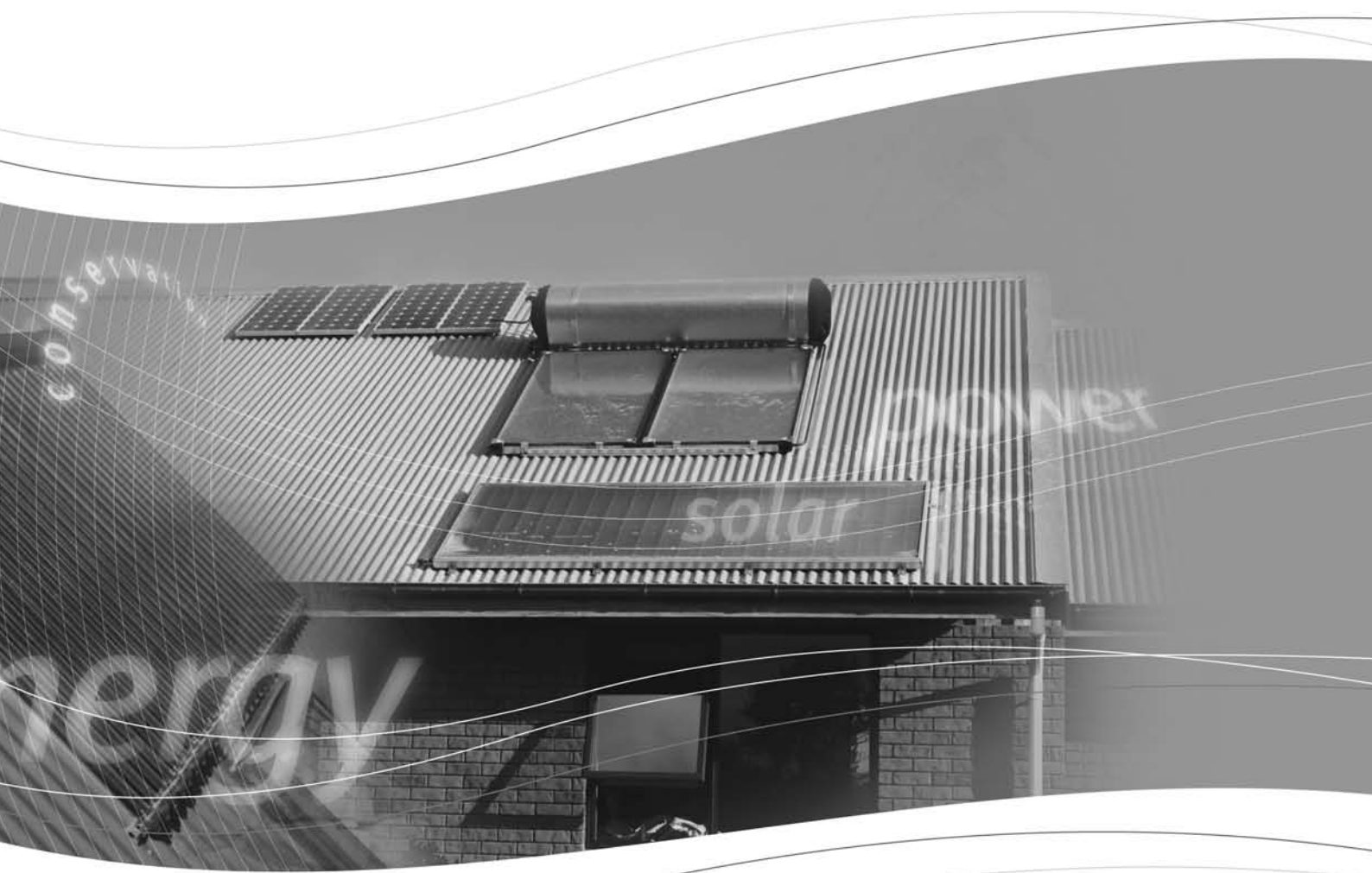


Solar water heating guidebook



A technical guide for
building industry professionals

October 2006



Improving energy choices



Introduction

For economic and environmental reasons solar water heating systems are becoming a popular option for home water heating in New Zealand, and are also beginning to feature in commercial and industrial applications.

Making greater use of the sun's energy to heat water contributes towards reducing greenhouse gas emissions, helps lower New Zealand's dependency on non-renewable resources and reduces the rate of electricity demand growth.

It also offers benefits for individuals. In many New Zealand households, between 30% and 50% of energy costs can be attributed to heating water, and an effective and correctly installed solar water heating system can be sized to reduce electricity consumption for water heating by between 50% and 75% over the course of a year. Solar water heaters can also make a major contribution to the supply of hot water for commercial and industrial applications.

This guide provides information such as the costs and benefits of solar water heating, compliance with the New Zealand Building Code, residential and commercial applications of solar water heating and the design and installation of solar water heaters.

The appendices to this guide provide additional technical information, but it should be noted that this is not an installation guide. Consult with an accredited solar water heating supplier, building or engineering professional as necessary.

This publication is intended to provide a general guide for building industry professionals specifying solar water heating systems for residential, commercial or industrial use.

EECA plans to update the guide when necessary and welcomes feedback on the content. If you have any suggestions for additional material or changes, please email EECA at info@eeca.govt.nz.

ACKNOWLEDGEMENTS:

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It is based on a number of existing publications including SWH Systems in New Zealand, published by EECA in 1999, and prepared by Sue Clark, Jacky Lee and Arthur Williamson.

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DISCLAIMER:

Although every care has been taken to ensure that this publication and possible interpretations thereof are as accurate as possible, EECA does not accept any liability for consequences arising from reliance on any information and/or analysis contained herein.

It should be noted that this publication has not attempted to be fully comprehensive on all technical aspects but to raise the key issues and questions that could inform an interested party.

In addition, the mention of individual brand names is in no way to be seen as an endorsement of those individual brands. Where trade names are mentioned, they are intended to be of assistance to the reader as examples of equipment described. However, they should not be taken as the only types available, and readers should investigate fully with companies operating in their locality. There may, however, be other brands that could also illustrate the point that have not been included. In every case readers are asked to use this publication as a guide only and to ensure that they make their own enquiries with a range of manufacturers, installers, independent advisors and users of solar water heating.

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Information for Clients

THE BENEFITS OF SOLAR WATER HEATING

The benefits of solar water heating include energy cost savings for users and environmental benefits, as detailed below.

The actual savings and benefits of installing a solar water heater can vary widely, however, so it is important that energy and cost savings for each system are assessed individually. The table below indicates some average savings.

Hot water delivery	In summer months it may be possible to heat all the water you need with solar energy. This will be significantly less in winter months, but an effective and correctly installed solar water heating system can reduce electricity consumption for water heating by between 50% and 75% over the course of a year.
Electricity or gas savings	An average domestic solar water heater may save a householder about 2,200kWh/year, although this can vary considerably depending on how much hot water you use, the solar water heating system and the quality of the installation.
Cost savings each year	The more hot water that is heated with solar energy instead of electricity or gas, the more you can save on your power bill. The energy and cost savings for each system installed need to be assessed in each case, however a typical residential installation could save \$350–\$450 a year depending on the cost of your electricity or gas supply.
Environmental benefits	For every average residential solar water heating system installed, about 1.4 tonnes of carbon dioxide (CO ₂) are avoided each year. Three solar water heaters installed are equivalent to avoiding the CO ₂ emissions from one car.

THE COSTS OF SOLAR WATER HEATING

Because each installation is different, the costs of solar water heating can vary widely. At present, solar water heaters for residential homes typically cost between NZ\$4,000 and \$8,000 installed. These systems normally have between 2.5 square metres and 4 square metres of panel collector area, a cylinder to store the heated water, and often come with auxiliary equipment like pumps and controllers.

The economic viability of the solar water heater will depend on the price of displaced electricity, gas or other energy prices. Other factors include the quality of installation, the size of the system, the cost of finance and any measurable effect on the value of the house. A realistic 20-year lifetime of high-quality systems should also be taken into account.

Commercial solar water heater installations will normally have a shorter payback period than household installations because of the economy-of-scale benefits and sometimes increased flexibility to install an efficient design.

In general, the cost of installing a solar water heater in an existing house is more expensive than for a new building. This is because piping may have to be installed in parts of the house that are hard to access, and additional structural framing of the roof may be required for solar water heating systems that include a hot water cylinder on the roof.

The costs of solar water heating for underfloor heating in houses and large commercial applications will vary widely and are likely to be in excess of \$10,000. The cost will depend on a range of factors, not the least being the amount of hot water needed and consequently the size of solar water heating system required.

System costs can be reduced for people building new homes by factoring changes to accommodate a solar water heater into the roof structure design.

COMMERCIAL SOLAR WATER HEATING SYSTEM COSTS

There are few commercial solar water heating systems in New Zealand at present on which to base costs for larger-scale solar water heating systems. However, a study undertaken for EECA in 2005 attempted to establish the system cost related to system size¹.

The main points to note are that, as with residential installations, there are many cost variables that will affect the overall system cost for commercial solar water heaters, including: design, consents, collector type, the need for collector framing and structural supports, heat exchangers, piping, hot water cylinders and installation.

There appear to be clear economies of scale above about 100 square metres of collector panel area as a result of spreading tendering, design and installation costs over greater-sized systems and the discount that applies to large purchases.

Many commercial applications of solar water heating are simply multiples of single residential solar water heaters.

¹ *Developing the Market for Larger Scale Solar Water Heating Applications in NZ*, McChesney, East Harbour and Enercon, EECA, 2005. Available at www.eeca.govt.nz.

AESTHETICS

There is a wide variety of solar water heating system types and designs, but they all require collector panels to be situated on the roof to absorb the solar energy for heating the water. Although a collector panel cannot be hidden, it can be made to look similar to a skylight by the choice of colour of the collector panel casing, or by inserting the collector panel flush with the roof line. Some collectors have glass tubes which blend with corrugated roofs (see photos below, Figures 1–4).



Figure 1: Evacuated tube solar collector panel installed on corrugated iron roof (photo by Emsol)

Some systems also have the hot water cylinder mounted on the roof. With other systems the cylinder is installed in the ceiling space or at floor level, although this takes up space that could be used for other purposes.



Figure 2: Flat-plate solar collector panel with hot water cylinder mounted on the roof (photo by Emsol)



Figure 3: Flat-plate solar collector panel looking similar to a skylight (photo by Emsol)

A solar water heating system can be designed and built into the aesthetics of a new building so that it is not intrusive to the building design lines.



Figure 4: Flat-plate solar collector panel with pipe insulation weather protected (photo by Emsol)

Homeowners are sometimes concerned with the colour of pipes, however these should be covered with insulation that is weather protected. This provides an opportunity to paint or tape the insulation with a colour that blends in with the roof colour.

MAINTENANCE REQUIREMENTS

Essentially, a solar water system requires little maintenance, but for maximum performance (and energy savings) some key points are summarised below:

Hot water cylinders need to be maintained in a similar manner to normal electric hot water cylinders – hot and cold relief valves should be flushed every six months, and the anode in a glass-lined water container changed every five years (more frequently in hard water areas).

Collector panels that are out of sight should occasionally be visually inspected for leaks, which may occur in the case, glass or pipes. Condensation on the glass or wet insulation indicates the system may be leaking. The glass should be washed if dirty. (This is usually a problem only if it is protected from the rain or during long dry periods, near dusty roads or when pollen levels are high.) Check for shading at the same time – trees may grow unnoticed. Debris or bird droppings may gather on or around the collector panel, reducing solar absorption or creating an opportunity for roof cladding corrosion.

Although not common, broken glass or damaged glazing should be replaced immediately as water coming in will cause rapid deterioration of the absorber's surface and insulation.

Frost protection methods that use frost plugs (which are increasingly rare) sometimes need resetting in freezing conditions. If the system uses glycol or a water-glycol mixture, this should be replaced about once every five years, according to the manufacturer's instructions.

Manufacturer's instructions should be followed for any other maintenance issues or requirements over the life of the system, and many issues during the first year's service would normally be a warranty issue.

SOLAR WATER HEATER SYSTEM CONFIGURATION AND COMPONENTRY

The designs of solar water heating systems, and the methods dealing with frost and overheating, vary widely.

There are different types of:

- system configuration,
- collector panels,
- hot water cylinders (also called storage cylinders or containers),
- heat transfer mechanisms, and
- auxiliary equipment.

These different aspects are explained in further detail as follows.

SYSTEM CONFIGURATION

There are two main types of system configuration:

- an “open loop” system where the water in the system is circulated through the collector panel and heated directly before returning to the hot water cylinder, and
- a “closed loop” system where heat transfer fluid in the primary circuit of the system (including the collector panel) is circulated through a heat exchanger in the hot water cylinder, so there is no mixing of the water being stored and the heat transfer fluid.

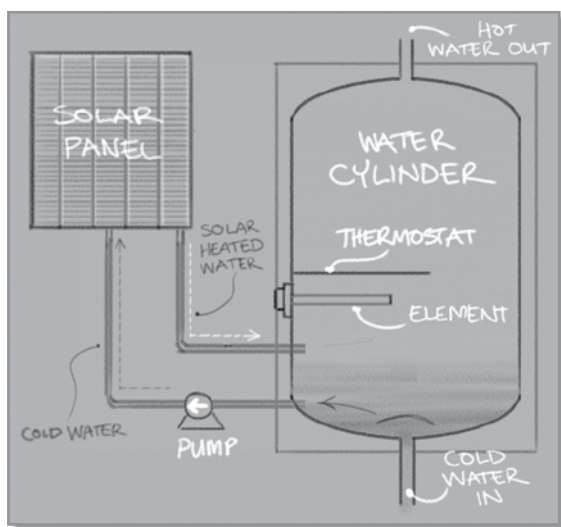


Figure 5: Open loop system with pump circulation

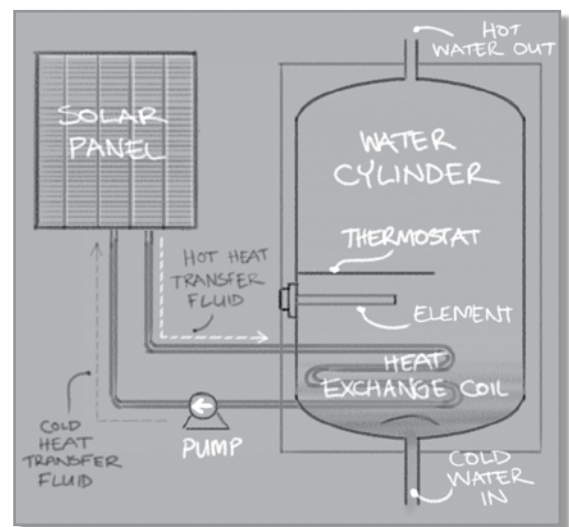


Figure 6: Closed loop system with pump circulation

COLLECTOR PANELS

There are three main types of solar collector: unglazed panel; glazed flat plate panel; and evacuated tube panel.

- Unglazed collector panels are typically used with swimming pools. Collectors are either made of webbed mats of small diameter flexible tubes or a collection of single 20 millimetres poly-pipes. They are matt black in colour and cover a large area.
- The glazed flat plate panel collector consists of a flat sheet absorber enclosed within an insulated housing and transparent cover. It absorbs sunlight and transfers the heat into the fluid flowing through the collector panel. The common size for a house is one to three panels, 2–6 square metres in total. For residential applications the absorber is enclosed within an insulated housing with a transparent cover. The whole enclosure acts as a greenhouse. It reduces heat loss, enabling the collector to work at elevated temperatures and ensures that a high percentage of the solar energy goes into the water.

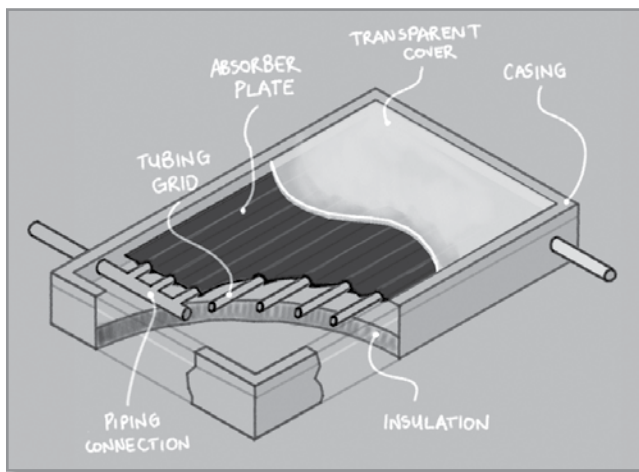


Figure 7: Flat plate panel detail

- The evacuated tube panel is made up of a series of glass tubes (1,500–1,800 millimetres long) sloping lengthwise up and down the roof. Some collectors include a heat exchanger jacket at their upper end, and heat pipes in each tube. Liquid in the heat pipes evaporates, rises and heats the water in the heat exchanger jacket. Other collectors have water passing directly through the copper tubes within each glass tube, instead of heat pipes. In every case the glass tubes are double-glazed with a vacuum to reduce heat loss, and some are equipped with a reflecting mirror at the back.

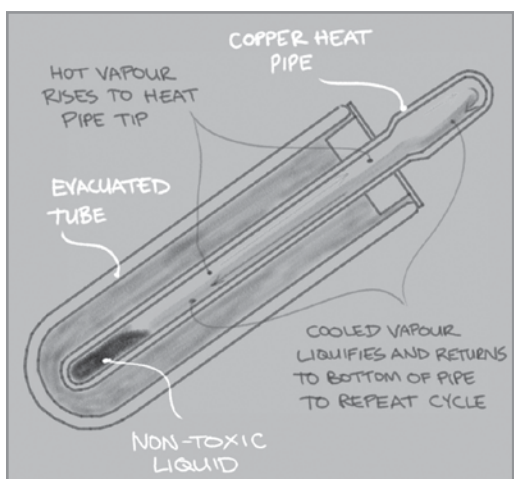


Figure 8: Detail of an evacuated tube with heat pipe

HOT WATER CYLINDERS

Solar hot water cylinders are often larger than conventional electric heated cylinders, to enable much more solar heated water to be stored. They also have separate solar connection ports and the element is specially positioned to avoid using extra electric heating unless required.

Specialist solar hot water cylinders have the thermostat and the element higher up within the cylinder, as shown in Figure 9. This means that water in the bottom of the cylinder is heated only by the solar heater. A lot more water must be drawn off before the electric element is thermostatically turned on. If it is a hot sunny day, it may not turn on at all, as the water below the element will be heated by solar energy before it rises to the level of the thermostat.

Some solar hot water cylinders can be mounted vertically or horizontally.

There are a number of methods of connecting existing hot water cylinders. One option is using a five-way port that screws into the bottom of a standard cylinder. Generally, using existing cylinders requires a pump circulation system. A controller connected to the electric booster element is vital to get the most benefit from the system and to avoid using electricity unnecessarily.

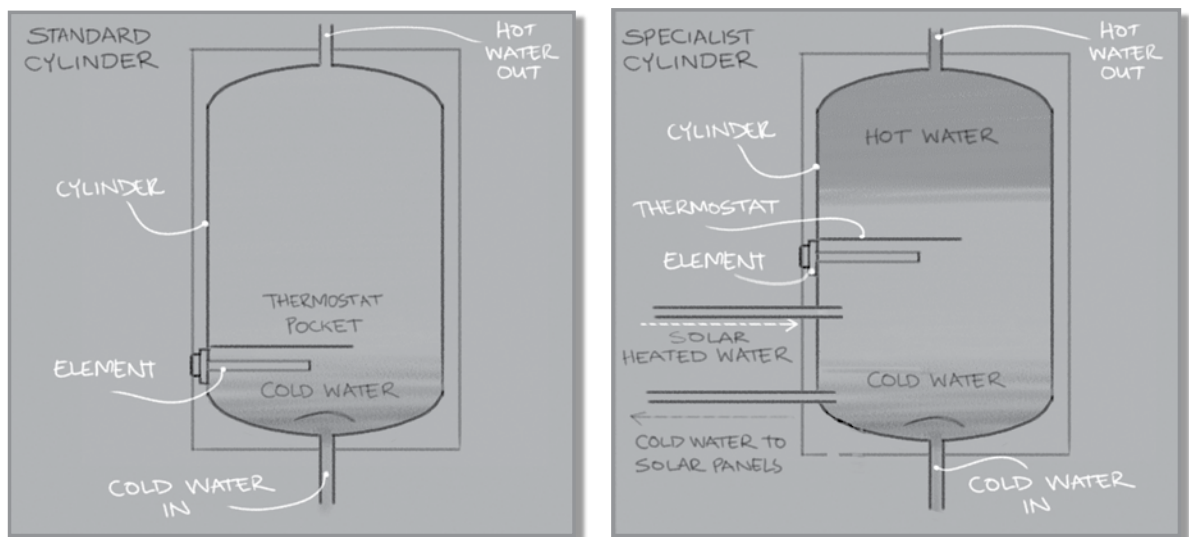


Figure 9: Comparison between standard and specialist solar hot water cylinders

HEAT TRANSFER MECHANISMS

There are also variations in the way that heat is moved throughout the system. The design can either be based on:

- (a) natural circulation by thermosiphon (these are often called “passive systems”). Heated transfer fluid in the collector creates a natural convection and rises above cooler fluid. The cool water (or heat transfer fluid) moves down from the hot water cylinder or heat exchanger to and through the collector. After being heated by the sun, the more buoyant heated fluid then moves up again; or
- (b) forced circulation using a pump (these are often called “active systems”). The pump moves the water or transfer fluid through the collector panels and back to the hot water cylinder. While some electricity is required to operate the system, there is a greater flexibility of layout because the cylinder can be located at ground level.

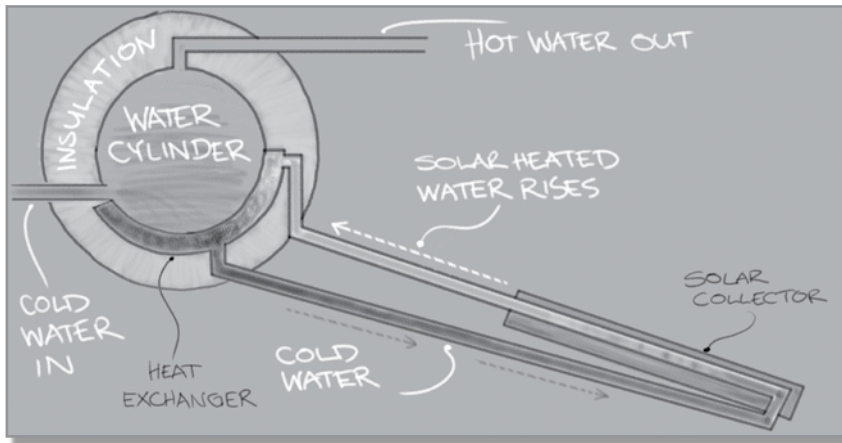


Figure 10: Thermosiphon circulation

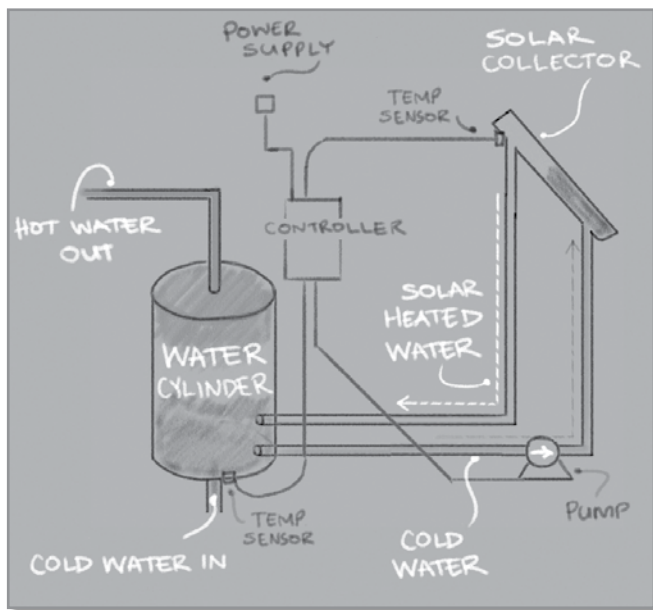


Figure 11: Open loop system with pump circulation

AUXILIARY EQUIPMENT

Depending on the type of system you select, different auxiliary equipment is needed to make the solar water heating system function.

- **Pumps**

Pumps are used to circulate the heat transfer fluid or water between the collector and water cylinder. Always follow the manufacturer's instructions regarding pump size and type. For a residential installation, a 3-speed 90 watts pump is common. Low flow rate is recommended for greater efficiency.

For a drain-back solar arrangement (see section below on frost protection) a special pump and valves must be installed.

- **Controllers**

Controllers are used to control pump circulation (unless it is a thermosiphon system) and the supplementary energy booster.

Pumped systems use a differential controller for overheating and frost control. This controller will trigger the pump when the solar panels are approximately 10 degrees Celsius warmer than the hot water cylinder, and will stop the pump when the difference is approximately 5 degrees Celsius.

There are two types of supplementary energy booster controllers – time trigger controllers and minimum temperature controllers.

Time trigger controllers operate on the principle that the supplementary energy booster is often turned off during the day, to allow maximum use of solar energy during this time. However, the timer can also be set to operate the booster before periods of high water consumption. This can greatly increase the efficiency of the overall system.

Minimum temperature controllers simply trigger the supplementary booster element whenever the container temperature drops below a minimum pre-defined temperature.

CHOOSING A SYSTEM

EECA recommends always using an industry accredited supplier and installer. A database of accredited suppliers and installers can be found on the Solarsmarter website (www.solarsmarter.org.nz).

WHAT TO CONSIDER: BUYING A SYSTEM

Several factors are crucial to ensure the most benefit is obtained from a solar water heating system. These include consideration of hot water requirements, appropriate cylinder size, adequate frost protection and the design and set-up of the controller (to minimise use of extra heating).

Obtaining quotes and information from several industry accredited suppliers or installers is advised to ensure selection of the best system at a competitive price.

WHAT TO CONSIDER: COLLECTOR PANELS

Collector efficiency is the amount of solar energy falling on the area of the collector that is transferred to the water or heat transfer fluid. The efficiency varies with operating conditions such as solar intensity, ambient temperature, operating temperature of the collector and wind speed over the collector. In New Zealand's temperate climate the efficiency of flat plate and evacuated tube collector panels is very similar, so both are suitable for any application.

WHAT TO CONSIDER: HOT WATER CYLINDERS

Conventional hot water cylinders in houses are usually 180 litres or less. This storage capacity is generally too small for a solar water heater to achieve optimal performance for a household of three or more people.

Specialist solar water heater hot water cylinders are often larger (270–300 litres is common), so much more water heated by the sun is stored, and the use of booster electricity or gas is minimised.

WHAT TO CONSIDER: FROST PROTECTION

Frost protection must be provided to avoid damage in frost prone areas. Table 3 in Appendix 2 indicates the number of days each month when the ambient temperature reaches freezing point for different regions of New Zealand.

In closed loop systems, the heat transfer fluid in the collector panels – usually a water/glycol mixture – has anti-freeze properties. This includes both pumped systems and thermosiphon circulation systems.

On some open loop and pump circulation systems, temperature sensors turn the pump on to run the colder water from the bottom of the cylinder through the panel before it freezes. It should be noted, however, that this freeze protection will not work during a power outage.

Another method used for open loop is a drain-back system where a frost valve opens and drains the collector panels during frost periods.

Frost valves should also be installed to let water flow through the collector panels when the temperature is close to freezing.

Frost tubes should also be considered. These enable the water in the collector panels to freeze without damaging them. The devices absorb any pressure build-up created by the water expanding or freezing.

WHAT TO CONSIDER: HEAT TRANSFER MECHANISM

Natural circulation by thermosiphon has the advantage that it does not require a pump and therefore is not dependent on electricity. This makes the system relatively simple and reliable.

A pump system has the main advantage that the hot water cylinder can be located at a level below the collectors. This is suitable with a renovation where a hot water cylinder already exists at floor level, or if the owner does not want to see the cylinder on the roof. It is essential that the pump is used in conjunction with a controller to ensure the pump operates only when necessary.

WHAT TO CONSIDER: AUXILIARY EQUIPMENT (PUMPS AND CONTROLLERS)

In a pump or forced circulation system, the heat transfer fluid flow in the collector panel is generated by a small pump which is switched on and off by a temperature differential controller. The controller senses the temperatures of the collector and the cylinder.

Another highly important controller is a supplementary energy controller, which is a 24-hour timer set up to control the supplementary energy source so that it boosts temperatures prior to high consumption of hot water, and turns off the boost during other periods or when the sun can heat the water. Failure to control the supplementary energy source in this way can reduce the performance of the system.

Suppliers have different controllers for different systems so check with them about how these should be used. This is an aspect of system choice to which special attention should be paid.

The way in which control parameters are set up will affect the system performance significantly. It is important that hot water use requirements are well understood and controls set appropriately. Also, adequate instructions and training should be given to the user.

WHAT TO CONSIDER: SUPPLEMENTARY ENERGY

Most solar water heaters have some form of supplementary heating. The systems can be electric, gas or solid fuel (wetback) boosted. The supplementary boost is often not required in extended periods of good weather, for example in summer months, as solar energy provides all the heating required.

- Electric boosted systems have an electric element inside the hot water cylinder to heat water. In specialist solar hot water cylinders the electric element will be positioned to maximise the solar contribution.
- Gas boosted systems either have a gas burner in the hot water cylinder, or as a separate unit that boosts the temperature of the water before it is used.
- Wetbacks (solid fuel boosters) heat the water through a heat exchanger in the back of the firebox. The wetback loop should be a separate plumbing loop and not in-line with the solar collector panel.

This supplementary energy should be controlled (see earlier section on “Auxiliary equipment”) so that the water is heated as much as possible by solar energy, and so that the system provides hot water when it is required by the household. Controlling the supplementary boost is also important to ensure the system complies with the requirements of the New Zealand Building Code.

The New Zealand Building Code requires that solar water heating hot water cylinders reach at least 60 degrees Celsius once a day in order to control the growth of bacteria such as Legionella.

The supplementary energy source can also be automatically controlled by a thermostat that cuts in when the tank temperature falls below a desired level. However, unless a properly configured controller is used it is likely the system will not perform to its potential. Relying on the thermostat method of control can defeat the purpose of having a solar water heater. For example, electric booster elements that are just controlled by a thermostat may turn on at night, which means when the sun rises the water is already hot and there is little useful heating to be done.

In many parts of New Zealand the local electricity network company uses ripple control systems to switch off hot water heating at times of peak electricity demand. For this reason it is important that only the supplementary heating is connected to a ripple controlled building electricity circuit, and that neither the pump nor the controller are connected to a ripple control circuit. This is particularly the case for an open loop system where the pump is used for frost protection.

Compliance, Standards and Legal Requirements

REGULATION

BUILDING CONSENTS

The installation of a solar water heating system requires a Building Consent because solar water heating systems interact with potable water supplies and can involve heavy loads on roof structures if the hot water cylinder is mounted on the roof.

A Building Consent is also required where there is a change to the potable water supply system and to the heat source. Other permits may be required to cover electrical alterations, or where there is a building height restriction.

All plumbing work will require certification by a craftsman plumber. A registered electrician will need to certify any electrical work that may be needed. Certifications may be in the form of a Producer Statement as required by the Building Consent.

Solar water heating installers should ensure that any necessary Building Consents are obtained and adhered to. An installer must then be able to demonstrate to the Consent Authority that the installation meets the requirements of the New Zealand Building Code.

- For new dwellings, the solar water heating system is usually included in the overall consent for the building. In this case the plumbing approval is usually done by the designer, specifier or the plumbing contractor. Structural approval is done during the process of approving the design of the trusses with the trusses merchant, by taking into account the specific load of the hot water cylinder (not applicable if the system does not have a cylinder on the roof).
- For installing solar water heating on existing dwellings, the installers usually provide a signed Producer Statement confirming they have installed the solar water heating system according to the requirements of the New Zealand Building Code.

If the hot water cylinder is not on the roof, the Building Consent should be submitted as a minor plumbing alteration. However, when the cylinder is on the roof, the city council will require evidence that the existing structure can cope with the load.

System suppliers often provide pre-prepared supporting documentation to accompany an application to help installers obtain Building Consents with the minimum of effort. The documentation may include acceptable structural support arrangements for specific system models.

STANDARDS AND REQUIREMENTS

THE NEW ZEALAND BUILDING CODE

The Building Code is the responsibility of the Department of Building and Housing and is available from its website (www.dbh.govt.nz).

In terms of Code compliance, the installation of a solar hot water system is mainly a plumbing or water supply matter (see Clause G12 of the New Zealand Building Code), but it can also be a structural matter in regard to the necessary roof strength.

Clause G12 sets out the requirements for system installation. The New Zealand Building Code has a number of compliance documents that, if followed, ensure that Code compliance is achieved. The latest version of these compliance documents should be consulted. Territorial authorities need to be satisfied that the proposed work will comply with the New Zealand Building Code in order to issue a Building Consent.

TECHNICAL STANDARDS

There are two joint New Zealand/Australian Standards relating to solar water heating, covering the manufacture of systems (AS/NZS 2712) and system installation (AS/NZS 3500.4).

Compliance with these Standards provides assurance that the system is built to a high standard and the materials used are of the best quality available, and that it has been installed correctly.

There is a range of other Standards that these two standards refer to or that may be needed for particular conditions. These include, for example, NZS 3604 for building structures, and AS/NZS 4692 for hot water cylinders and heat loss.

AS/NZS 2712: SOLAR AND HEAT PUMP WATER HEATERS – DESIGN AND CONSTRUCTION

The Standard AS/NZS 2712 sets out requirements for the manufacture of solar water heating system components and their combinations for either a packaged or customised system. The Standard focuses on physical performance, durability and safety aspects of product design and manufacture.

In a packaged system, the components (collector panel, hot water cylinder, auxiliary equipment) are part of the same unit which is designed for integrated operation and is tested as a system. A custom-built system, however, is one that is assembled, often on-site, from unrelated components (for example, if you use an existing cylinder as part of the system).

The components of either a packaged or custom-built system must each comply with the relevant tests of AS/NZS 2712.

AS/NZS 2712 is currently being reviewed to make it more performance based, to deal better with customised systems and to include auxiliary equipment such as pumps and controllers.

AS/NZS 3500.4: PLUMBING AND DRAINAGE PART 4: HEATED WATER SERVICES

The New Zealand Building Code requires that a system must be installed in accordance with AS/NZS 3500.4.

AS 4234: CALCULATION OF ENERGY PERFORMANCE

This Standard describes the methodology used to calculate the performance of complete, packaged systems. It uses a combination of component tests and mathematical modelling. A packaged system, comprising a collector panel, cylinder and auxiliary equipment, can be modelled to the two New Zealand zones in the Standard. Components have to be grouped together as a specific “packaged system” to be modelled. This allows the efficiency of systems to be compared under standard reference conditions.

The Standards are available from Standards New Zealand’s website (www.standards.co.nz).

INDUSTRY CODE OF PRACTICE

The industry has a written best practice Code of Practice which the product supplier and installer are expected to meet. The Code of Practice integrates the formal technical standards with best practice and also covers aspects of the relationship with purchasers. This is titled *Code of Practice for the Manufacture and Installation of SWH Systems in NZ*, and is available from the SIA website (www.solarindustries.org.nz).

ACCREDITATION

The industry has established a supplier accreditation system to provide confidence to potential purchasers that their system meets the appropriate standards. To be accredited, a supplier will have to meet the relevant performance criteria, including those set out in the Code of Practice.



Solar water heating applications

Solar water heaters are used for a wide range of heating needs. They are popular for heating potable water in homes and a small number of households also use solar water heaters for their swimming pools, or to enhance spa pools and underfloor space heating. The use of solar water heaters in commercial applications is growing as well and ranges from being used for hot water requirements in the tourism and accommodation industries to preheating water used in space heating and steam boilers.

RESIDENTIAL DWELLINGS

Residential solar water heating systems are proven technology, and are complementary to other methods of water heating, as follows.

RESIDENTIAL INSTALLATIONS WITH GAS OR ELECTRICITY BOOST

Most solar water heaters installed in the domestic market use electricity or gas as a supplementary boost. During periods of low solar gain, the electric or gas boost can raise the temperature of the water in the hot water cylinder so that there is a constant supply of hot water.

RESIDENTIAL INSTALLATIONS WITH A WETBACK

A solar water heating system may also be combined with other heat sources such as a wetback. This combination works well as the solar system performs best in summer and the wetback provides extra water heating in winter. Some homes with both solar and a wetback do not need boosting with electricity or gas in winter.

Wood burners used with solar water heaters need to be those that comply with air emission levels set by the local territorial authority.

Only experienced installers should install solar water heating systems with wetbacks.

Wetbacks can be run in both a low pressure system and a mains pressure system using a heat exchanger.

SOLAR PRE-HEATERS WITH INSTANTANEOUS GAS/ELECTRIC HEATERS

A solar water heating system can be used as a pre-heater to an instantaneous electric or gas heater. In such applications, the instantaneous heater provides the supplementary heating at the time it's required.

SUPPLEMENTARY HEATING FOR HOUSEHOLD SWIMMING POOLS

A solar water heating system can be used to supplement heating of a swimming pool. This will increase the water temperature so it's warmer during summer months and warm for more weeks of the year. The system will require a specific design to meet the needs of the householder and size of the collector panels should be similar to the swimming pool surface area.

SUPPLEMENTARY HEATING FOR HOUSEHOLD SPACE HEATING AND UNDERFLOOR HEATING

A solar water heating system could also be used to supplement underfloor or space heating delivered by a heating source such as an oil or gas boiler. For solar to make a significant contribution to underfloor heating will require a much larger collector panel area to provide adequate hot water for heating in winter, and a burner to warm up the dwelling when solar radiation is unavailable. If a large collector panel area were installed, then there would need to be a use for the significant amount of hot water produced in the summer when the underfloor heating is not required. The excess heat could be dumped to a swimming pool. Large-scale systems require larger hot water cylinders, with associated pumps and valves. A supply of heated water for space heating can require the use of fan coil units.

Such a system would also require a specific design from a supplier or design engineer.

COMMERCIAL BUILDINGS

There is an enormous range of potential applications for larger-scale solar water heating in New Zealand. Possible candidates include uses for low temperature hot water or as a pre-heater for higher temperature hot water use (Table 1).

Table 1. Potential opportunities for large-scale solar water heating in New Zealand

Industry Sector	Potential Opportunities for Large-Scale Solar Water Heating				
Food Industry	Milk factory	Confectionery/ bakery	Tinned goods	Meatworks	Desalination of sea water
Forestry/ Agriculture	Timber/food drying	Greenhouses	Nursery	Dairy farm	Fish farm
Textiles	Tannery	Leather treatment	Cloth refinery	Dyeing/ finishing	Textile processing
Chemical Industry	Cosmetics	Detergents	Pharmaceutical	Wax	Distillery
Beverages	Winery	Liquor distillery	Brewery	Soft drink	Fruit juice
Service Industry	Hotel/motel	Takeaway restaurant	Gymnasium/ swimming pool	Events centre	Sports stadium
Institutions	Hospital	Prison/military barracks	Boarding establishment	Retirement home	School

Smaller commercial systems may simply be multiples of a standard domestic-type system, including multiples of domestic hot water cylinders. This may be the most economical solution – utilising the economies of scale of bulk manufacture and simplified design and installation. These are more likely to be closed loop rather than open loop systems. Multiple domestic-type systems may be installed in parallel or in series.

Where the volume of hot water required is larger than can be economically supplied by domestic systems, an array of standard collector panels may be connected to a large-volume commercial hot water cylinder. Some suppliers have specially-designed large-volume cylinders which may include specific supplementary heating mechanisms. The array of collector panels may be connected in series or parallel. The collector panels need to be designed by an engineer to ensure that friction flow losses are minimised and that efficient flow is achieved within collectors. The Brisbane TAFE resource book provides guidance on design (see Appendix 3).

Design and specification

GENERAL PRINCIPLES

Each system needs to be designed and installed to meet the needs of the commercial hot water user or individual householder and their property.

Typical hot water requirement for a household is 50 litres per person per day.

The design of solar water heating equipment and pipework is site-specific for every application. No two installations are the same and each installation needs to be assessed independently. While there are some common attributes about a number of installations, the way hot water is used within the dwelling or commercial premises will differ even from that in a similar building and layout. People all use hot water differently and this can have an effect on the design of a system.

Some of the broad parameters for a system will be specified by a homeowner, building owner, architect, builder or engineer. The design of the system would normally be completed by an industry accredited solar water heater supplier or approved installer, or a solar or design engineer. This will also depend on the complexity of the system required.

Systems are generally sized so that during summer months they can provide nearly all the hot water required, and during the winter months additional booster or supplementary energy is needed.

Supplementary energy may be provided by electricity or gas. Regardless of the source of supplementary energy, it should be controlled so that heating only occurs after the opportunity for solar gain has been allowed. This is generally achieved by using a controller to regulate when supplementary energy is available.

HOT WATER CYLINDER CAPACITY

The volume of the hot water cylinder for the solar water heating system should not be less than the daily hot water consumption for the household, but ideally it will be at least 1.5 or 2 times the volume of the household's daily hot water consumption. Most domestic solar water heating installations have a hot water cylinder capacity of around 300 litres.

COLLECTOR PANEL SIZE AND PLACEMENT

The collector panel on a typical domestic solar system is between 2.5 and 4 square metres. The actual size is related to the size of the hot water cylinder, working to a ratio of one square metre of collector panel per 40–90 litres of hot water cylinder.

Collector panels should be located on roofs with optimal slope which should be taken into account during the building design. These aspects are more difficult to address for placing a solar system on to an existing roof.

Ideally a solar collector panel should face true north and be tilted from the horizontal at an angle greater than 10 degrees. An ideal angle is equal to the latitude of where the building is located. However, it's possible to make quite large deviations from this without affecting performance greatly. The performance will be satisfactory as long as the collector is within the north-east to north-west quadrant and tilted at an angle greater than 10 degrees and within 20 degrees of the "latitude value".

This gives the best overall energy performance when averaged over the whole year. Minor deviations from this do not have a significant effect on the total energy collected.

COLLECTOR PANEL POSITIONING

Optimal direction: North facing.

Acceptable: A deviation of up to 45 degrees is permissible (resulting in 4–18% reduction in performance depending on collector panel type and pitch). If a choice between north-east and north-west must be made, it is useful to favour a more easterly direction if major water use is before 2pm and more westerly if major use is after 2pm. Extra collector panel area can more than compensate for less than ideal collector panel orientation.

Guide: A table showing the variation in solar output for different directions is in AS/NZS 3500.4 Appendix J.

Optimal pitch: The angle of inclination should be equal to the angle of latitude, but not less than 10 degrees. Note that if the solar collector panel faces significantly east or west of north then a lower latitude inclination will give better performance.

Acceptable: A deviation of up to ± 20 degrees from angle of latitude is acceptable. The minimum elevation of 10 degrees is still essential, and a maximum of 40 degrees is often recommended, although collector panels have been positioned as steeply as 60 degrees for improved winter performance and still appear to perform well.

The optimum angle will give a greater collected energy in the summer than in the winter. Lowering the angle below the optimum will emphasise summer collection even further at the expense of winter collection. Raising the angle will improve winter collection, while reducing summer collection.

In systems where collector panels are combined with wetbacks, the collectors are set at the flatter angles to emphasise summer performance because the winter water heating will come largely from the wetback.

HOT WATER CYLINDER LOCATION

With a thermosiphon system, the hot water cylinder or heat exchanger must be positioned higher than the collector panel with the connecting pipes sloping continuously at a specified angle (greater than 10 degrees to the horizontal) to ensure proper performance.

When combining solar and a wetback it is important to keep the two circulation circuits totally apart, using separate cylinder ports for the wetback and solar connections.

RETROFITTING ON TO RESIDENTIAL DWELLINGS

A solar water heating system can be added to an existing conventional residential hot water system. If the existing hot water cylinder is in good condition a pumped system can be installed by addition of collector, pump and controllers. Suppliers have different methods of ensuring the separation of solar heated water from incoming cold water.

When retrofitting to an existing cylinder, it is important to achieve an appropriate collector panel to hot water cylinder volume ratio (see “Hot water cylinder capacity” above), and ensure the cylinder is not in poor condition.

COMMERCIAL OR INDUSTRIAL DESIGNS

The Brisbane *TAFE Solar Water Heating Systems Resource Book* provides examples of how to design for more complex applications such as for commercial or institutional facilities. In these applications the fluid flow calculations should be undertaken by a qualified and experienced building services engineer.

A number of solar water heating suppliers have their own design tools for systems.

The Solahart website (www.solahart.com.au) has a useful design tool for calculating the energy output from specific Solahart systems throughout New Zealand.

The RetScreen calculation tool developed by the Department of Natural Resources Canada is available free from their website (www.retscreen.net).

Tools commercially available include T-Sol, available from www.tsol.de/tsol.htm



Installation requirements

If you are a solar water heating installer, or require a more in-depth understanding of solar water heating technologies and system configurations, the Solar Industries Association (SIA) can provide information on training courses available.

It is important to use an experienced installer to minimise any problems with installation.

Solar water heating installations should be in accordance with the requirements of Clause G12 of the New Zealand Building Code.

INSTALLATION OVERVIEW

Systems installed in homes sometimes perform considerably below the performances achieved in laboratories and under test conditions. This is usually because, in the laboratory, the system is set up for optimal performance, whereas in a real situation it often needs to conform to other physical constraints.

Most real situation factors add small inefficiencies and these together can sometimes become significant, so care should be taken during both the design and the installation of the system.

The following factors may affect efficiency:

- **Thermostat setting** is the largest factor in the performance of solar water heaters where savings may be reduced if the setting is too high or not controlled by a controller.
- **Controllers** for the supplementary energy should be installed and should be set correctly to maximise system performance. In addition, the controller for pump circulation (on active systems) should be set correctly.
- **Tilt and orientation** of the collector panel towards north may be less optimal than in a test situation², as collector panels are often put on roofs that have not been designed for a solar water heating installation.
- The **collector panel** may be shaded for part of the day in real locations.
- If a **separate solar hot water cylinder** is used and then heated water transferred to another boosted hot water cylinder, up to 5% of energy savings can be lost.
- **Pipe lengths** between hot water cylinder and the collector panel may be considerably longer in real situations than in laboratories, with corresponding energy losses.
- The **hot water cylinder** may be further away from frequently used taps than a conventional hot water cylinder. This increases pipe losses. This is particularly true in retrofitted solar water heating systems involving existing cylinders.
- The **collector panel area** or hot water cylinder **size** may be mismatched with consumption: savings will consequently be affected.

² The drop in performance will depend a little on the type of collector panel. Some models claim only a 4% reduction in performance with angles up to 45° from north and 20° from the angle of latitude. Specific information on particular collector panels should be sought from the suppliers.

STRUCTURAL SUPPORT REQUIREMENTS

Systems that have a hot water cylinder mounted on the roof or in a loft require special fixings and support structures. The installer needs to note the positioning and method of installed fixing screws. Consideration also needs to be given to the strength of the roof structure where a cylinder is mounted on top of a roof. (References: *New Zealand Building Code for Structures*; *Manual for Structural Assessment for Installation of Solar Water Heating in Domestic Dwellings*; NZS 3604:1999 Timber Framed Buildings; and Code of Practice, Section 5.4.) See Appendix 3 for more information.

The installer should check that fixing screws have not split the rafter or purlins or, worse, missed them altogether. Also, the correct number, size and penetration depth of fixings should be to specification. Installers should be able to provide consenting authorities or auditors with a structural design or building permit for these, particularly on roofs with a steep inclination.

If an earthquake strap has not been fitted to the hot water cylinder, the owner should be asked to consider this option.

INSULATION

Insulation of piping and solar equipment is important to maximise the benefits obtained from investment in a solar water heating system. All hot pipes, including bends, should be insulated, as should equipment such as valves.

Exposed insulated pipes should be UV protected.

PIPE MATERIALS

The choice of pipe material is very important, as a solar water heating system is an uncontrolled heat source that can reach very high temperatures if the pressure or temperature relief valves fail. It is generally standard practice to use only copper piping, except in regions where the water is corrosive to copper. Some non-metal pipe materials can be used on parts of an installation, providing they are specifically manufactured to withstand high temperatures and pressures.

TEMPERING VALVES

The New Zealand Building Code requires hot water systems to “avoid the risk of scalding”, which usually leads to the use of tempering valves on new hot water systems (as one acceptable solution to this requirement). Territorial authorities require the fitting of a tempering valve when new wetbacks or solar systems are fitted, to produce the recommended safe temperature of 55 degrees Celsius.

Existing wetbacks do not legally require a tempering valve. However, a wetback or solar system can create very high water temperatures – up to 100 degrees Celsius. Without a tempering valve, house occupants are in danger of being burnt. The risk is increased by the fact that high temperatures can be intermittent and unexpected.

Without a tempering valve, the high temperatures also pose a risk to appliances that use hot water. Many dishwashers and washing machines are designed with a 65–80 degrees Celsius (maximum) hot water temperature. Components may fail at higher temperatures and they will carry no manufacturer’s warranty at such high temperatures. The plastic plumbing used in many homes may fail if exposed to near boiling water for more than short periods of time, as it is considered to be suitable only for temperatures less than 90 degrees Celsius. This is particularly relevant for open loop solar water heating systems.

USAGE REGIME AND PERFORMANCE

Performance can be modified significantly by adjusting hot water usage patterns, and the proportion of the hot water cylinder which is heated by the electric booster is a significant performance factor. Sometimes a dual element cylinder provides more flexibility, with a small-volume fast reheat element available at the top of the cylinder. Often this is all that is required and the bottom element is only used at times of high demand.

The choice and use of a supplementary energy controller can also affect the level of solar gain achieved, and the overall performance of the system. Some suppliers provide remote sensing thermostats and electronic temperature read-out units. For example, some industry accredited suppliers will provide, when asked, an electronic optimiser which considers the temperature of the water, outdoor temperature, time of day and usual usage pattern before “deciding” whether to use electricity to boost temperatures.

INTEGRATING WITH WETBACK WATER HEATING SYSTEMS

Similar to solar water heaters, the quality of the installation of wetbacks will significantly affect performance and safety. These important factors are explained in Domestic Hot Water Options and Solutions, CAE, 2001 and Standard AS/NZS 3500.4. These include the slope and distance of pipes between the wood burner and hot water cylinder, avoiding heat loss due to back circulation, managing an uncontrolled source of heat that is capable of boiling, and installing low-pressure open-vented hot water cylinders, unless more complex designs are used.

Care is required when designing and installing systems so the overflow or dumping of near boiling water onto roofs and into pipe drains or gutters will not cause damage. This can occur when little or no hot water is used, such as during vacations, and a temperature or pressure relief valve activates.



Appendix 1: Glossary of Terms

Absorber: a device within a collector for absorbing radiant energy and transferring this energy as heat into a heat transfer fluid.

Ambient temperature: the average temperature of the air that surrounds the equipment.

Collector panel(s): a device that contains an absorber to absorb energy from the sun. This is installed either as a single unit or as part of an array of units, to heat water, which is stored in a cylinder or container.

Heat exchanger: a device that transfers the heat through a conducting wall(s) from one fluid into another.

Heat transfer fluid: water, or other fluid, in a collector or collector loop (sometimes a glycol mixture is used), which is used to transfer heat around the solar water heating system.

Integral system (or 'close coupled'): a solar water heating system in which the container and collector are constructed as a single unit. In these cases the collector feeds directly into the hot water cylinder.

Potable water: drinking water.

Solar gain: the energy derived from the sun.

Solar irradiation: the amount of energy per unit area of a surface, over a specified time interval. Often described over an hour or a day (for example MJ/m²/day).

Split system: a solar water heating system where components are in at least two different locations. For example, the collector panel may be on the roof, and the container located at ground level.

Supplementary or booster energy: any energy, other than the sun's energy, that is used to heat water in a solar water heater. This is most often an electric element or gas boost. The supplementary energy source should be controlled to make the most use of the sun's energy.

Thermosiphon: the natural movement, based on convection, of a heated fluid above a cool fluid. This simplifies the process of moving heated fluid and also heat transfer in a solar water heater, as an electric pump is not required.



Appendix 2: Performance and climate variables

ENERGY PERFORMANCE MODELLING METHODOLOGY

The efficiency of solar water heating systems can vary, although this is often due to factors other than collector panel efficiency. Nevertheless, it is possible to compare systems in standard reference conditions. An energy performance test methodology in the Standard AS 4234 is being modified for New Zealand climatic conditions.

This Standard describes the methodology used to calculate the performance of complete, packaged systems. It uses a combination of component tests and mathematical modelling, and allows testing for each of two irradiation zones as shown in Map 1. Copies of the Standard will be available from Standards New Zealand (www.standards.co.nz).

Suppliers will be able to provide information on their system energy performance by reference to performance calculations undertaken using the Standard AS 4234. Calculations are to be those applying for Zone 4 until relevant information is available for the respective New Zealand zones.

IRRADIATION IN NEW ZEALAND

The calculated values of total daily global energy and total yearly available energy can indicate the “solar quality” of a site.

The global, direct and diffuse irradiances vary as functions of time of day, day of year and from year to year. For a given site, Typical Reference Years (TRY) are produced. They represent 8,760 hourly expected values for global, direct and diffuse irradiances.

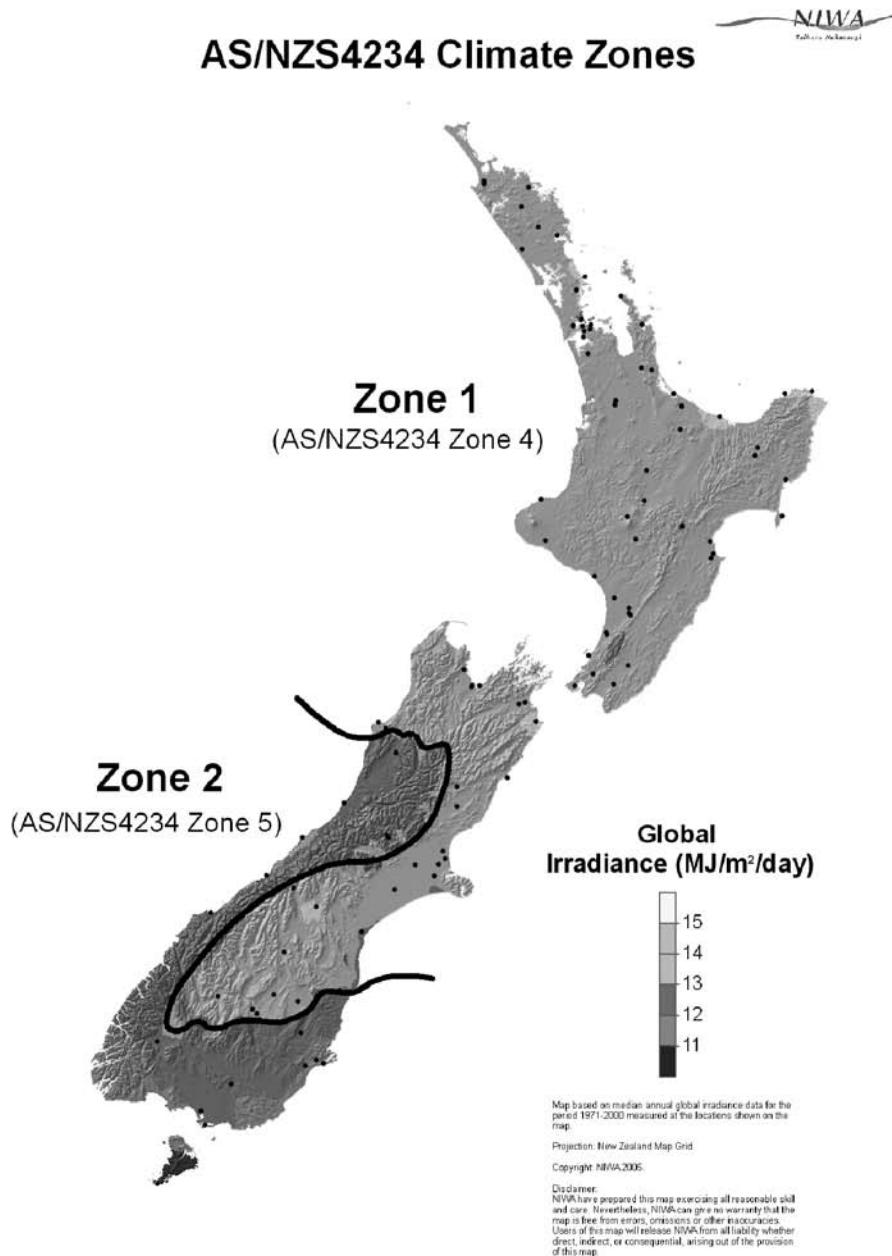
Such values are available for a number of sites in New Zealand (Kaitaia, Auckland, Wellington, Christchurch, Invercargill). They can be successfully used to calculate the expected output from a variety of solar conversion systems at those sites on an hourly, daily and yearly basis. These TRY can also be used to calculate total daily energy expected on a horizontal surface and total daily energy in the direct sun beam. TRY can also be used to calculate the total yearly solar energy available to solar conversion systems.

TRY irradiation values for Auckland, Wellington, Christchurch and Dunedin are available from the New Zealand Photovoltaic Association website (www.nzpva.org.nz), from the NIWA Climate website (www.niwascience.co.nz) or from EECA (www.eeca.govt.nz).

Solar energy measured in MJ/ square metre information on all regions in New Zealand is shown in Map 1³.

³ This map of mean daily solar radiation for New Zealand is based on an interpolation of climate station data collected during the period 1971–2000. The location of these climate stations is shown on the map. Areas close to climate stations have a higher degree of accuracy than areas where there has been no collection of solar radiation data.

Map 1. Irradiation in New Zealand.



⁴ NIWA makes no representations or warranties regarding the accuracy of the information shown on this map or in Table 2, the use to which the information may be put, or the results to be obtained from the use of the information. Accordingly, NIWA accepts no liability for any loss or damage (whether direct or indirect) incurred by any person through the use of or reliance on the information, and the user shall bear and shall indemnify and hold NIWA harmless from and against all losses, claims, demands, liabilities, suits or actions (including reasonable legal fees) in connection with access and use of the information to whomever or how so ever caused. The copyright and all other intellectual property rights in the information remain vested solely in NIWA. NIWA is to be acknowledged in publications (relating to the map or Table 2), or products based on these.

Table 2 also shows the monthly irradiation data for 20 locations throughout New Zealand. The data is based on information available from the National Institute of Water and Atmospheric Research (NIWA)⁴. If you require more accurate data than is available here you should contact NIWA's National Climate Centre for more information.

Table 2. Solar Irradiation Data

MEAN DAILY GLOBAL RADIATION (megajoules/square metre)

Data are mean monthly values of mean daily global radiation for the 1971-2000 period for locations having at least 5 complete years of data

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
KAITIA	21.7	19.4	16.4	11.6	8.5	7.0	7.7	10.1	13.5	16.9	19.9	22.1	14.6
WHANGAREI	20.8	18.4	15.5	11.3	8.4	7.1	7.4	10.3	13.7	16.9	18.8	20.4	13.8
TAURANGA	23.0	20.2	16.4	11.4	8.1	7.0	7.1	9.8	13.7	17.2	20.4	22.6	14.6
ROTORUA	22.5	19.6	16.0	11.1	8.0	6.3	6.7	9.4	12.9	16.6	19.5	21.6	14.1
AUCKLAND	23.1	20.1	16.0	11.7	8.3	6.6	7.9	10.0	13.8	17.5	20.9	23.1	15.0
HAMILTON	21.7	19.2	15.8	11.1	7.7	6.2	6.7	9.0	12.7	15.9	19.9	22.0	14.1
NEW PLYMOUTH	23.2	20.9	16.3	10.8	7.6	6.1	6.7	9.7	13.0	16.7	20.9	22.6	14.7
MASTERTON	21.7	19.0	15.2	9.7	7.0	5.5	5.9	8.6	12.6	17.0	20.6	22.5	13.8
GISBORNE	22.6	19.4	15.4	10.8	7.9	6.6	6.8	10.0	13.9	18.5	20.7	23.0	14.6
NAPIER	22.1	19.4	15.5	10.8	7.8	6.3	6.8	9.7	13.6	18.4	20.8	22.5	14.5
PALMERSTON NORTH	21.9	19.2	14.7	10.1	6.8	5.2	5.9	8.4	11.8	15.7	19.0	20.9	13.6
WELLINGTON	23.6	19.9	15.1	10.3	6.6	4.9	5.7	8.1	12.3	16.9	20.9	22.6	14.0
WANGANUI	23.8	21.5	15.6	10.9	7.7	6.1	6.9	9.3	13.3	17.1	21.2	23.7	14.9
WESTPORT	20.9	18.7	14.5	9.2	6.5	4.8	5.7	8.2	11.6	14.4	19.5	20.0	13.0
HOKITIKA	20.7	18.1	13.8	9.2	5.8	4.5	5.3	7.7	11.5	14.9	19.2	20.5	12.6
NELSON	23.4	20.5	15.6	11.2	7.6	5.7	6.2	8.8	13.2	17.2	21.0	22.9	14.4
BLenheim	23.1	19.8	15.9	11.1	7.5	5.8	6.5	9.0	12.9	17.5	20.8	22.5	14.3
KAIKOURA	21.3	18.7	14.9	10.1	7.1	5.3	6.1	9.1	12.8	17.8	21.1	22.4	13.9
CHRISTCHURCH	21.9	18.6	13.9	9.5	6.1	4.6	5.1	7.7	12.1	16.8	20.6	22.2	13.3
TIMARU	20.0	17.3	14.4	9.3	6.2	5.5	6.2	8.9	13.0	16.7	20.4	21.2	13.2
DUNEDIN	18.5	17.2	12.3	8.1	4.9	3.6	4.5	6.8	11.0	14.3	17.1	18.9	11.4
MANAPOURI	21.4	18.5	13.6	8.4	5.0	3.7	4.2	7.2	11.4	15.8	19.9	22.5	12.7
QUEENSTOWN	23.9	20.8	15.5	10.2	6.3	4.7	5.7	8.6	13.0	18.0	21.7	24.3	14.4
CLYDE	22.2	19.2	15.0	10.0	5.9	4.3	4.7	8.0	12.3	17.5	21.3	22.8	13.6
INVERCARGILL	20.4	17.5	12.6	7.9	4.6	3.6	4.3	7.0	11.1	15.5	19.8	21.5	12.1
CHATHAM ISLAND	20.0	16.9	12.8	8.6	5.1	4.0	4.7	7.2	10.9	15.2	18.9	20.7	12.3
ANTARCTICA SCOTT BASE	25.4	13.7	4.5	0.4	0.0	0.0	0.0	0.1	2.5	11.2	23.3	29.3	9.2

Table 3. Freezing Areas within New Zealand
(Number of days each month when the ambient temperature reaches freezing temperature)

MEAN NUMBER OF DAYS OF GROUND FROST													
Data are mean monthly values of the number of days with ground frosts for the 1971-2000 period for locations having at least 5 complete years of data													
Station details are available in separate table													
Location	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
KAITIA	0	0	0	0	0	0	0	0	0	0	0	0	1
WHANGAREI	0	0	0	0	1	3	4	2	1	0	0	0	11
AUCKLAND	0	0	0	0	1	3	4	2	1	0	0	0	10
TAURANGA	0	0	0	1	5	9	12	9	4	2	1	0	42
ROTORUA	0	0	0	2	8	12	14	11	7	3	1	0	57
TAUPO	1	1	1	3	8	12	16	14	9	7	3	1	69
HAMILTON	0	0	1	3	8	11	14	11	7	3	1	0	63
NEW PLYMOUTH	0	0	0	0	1	4	4	3	1	0	0	0	15
MASTERTON	0	0	1	2	8	11	13	12	8	5	2	1	60
GISBORNE	0	0	0	0	3	8	9	8	3	1	0	0	33
NAPIER	0	0	0	0	3	7	7	7	3	1	0	0	29
PALMERSTON NORTH	0	0	0	1	4	8	10	8	4	2	1	0	38
WELLINGTON	0	0	0	0	1	2	3	3	1	0	0	0	10
WANGANUI	0	0	0	0	0	1	3	2	0	0	0	0	7
WESTPORT	0	0	0	0	2	6	8	6	2	0	0	0	26
HOKITIKA	0	0	0	2	5	12	15	12	5	2	1	0	54
MILFORD SOUND	0	0	0	1	7	14	16	13	5	2	1	0	56
NELSON	0	0	1	4	12	18	21	17	10	4	1	0	88
BLenheim	0	0	0	1	6	15	16	13	6	2	0	0	60
KAIKOURA	0	0	0	0	2	6	8	6	4	1	0	0	27
MT COOK	1	1	3	9	19	22	24	23	14	8	3	1	140
CHRISTCHURCH	0	0	0	2	9	16	16	15	9	3	1	0	70
LAKE TEKAPO	1	1	5	11	21	25	27	25	16	9	5	3	149
TIMARU	0	0	2	5	12	21	23	19	12	5	3	0	100
DUNEDIN	0	0	0	2	6	13	16	12	7	3	1	0	58
QUEENSTOWN	0	0	1	5	13	21	24	21	14	7	3	0	107
ALEXANDRA	1	2	3	10	19	26	27	26	19	12	6	2	148
INVERCARGILL	1	2	3	6	9	16	18	16	11	6	4	2	94
CHATAM ISLAND	0	0	0	0	0	1	1	1	1	0	0	0	4

Appendix 3: References and resources

Information to assist potential purchasers or building professionals is available at:

- Energy Efficiency and Conservation Authority website (www.eeca.govt.nz)
- SolarSmarter website (www.solarsmarter.org.nz)
- Solar Industries Association website (www.solarindustries.org.nz).

These websites provide information on system suppliers, installers and basic information on the operation of solar water heating systems.

Examples of the guides and reports currently available are:

- Code of Practice for Manufacture and Installation of SWH Systems
- Solar Energy Use and Potential in New Zealand
- The Potential for Use of Solar Water Heating in Motels
- Solar Water Heating Monitoring Guide
- Guide for Solar Water Heating Installation Auditors
- Solar Water Heating Factsheet.

Solar water heating suppliers generally have websites with a lot of information about their products.

Important Standards and documents referred to in this guide include:

- AS/NZS 2712 Solar and heat pump water heaters – Design and construction Amendment Oct 2005
- AS/NZS 3500.4 Plumbing and drainage, Part 4: Heated water services
- Code of Practice for manufacture and Installation of Solar Water Heating Systems in New Zealand, New Zealand Solar Industries Association
- AS 4234 Solar water heaters – Domestic and heat pump – Calculation of energy consumption
- AS/NZS 4606 Storage water heaters
- AS/NZS 4602 Low pressure copper thermal storage electric water heaters Amendment 1.

Solar water heating installer training courses are available at selected training institutes around the country. Please contact the Solar Industries Association (www.solarindustries.org.nz) for more information.

Self-teaching resource books are:

Brisbane TAFE, Solar Water Heating Systems Resource Book and Solar Water Heating Systems Learning Guide

Available by purchase from:

QLD Textbook Warehouse
PO Box 3220
Bracken Ridge 4017
Queensland
AUSTRALIA

Fax: 61 7 3261 1966

Email: qldtextbook@iprimus.com.au

Enquiries, including price lists and order forms for the SWH books, can be made through their website (www.qldtextbook.com.au).

Swinburne University of Technology TAFE, NUER 10 Solar Water Heating Systems, Certificate IV in Electrotechnology Renewable Energy.

Business Council for Sustainable Energy (www.bcse.org.au), Solar Water Heating Training Course Installer and User Guide.