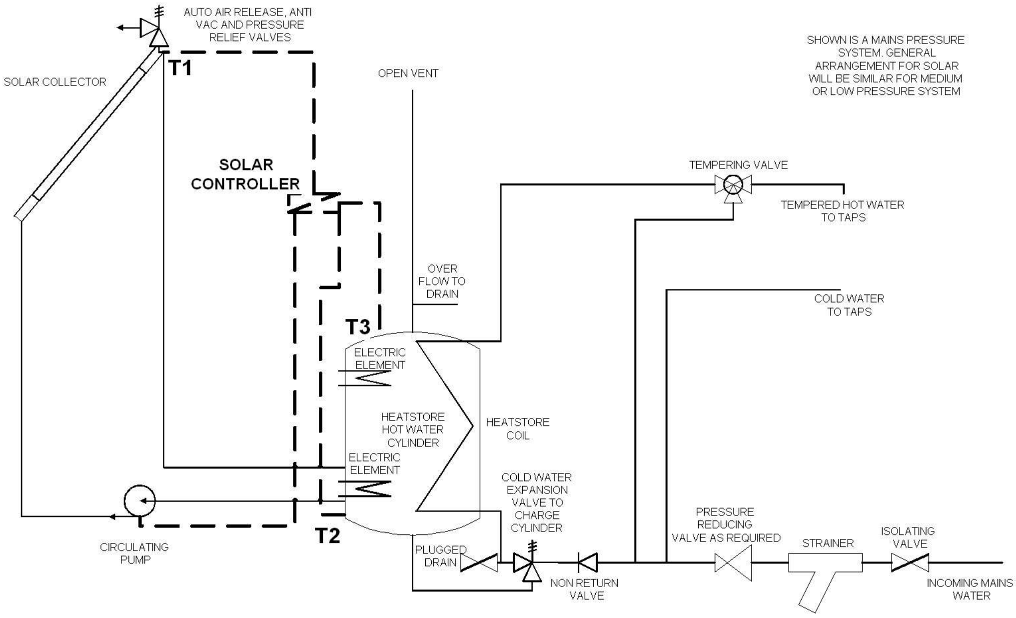
Figure 24. Mains pressure drainback system using a closed loop system

Mains pressure hot water drainback system using a heatstore cylinder – see figure 25 below, these systems are becoming more common as again they offer significant advantages over closed loop systems. The cost of installing these systems is much lower than a conventional closed loop system using glycol and therefore these systems are often being installed with an instantaneous gas heater to boost the water temperature upon demand. This results in a seamless hot water demand for the client at a cost similar to those for conventional systems and without the maintenance issues associated with propylene glycol.

The heatstore cylinder is a low pressure copper cylinder with around 45 metres of mains pressure copper coil heat exchanger inside. The solar collectors can be installed above the water level in the cylinder and provided the system is installed properly the system should operate similar to the low pressure system with the header tank as described above. The hot water however is supplied at mains or high pressure, the cold water enters and is heated as it passes through the coil to be supplied to the points of use. See the next article on options for boosting the water temperature for details of installing an instantaneous water heater.



HEAT STORE SOLAR SYSTEM SCHEMATIC

Figure 25. Mains pressure hot water drainback system using a heatstore cylinder

Reliability

As a solar water heating system returns savings over an extended period of time and is generally not located in an readily accessible position, the system needs to be installed and operate with minimum intervention from either the owner or the installer. We all have a duty to ensure the systems we specify or install are fit for purpose and will provide maximum savings for the client. Incorrectly designed and installed systems will not only provide headaches for those involved in that particular installation but it will have a significant impact upon how the industry is perceived and whether such systems are seen as an appropriate solution to the rising cost of energy and the impact to the environment.

Existing hot water cylinder heating Source

Once the solar hot water system is installed the existing hot water heating source needs to be managed to minimise the energy consumed heating water, maximise the use of the solar heating system and minimise the risk of Legionella forming within the hot water cylinder and system.

Under normal circumstances the heating source is turned off and is only turned on when additional hot water is required or to minimise the risk of Legionella. There are several options to manage the heating source, manually or automatically.

The first and most popular method is for the occupants to monitor the temperature within the hot water cylinder, using the controller, to ensure there is sufficient hot water for their requirements. The temperature below which additional hot water is required will vary from household to household and the occupants will determine this temperature over time. If additional hot water is required the backup heating should be able to be turned on and once the water is up to temperature should be automatically turned off. This manual control, providing the heating is automatically turned off, should result in the backup heating being on the least amount of time and provide the greatest savings.

Figure 26 "One Shot" Backup heating controller, allows manual control of the backup heating. The heating is manually turned on and will be automatically turned off, maximising the savings from the solar system

The EcoSolar UVR61-3 controller is able to automate the above process by determining if there is sufficient hot water in the cylinder at the end of the day and automatically turning on and off the heating as required. This allows the EcoSolar heating systems to be seamlessly integrated in to your lifestyle.

Some systems rely upon a large cylinder with two or more immersion heaters, the ones at high level being permanently switched on. Although this provides a continual supply of hot water, its operation increases the amount of energy consumed and reduces the amount of energy savings the user is likely to achieve. Another option, although having a greater capital cost, is to install a preheating solar system, these options will be discussed in greater detail in a future article.

For maximum savings when installing solar on to gas heated cylinders a solenoid valve is installed on the main gas burner line to hold off the main burner, the solenoid is then initiated by a timer. This will also be the subject of another future article.

Legionella

Unless the hot water cylinder is being heated regularly to greater than 60^{O}C, there is a risk of Legionella establishing itself in the hot water cylinder. In order to minimize this risk the water should be heated to 60^{O}C for 6 hours once a week. This function can be manually managed or EcoSolar are able to supply controllers or timers that take care of this function for you. If you are managing this yourself we recommend that the water is heated at the same time each week this way the management will hopefully become habitual. If the cylinder has two immersion heaters the lower one should be initiated to maximise the amount of water heated.

Please note that the above will limit but not prevent Legionella from establishing it's self in the hot water cylinder. The shower head is most at risk most pipework is also a risk area. All the pipework should be regularly flushed to limit the establishment of Legionella this is the case on all hot water systems, more so where tempering valves are installed as the water downstream of the tempering valve only reaches 45^{O}C which is an optimum temperature for Legionella growth.

Safety

In addition to the normal conventions for safety, when installing or working on the system please take note of the following;

- Isolate electrical supply to controller, pump and electric water heater booster
- Wait for the system to cool down
- Wear protective clothing due to sharp edges and hot components.
- Turn off the water supply
- Release the water pressure using the relief valves
- Cover the collectors and pipes etc with cardboard or sheets to limit heat gain from the sun

Periodic Maintenance

To ensure correct system operation and to retain the system and component Warranty, the system must be maintained in accordance with the recommended levels of maintenance. Please also refer to the operation and maintenance manual and check lists for further information. However, generally the periodic maintenance should consist of the following;

Every 6 Months

- Clean solar panel glazing
- Check drains free of obstructions

Annually

- Check solar panels for shading
- Measure and test Propylene Glycol antifreeze acidity level and colour (closed loop glycol systems)
- Check solar system pressure (closed loop glycol systems)
- Check water level (drainback systems)
- Check thermal and pressure relief valves and pressure relief valves for correct operation
- Check tempering valve for correct water temperature
- Check for worn seals around the solar panel
- Check cables to thermocouple sensors
- Check temperature sensor displayed temperatures
- Check electrical system and water booster heater
- Check pump and differential controller operation

3 years

- Check system and connections for leaks
- Replace pressure and thermal relief valves

- Replace cylinder sacrificial anodes
- Clean out strainers
- Check pump and differential controller

Glazing maintenance

The glazing will require periodic cleaning, ensure you have a suitable standing area, that will not become wet during cleaning or if it does, will not endanger. Clean during cool times of the day so the glass is not hot. Hose off, clean with a brush using simple green or similar and rinse off again.

During the life of the collector, the glazing may be damaged and require replacement. This can be a difficult and hazardous task if undertaken on the roof and so under most circumstances the collector would be removed from the roof to have its glazing replaced. The actual replacement of the glazing is a relatively easy task, aluminium extrusions clip on to secure the glazing in place with a "U" shaped EPDM seal.

Lever off and unclip the four outer perimeter extrusions using an approximately 75mm wide lever, once removed the glazing can be lifted off. Clean the collector absorber, leave to dry or moisture has entered the collector and replace the glass.

System handover

Before handing over the system the installer much check and ensure that all requirements have been met and the full installation is tested and commissioned. This shall include the water and electrical systems.

The owner shall be provided with the relevant instructions and shall be instructed on the correct operation and support required to obtain the most benefit from their installation.

The owner shall also be provided with copies of;

- Installation sizing / survey
- Installation inspection report
- Operating and maintenance instructions
- Manufacturers information
- Recommended maintenance check list

- Guarantees
- Code of Compliance and
- Other relevant certificates and information

Structural

Structural has not been dealt with in this document and it has been assumed that the building has been designed to NZS3604 or equivalent. It is the installer's responsibility to ensure that the necessary structural assessments have been made. The installation should be installed in accordance with The New Zealand Building Code (NZBC) G12 AS2

Basic wiring and programming of the ESR21 controller

Please refer to the solar controller booklet for specific installation and programming details, however the following will provide a logical process for programming the controller for a majority of installations.

- For hot water cylinders that require a temperature limit to be preset, the 3 sensor controller is required, the controller needs to be in Program 1, with the maximum temperature cut out to be set at both sensor 2 and sensor 3.

- The Sys PF, collector antifreeze function within the Men Menu shall be programmed and initiated where only water is circulated through the solar collector. Where antifreeze is within an indirect circuit no electronic frost protection is required. The settings should be programmed as follows; initiation $4^{O}C$, released $7^{O}C$.

- The heat quantity counter can be set up providing the water volume flow rate is known. This can be estimated by measuring the pressure across either side of the pump (when the pump is operating) and calculating the flow rate from the pump curve. If this is required binder tapping points will be required either side of the pump in straight section of pipework. Alternatively a flow meter can be temporarily installed to determine the flow rate. Care should be taken that this does not exert additional frictional losses which would decrease the flow rate from the norm.

Here follows instructions that should be read in conjunction with the instructions supplied with the controller. The controller must be wired correctly and programmed as follows.

PLEASE NOTE Ensure that the controller cables do not come into contact with the pipework between the solar collector and cylinder.

Initial wiring

- The reverse of the front plate has a wiring diagram, however remember that when the front cover is flipped over, this diagram is shown as the opposite to the connections on the back plate.
- The temperature sensor with the pink cable is sensor number 1 and shall be installed in the immersion socket on the top of the solar collector. The cable to this sensor may need to be extended, this shall be done using $0.75mm^2$ 2 core Trurip cable as supplied. Sensor number 2 is to be located measuring the water temperature at the bottom of the cylinder, sensor number three is installed to measure the temperature in the top of the cylinder. This is useful if the cylinder temperature is to be limited below a preset temperature.
- Connect the 2 temperature sensors to the terminals on the back plate. Sensor number 1 utilises the lower two terminals. Sensor number 2 the next two terminals up. If three sensors are to be installed, sensor number 3 shall utilise the earth from sensor number 2, i.e. combine one wire from sensor 2 and 3 into the 4^{th} terminal up and then the remaining wire from sensor 3 is in the 5^{th} terminal up .
- Connect the pump to the connections as detailed on the reverse of the front plate.
- Connect the mains supply to the connections as detailed on the reverse of the front plate.
- Recheck all terminations for correct location and good practice termination.
- Plug in and switch the controller on. The controller will go through its checking process and then display the temperature as sensed by sensor number 1.
- If any of the temperature readouts are 999 then remake all the connections on that sensor cable.
- Left and right hand arrowed buttons can be used to scroll through the displays, i.e. sensors 1, 2, 3 or the programming menus. If sensor number 3 is not installed it will display 999°C, this is normal.

Programming

When programming, if no buttons are pressed for a predetermined length of time, the controller leaves the programming menus and reverts back to the normal display of the temperatures being sensed. You will then have to go back into the programming menu entering the CODE passwords as required.

During normal use the left and right hand buttons are used to scroll through the different temperatures and the fault diagnosis screen. The up and down buttons are only used to enter programming on the $ENTER^{Par}$ and the $ENTER^{Men}$ screens During the programming the buttons are used in the following manner. The user presses the down arrow to select a value to change, one press of the down arrow will make the value flash, meaning that the value can be changed by pressing the left and right hand buttons, the left to reduce and the right to increase the value. Once the correct value is showing, a single press of the up arrow will select and confirm the value, the value will now stop flashing.

1. With the screen displaying the sensor T1 temperature, use the right hand arrow to scroll through, 4 presses of right hand arrow, from the T1 screen, until the words ENTER^{Par} are shown on the screen.

2. Now press the down arrow, to enter and start programming the parameters, CODE32 appears on the screen, if 32 isn't shown press the down arrow, now the right hand arrow to change the number to 32, then press the up arrow to select the code number.

3. With CODE32 on the screen and not blinking, if it is blinking press the up arrow, press the right hand arrow and the screen displays the software version i.e. VR 5.2. Now press the right hand arrow once, the screen shows PR 0^{Par}_{PROG}. This is programme 0 as described in the instruction booklet, this is the correct programme for two sensor solar hot water installations, if three sensors are installed programme 1 needs to be selected as follows. With PR 0^{Par}_{PROG} showing on the screen press the down arrow, PR 0 blinks, now press the right hand arrow until PR 1 shows, now press the up arrow to select it.

4. If you have programmed PR 1^{Par}_{PROG} skip Step Numbers Four and Five, else continue. Now press the right hand arrow and max$_{\downarrow}$ 75°C shows on the display, this is the temperature at low level in the cylinder that the pump will be stopped at to prevent the water in the cylinder being heated to a higher temperature. If the cylinder is copper, can sustain high temperatures, and a tempering valve is installed, this temperature may be increased to 90°C. You can change this temperature by pressing the down arrow, the temperature will blink, now press the left and right arrows to change the temperature, now press the up arrow to select the temperature. The max$_{\downarrow}$ temperature is always greater than max$_{\lrcorner}$ temperature. If when reducing the max$_{\downarrow}$ temperature it will not reduce any further, it is probably because the max$_{\lrcorner}$ temperature as described below in Step Number Five needs to be reduced first. Therefore go to Step Number Five then come back to Step Number Four before proceeding further.

5. Now press the right hand arrow, max$_{\lrcorner}$ 70°C is displayed on the screen. This temperature needs to be changed to being 5°C less than the temperature selected in Step Number Four above, in the case of the example above, this temperature needs to be changed to 90 – 5°C i.e. 85°C. This is done by pressing the down arrow, the temperature blinks, now use the left and right hand arrows to change the temperature and press the up arrow to select the required temperature. Now go to Step Number Ten.

If you have programmed PR 1 in Step Number Three, you have done so to limit the temperature in the cylinder to below a preset temperature. The following terms are used, max$_{\downarrow}$ is the temperature at low level in the cylinder at which the heating turns off. max$_{\lrcorner}$ is the temperature at low level in the cylinder at which the heating turns on again. The low level temperatures should be set at between approximately 5°C lower than those at the top of the cylinder, these values will need to be commissioned on a case by case basis depending upon the height of the cylinder. max$_{\downarrow}$ 2 is the temperature at high level in the cylinder at which the heating turns off. max$_{\lrcorner}$ 2 is the temperature at high level in the cylinder at which the heating turns on again. The max$_{\downarrow}$ 2 and max$_{\lrcorner}$ 2 temperatures shall be the maximum operating temperature as recommended by the cylinder manufacturer, in many cases for mains pressure steel lined cylinders this is 65 to 70^{O}C. The max↓ temperature is always greater than the max↑ temperature. If when reducing the max↓ temperature it will not reduce any further, it is probably because the max↑ temperature needs to be reduced first.

6. Press the right hand arrow and max↓ 75^{o}C shows on the display, this is the temperature at low level in the cylinder that the pump will be stopped at to prevent the water in the cylinder being heated to a higher temperature. You can change this temperature by pressing the down arrow, the temperature will blink, now press the left and right arrows to change the temperature, now press the up arrow to select the temperature.

7. Now press the right hand arrow, max↑ 70^{o}C is displayed on the screen. This temperature needs to be changed to being 5^{o}C less than the temperature selected in point six above. This is done by pressing the down arrow, the temperature blinks, now use the left and right hand arrows to change the temperature and press the up arrow to select the required temperature.

8. Now press the right hand arrow, max↓ 2 is displayed on the screen, . This temperature needs to be changed to being below the manufacturers maximum recommended temperature. This is done by pressing the down arrow, the temperature blinks, now use the left and right hand arrows to change the temperature and press the up arrow to select the required temperature.

9. Now press the right hand arrow, max↑ 2 is displayed on the screen. This temperature needs to be changed to being 5^{o}C less than the temperature selected in Step Number Eight above. This is done by pressing the down arrow, the temperature blinks, now use the left and right hand arrows to change the temperature and press the up arrow to select the required temperature.

10. Now press the right hand arrow, diff↑ 8.0K shows. When the sensor in the solar collector senses a temperature 8^{O}C greater than the lower cylinder temperature the pump is turned on. This value should be reduced to 5^{o}C. This is done by pressing the down arrow, the temperature blinks, now use the left and right hand arrows to change the temperature and press the up arrow to select the required temperature.

11. Now press the right hand arrow and diff↓ 4^{o}C shows on the display. When the sensor in the solar collector senses a temperature 4^{o}C greater than the lower cylinder temperature the pump is turned off. This value should be reduced to 3^{o}C. This is done by pressing the down arrow, the temperature blinks, now use the left and right hand arrows to change the temperature and press the up arrow to select the required temperature.

12. Now press the right hand arrow and A Auto shows on the display. This is the automatic control mode and should be left alone. If ON is selected with a hand at low level the pump is switched on permanently, if the OFF is selected the pump is switched off permanently.

13. Now press the right hand arrow, once CODE32 is displayed press the right hand arrow and then press the up arrow. Then press the left hand arrow until T1 is displayed on the screen. Now press the right hand arrow 5 times, ENTER ^{men} is displayed on the screen. Press the down arrow Engl should be displayed, this is the language for the programming. If Engl is not displayed, English should be selected, this is done by pressing the down arrow, the Engl blinks, now use the left and right hand arrows to change the language and press the up arrow to select the required language.

14. Now press the right hand arrow, once CODE 0 is displayed, press the down arrow, CODE0 blinks, increase the number to 64 by pressing the right hand arrow, then press the up arrow to select the required code number.

15. Now press the right hand arrow, SENSOR is displayed, this should not be changed and should be displaying S1 KTY if the standard sensors have been supplied. If different sensors are being installed these should be selected under this SENSOR menu screen.

16. Now press the right hand arrow, SYS PF is displayed, press the down arrow. CET is displayed. This is to protect the pump and will not turn the pump on if the water temperature is too high. Press the down arrow, it should be switched ON, now press the right hand arrow, this is the maximum collector temperature, the temperature at which the pump will switch off. Leave set at 130°C for most cases, change if required using the down arrow then right hand arrows then select using up arrow. Now press the right hand arrow, this temperature is also to protect the pump, it is the temperature that the pump turns on again after having been turned off due to the high temperature limit as described above, leave set at 110°C, change if required using down arrow then right hand arrows then select using up arrow.

17. Now press the up arrow, CET is displayed, press the right hand arrow, FROST is displayed, this is the freeze protection and needs to be initiated for direct systems. It will turn the pump on at the lower temperature, heat up the collectors and turn the pump off at the higher temperature. To initiate press the down arrow, OFF is displayed, press the down arrow and the right arrow to turn on, then the up arrow to select, ON will stop flashing. Generally set the on temperature to 4deg.C and the off temperature to 7deg.C. With ON displayed press the right arrow, 2 is displayed, now press the right arrow again, 4 is displayed. Press the down arrow and increase the number to 6°C by pressing the right hand arrow, then press the up arrow to select the required temperature. Press the left hand arrow, 2 is displayed, press the down arrow, now the right hand arrow to increase to 4deg.C. Now press the up arrow to select the temperature.

18. Now press the up arrow again, FROST is displayed, now press the up arrow again.. Now press the right hand arrow Start f is displayed, this is factory set to off and should normally remain off

19. Now press the right hand arrow ART is displayed, this is the after run time for the pump and is normally is left at 0.

20. Now press the right hand arrow

21. F Check is displayed, this needs to be turned on, press the down arrow, press the right hand arrow and press the up arrow to select.

22. Now press the right hand arrow HQC is displayed, this is the heat counter, i.e adds up the heat absorbed from the solar system, if it is to be initiated refer to the manual.

Controller user guides

The user guides for the ESR21 and the UVR61 are shown below, copies of these are available from the website for inclusion in the operation and maintenance manual.

Solar System Control Using EcoSolar ESR 21 and One Shot Back up Heating Controller

Overview
The ESR 21 Solar Controller is a multi function controller which automates the solar water heating system. Temperatures within the solar collector, the bottom and the top of the cylinder are monitored and displayed on the clear LCD screen. The backup heating system is managed manually using the "One Shot" controller.

1. Ideally the backup water heating systems should remain off.
2. The user should monitor the water temperatures at the top of the hot water cylinder (T3).
3. If the water temperature is below the predetermined set point, press the boost switch, the green neon on the "One Shot" will turn on
4. The over ride button should only be used if there is significant water consumption
5. If all the water has not been heated to 60 OC for a period of 7 days boost the cylinder water temperature using the lowest electric element.
6. If the cylinder has two electric elements, the top element is used to boost the water temperature, the bottom element is only used for Legionella control or if a full cylinder of water is required. The bottom element may/may not be controlled with a "One Shot" controller if it isn't the main isolator should remain switched off and only switched on as required above.

System Control
The ESR 21 Solar Controller is a multi function controller which automates the solar water heating system. Temperatures within the solar collector, the bottom and the top of the cylinder are monitored and displayed on the clear LCD screen. The solar heating pump is normally off and only turned on when the collector is warmer than the bottom of the cylinder, i.e. there is heat to recover from the solar collector.

The solar controller also has a defrost function which is initiated in open loop systems where the water in the cylinder is circulated through the solar collector. The defrost function is initiated if the collector temperature has dropped to a point where there is a potential of freezing, in which case, the controller turns on the pump to circulate water from the cylinder to the collector to raise the collector temperature.

The Solar Controller also has the capability to data log the heat being recovered from the collector, this requires the optional flow meter to be installed.

The Solar Controller has four buttons of quadrant appearance located to the left of the LCD display. Pressing the left and right buttons allows the user to scroll through the different temperatures being monitored, the fault diagnosis screen and the two programming screens. The up and down buttons are only used during system programming and should not be used by the occupier. T1 is the temperature in the top of the solar collector, T2 is the temperature in the bottom of the hot water cylinder and T3 is the temperature in the top of the hot water cylinder.

Backup Water Heating

The backup water heating system needs to be managed to maximise the use of the solar heating system, minimise the energy consumed heating water, and minimise the risk of Legionella. The backup heating system is normally electric elements although gas, diesel and heat pump systems are also common. Cylinders with electric elements, larger than 200 litres capacity, will generally have two elements, one at low level the second at high level. Under normal circumstances the backup heating source is turned off and is only turned on when additional hot water is required or to minimise the risk of Legionella.

The user should monitor the weather and water temperature in the top of the cylinder (T3), over a short period of time they will determine the temperature below which additional hot water is required, this temperature will vary from household to household and depend upon hot water consumption. If the water does need to be heated the user should press the boost button on the EcoSolar "One Shot" controller. This controller will heat the water and automatically turn off the heating once the water is up to temperature, the user will not need to turn it off. The over-ride switch on the "One Shot" controller turns on and keeps on the electric elements. Under normal use the boost operation should suffice, however, if there is significant hot water usage the user may want to consider using the over-ride button.

In cylinders with multiple elements, with the "One Shot" connected to the top element, using the boost feature will heat only the top portion of the cylinder, which may be sufficient for normal usage. Using the over-ride feature will maintain the water in the top of the cylinder at the set point temperature, however this will consume significant energy and savings will be reduced.

Legionella Control

Unless the hot water cylinder is being heated regularly to greater than 60^{O}C, there is a risk of Legionella establishing itself in the hot water cylinder. In order to minimize this risk the water should be heated to 60^{O}C for 6 hours once a week. This function can be manually managed or EcoSolar are able to supply controllers or timers that take care of this function for you. If you are managing this yourself we recommend that the water is heated at the same time each week this way the management will hopefully become habitual. If the cylinder has two immersion heaters the lower one should be initiated to maximise the amount of water heated.

Please note that the above will limit but not prevent Legionella from establishing its self in the hot water cylinder. The shower head is most at risk most pipework is also a risk area. All the pipework should be regularly flushed to limit the establishment of Legionella this is the case on all hot water systems, more so where tempering valves are installed as the water downstream of the tempering valve only reaches 45^{O}C which is an optimum temperature for Legionella growth.

Solar System Control Using EcoSolar UVR 61 Solar Controller and One Shot Back up Heating Controller

Overview

The UVR 61 Solar Controller is a multi function controller which automates the solar water heating system. Temperatures within the solar collector, the bottom and the top of the cylinder are monitored and displayed on the clear LCD screen. The backup heating system is managed automatically and can also be initiated manually using the "One Shot" controller.

1. Ideally the backup water heating systems should remain off.
2. If the water is not up to temperature the solar controller will turn on the water heating at the predetermined time
3. Outside of the heater initiated times, the user should monitor the water temperatures at the top of the hot water cylinder (usually T3).
4. If the cylinder temperature has been limited, at this temperature the solar system will shut down
5. If the water temperature is below the predetermined set point, press the boost switch, the green neon on the "One Shot" will turn on
6. The over ride button should only be used if there is significant water consumption
7. If all the water has not been heated to 60 OC for a period of 7 days boost the cylinder water temperature using the lowest electric element.
8. If the cylinder has two electric elements, the top element is used to boost the water temperature, the bottom element is only used for Legionella control or if a full cylinder of water is required. The bottom element may/may not be controlled with a "One Shot" controller if it isn't the main isolator should remain switched off and only switched on as required above.
9. If you go away on holiday the Home / Away button should be set to Away, this will stop the cylinder from being heated everyday.

System Control

The UVR 61 Solar Controller is a multi function controller which automates the solar water heating system. Temperatures within the solar collector, the bottom and the top of the cylinder are monitored and displayed on the clear LCD screen. The solar heating pump is normally off and only turned on when the collector is warmer than the bottom of the cylinder, i.e. there is heat to recover from the solar collector.

The solar controller also has a defrost function which is initiated in open loop systems where the water in the cylinder is circulated through the solar collector. The defrost function is initiated if the collector temperature has dropped to a point where there is a potential of freezing, in which case, the controller turns on the pump to circulate water from the cylinder to the collector to raise the collector temperature.

The Solar Controller also has the capability to data log and download to a PC, temperatures around the system, solar radiation and the heat being recovered from the collector, these require the optional sensors and flow meter to be installed, together with a USB interface.

The Solar Controller has four buttons of quadrant appearance located to the left of the LCD display. Pressing the left and right buttons allows the user to scroll through the different temperatures being monitored, the fault diagnosis screen and the two programming screens.
The up and down buttons are only used during system programming and should not be used by the occupier. Generally, T1 is the temperature in the top of the solar collector, T2 is the temperature in the bottom of the hot water cylinder and T3 is the temperature in the top of the hot water cylinder. Please note the installer is able to change the sensor designation to suit a particular installation so the installer should advise you on this.

The UVR61 controller can also automatically control a solar water heating system to heat several different hot water cylinders from the same controller, the cylinders are prioritised. The controller can also automatically control wetback boilers, turning on a pump to recover heat from the fire only when there is heat to be recovered, i.e. the fire is hot. Multiple arrays of solar collectors in different locations can also be controlled, such as when collectors cannot be installed facing North and are instead installed facing East and West. The controller has an internal daily timer which is able to control 3 outputs, this function is often used to automate the backup heating. The controller will determine if there is sufficient hot water available at a predetermined time of day and automatically turn on and off the heating as required. The 6 sensors are able to be data logged via the optional D-Logg which can download through a USB port to a computer, providing daily graphs of the data and system performance and can also be exported in to Microsoft Excel.

Backup Water Heating

The backup water heating system needs to be managed to maximise the use of the solar heating system, minimise the energy consumed heating water, and minimise the risk of Legionella. The backup heating system is normally electric elements although gas, diesel and heat pump systems are also common. Cylinders with electric elements, larger than 200 litres capacity, will generally have two elements, one at low level the second at high level. Under normal circumstances the backup heating source is turned off and is only turned on when additional hot water is required or to minimise the risk of Legionella.

The UVR61 controller automatically turns on the water heating at a predetermined time of day. The controller usually controls the top element. If you go away on holiday the Home / Away button should be set to Away, this will stop the cylinder from being heated everyday.

Outside of the heated times, the user should monitor the weather and water temperature in the top of the cylinder (T3), over a short period of time they will determine the temperature below which additional hot water is required, this temperature will vary from household to household and depend upon hot water consumption. If the water does need to be heated the user should press the boost button on the EcoSolar "One Shot" controller. This controller will heat the water and automatically turn off the heating once the water is up to temperature, the user will not need to turn it off. The over-ride switch on the "One Shot" controller turns on and keeps on the electric elements. Under normal use the boost operation should suffice, however, if there is significant hot water usage the user may want to consider using the over-ride button.

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