Energy Efficiency and Conservation Authority
Te Tari Tiaki Pūngao

Evaluation Guidelines for Commercial Sized Solar Water Heating Systems

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April 2008

Introduction:

This document is to help professionals who are receiving large (commercial) sized SWH design proposals from installers to guide their selection of a suitable system for their requirements. It is intended to cover the most common aspects of commercial solar system design, and provide a background of information to serve as a basis for discussions with the system supplier / installer.

Large-scale solar systems are usually custom designed for a particular application. Therefore, the better the information the system designer has about the proposed application, the better they are able to design an appropriate system. It is important to spend the time early on in the process to discuss the requirements and expectations of the system with the system supplier.

This guide is designed to highlight the design areas where particular care needs to be taken when choosing a suitable solar system for an application. For more in-depth analysis, it is strongly recommended an independent consultant review the proposed system. Additional time spent at this stage of the process can greatly reduce complications once the system is installed.

General information required from the system supplier:

The solar industry has been implementing a range of Standards that suppliers and their products are required to comply with. The following details information that are recommended or required for all solar systems in New Zealand.

1) **SIA Accredited Supplier and Approved Installer**
   It is recommended that systems be supplied by Solar Industries Association (SIA) Accredited Suppliers or their nominated agents. Installation should be undertaken by the Accredited Suppliers nominated Approved Installers.

   SIA Accredited Suppliers are bound by an industry "Code of Conduct" and "Code of Practice" which outlines their roles and responsibilities to the customers. A copy of these documents can be obtained from the SIA website. www.solarindustries.org.nz

2) **Standards Compliant Product**
   To ensure the quality and performance of the system that is proposed to be installed all components within that system should have been tested to the relevant Standard to demonstrate compliance.

   Compliance may be demonstrated by the provision of AS/NZS 2712 certification.
   The rollover period for accepting these standards is:
   AS/NZS 2712: 2007, valid indefinitely
   AS/NZS 2712:2002, valid until 1 July 2009
   NZS 4613, valid until 1 July 2008

3) **Cylinder heat-loss test to AS/NZS 4692.2:1996 (MEPS)**
   Storage loss from cylinders is a significant proportion of the total energy demand for a heated water system. The Minimum Energy Performance Standard (MEPS) for hot water cylinders defines the maximum allowable heat loss for cylinders in New Zealand. The New Zealand MEPS for hot water cylinders requires a lower heat-loss than the Australian MEPS and is preferred. All MEPS tested and compliant tanks are listed on the Australian energy rating website, www.energyrating.gov.au

4) **Manufacturer's Documentation**
   SIA Accredited Suppliers are expected to provide installers with appropriate installation manuals, and system owners with operating manuals as set out in the Code of Practice. Management of the SWH system and understanding the control parameters are critical to the long term efficiency of the system and especially if the demand load changes in the future.

5) **Building consents**
   Building Consents will be required for installing any large scale (commercial) Solar Water Heater (SWH) and any proposal should include this cost, including if applicable any engineering details required.

Choice of Collector Type:

It is important to consider the different operating characteristics of the solar water technologies that are available. In general, each collector will have an optimised performance at a particular temperature range. The most appropriate collector type will depend on the location of the system, and the operating conditions the system is designed for.

- The unglazed collectors are best in warmer regions where a high volume of low temperature preheated water is required. At fluid temperatures 5ºC-10ºC above ambient air temperature, the performance drops considerably.
- The glazed collectors are best as preheat systems where approximately 30 - 60ºC preheated water is required. The non-selective surface collectors are best at the lower end of this range, and titanium oxide coated absorbers (TINOX) are better at the higher end. Black chrome (selective surface) absorber is the intermediate choice.
- The evacuated tube collectors function best at higher fluid temperatures, particularly as integrated systems. They also work well in colder climates, at higher elevations, and in particularly windy locations. The absorber is also resistant to corrosion from salt spray in places where this is an issue. Often a reflector is used behind the tubes to improve performance. Ensure the reflector material is suitable for the environment. Systems where the reflector is an integral part of the collector, performance may require periodic cleaning in some locations.

PREHEAT VERSUS INTEGRATED SYSTEMS

Preheat systems usually work by limiting the maximum temperature rise achieved by the solar system to approximately 60ºC. Systems designed to heat to higher temperatures are usually integrated systems with a greater ratio of combined collector output to the required load.

- A Low ratio of collector area to load will see the system rarely operating above 50ºC. These systems rely on a rapid turnover of water in the auxiliary heating system, and are exclusively designed as preheat systems. These systems will generally have less than 1 m^2 / 100 L of daily hot water demand*.
- A Moderate ratio of collector area to load will result in maximum temperatures achieved in the 60 – 80ºC range during summer. These systems can be either pre-heat or integrated systems. These systems will generally have 1-2 m^2 of collector / 100L of daily hot water demand*.
- A High ratio of collector area to load will result in the solar system during summer frequently operating above 80ºC, and is likely to reach stagnation conditions at times. These systems are best designed as integrated systems. These systems will have greater than 2 m^2 of collector per 100L of daily hot water demand*. Evacuated tube collectors are also well suited to these applications.

*There is a wide variation in the performance of different collectors, particularly at the higher temperatures, and between flat panels and evacuated tubes. These numbers relate to flat panels, and as a general approximation, multiply these numbers by 0.66 when using the absorber area of evacuated tube collectors.

The integration of the auxiliary boost heating with the solar circuit can result in better utilisation of available solar radiation at the time it is produced, provided it is properly designed. It is more demanding however on the control strategy used to limit the use of the auxiliary heat source. Ensure that the supplier has an effective control strategy that will allow the solar collectors to work efficiently whilst ensuring the system can provide the require hot water demand. Systems that involve multiple cylinders installed in parallel require special attention to system design.

SYSTEM SPECIFIC INFORMATION REQUIRED FROM THE SYSTEM SUPPLIER:

1) Orientation and angle of the collectors

Solar systems need to be installed facing North (towards the equator), and tilted to approximately the latitude angle for optimum performance. In New Zealand, this means that the solar collectors should face true North, and be installed at 35-50º. In situations where the expected hot water demand is heavily biased to a particular time of the year (eg summer) then the angle the collectors are installed at may be adjusted to suit. This should only occur for the more extreme cases.

It is important to realise that the propensity of a system to enter over-temperature conditions is significantly increased when the collectors are installed at a low angle. This should be addressed by decreasing the collector area if the collectors cannot be raised to a steeper angle. Should enhanced winter performance be required, the collector can be installed at angles greater than 50º, and additional collector area installed without increasing the risk of excessive over temperature during summer. This can work particularly well with evacuated tube collectors.

2) Sizing of Tanks to Collector size
The size of the tanks required for an effective large scale solar system requires careful evaluation of the load, and timing of load for the system. For a preheat system, in general the tank size should be at least the daily hot water demand. For integrated systems, tank sizing is more complicated. In general the larger the solar storage, the better, however, where there is consistent hot water demand during the day, the storage tank volume can be significantly smaller. Some highly optimised system designs can work well with relatively limited storage, however such systems should always have highly detailed analysis of demand and supply of hot water such as that which is provided by modelling the system.

3) Optimum flow rates through collectors
The flow rate through the individual collectors should be between 0.25 – 0.75 $l/min/m^2$, although systems with variable speed pumps can have maximum flow rates higher than this. Systems using a constant pressure pump on the solar circuit need to ensure the collector flow rates are appropriate for the system under the range of conditions likely to be encountered.

4) Sizing of boilers for auxiliary heating.
The size of the boiler used to provide auxiliary heating has a significant effect on overall system performance. This is particularly an issue with integrated system designs, where the solar system is being retrofitted to an existing heating system. If the boiler is too large for the system, there will be excessive wastage of energy during start up and cool down of the boiler. If it is too small, the boiler will operate for longer periods of time, and is likely to compete with the solar system.

5) Reverse thermosiphoning protection
Reverse thermosiphoning occurs when warm / hot water is able to flow to a higher level in the system, cooling, and returning to the bottom of the system. Usually this flow is in the reverse direction to the pump flow, so a non-return (check) valve can be installed to prevent it occurring. The non-return valve usually has a small spring that allows water to flow one direction, but prevents flow in the other direction. In integrated systems, particularly those involving multiple cylinders, the prevention of reverse thermosiphons can be more difficult, and a consultant may be required to review the system.

6) Systems involving ring-mains
Many large-scale solar systems will involve hot water service via a ring-main system. It is important to ensure the ring-main is operating as efficiently as possible before adding a solar system to the heating system as ring-main losses will frequently be a significant proportion of total energy demand from the system. A consultant is recommended for these systems.

7) Insulation of pipework
Significant heat-loss from the system will occur if the pipes both to and from the collector are not fully insulated, this includes within the roof-space. Closed cell elastomeric pipe insulation is suitable for this provided it is fully weather protected and UV protected where used outside. Most adhesive tapes are not suitable to protect closed cell foam, see G12/AS2 or NZS 4305:1996 for suitable insulation solutions.

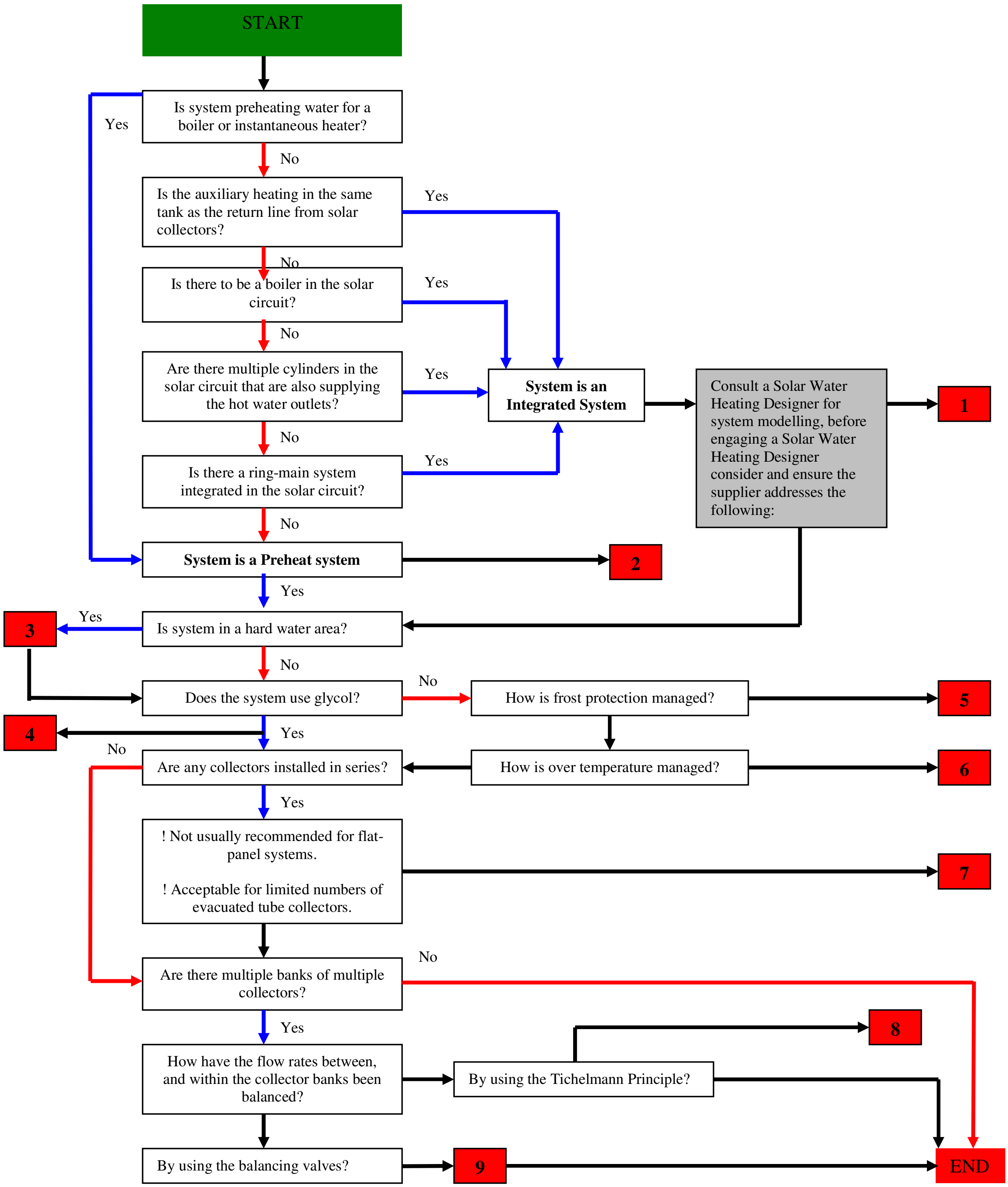
8) System commissioning and client training
The performance of large-scale solar systems can usually be fine-tuned once the system is installed and operating. It is therefore important that the installer allows time to commission the system to ensure that it is working as intended. The system should be added to a scheduled maintenance program to ensure that any operating faults that arise post commissioning are responded to.

9) Performance Analysis
Most preheat systems can be reasonably accurately sized, and the performance estimated using widely available calculation tools such as RETScreen™. However, for more complicated systems, and especially larger integrated systems, thermal simulation software such as TRNSYS™ will provide more accurate information about the sizing and optimisation of system components, and the effectiveness of the control strategy proposed for the system. It is strongly recommended for commercial systems that modelling data is provided to support any claims of energy savings.

Checklist for system:

- Is the supplier SIA Accredited?
- Has the system designer had experience in designing, installing and commissioning systems that meet or exceed expected energy savings
- Is the installation undertaken by Accredited Suppliers nominated Approved Installers?
- Has the collector been tested to, and passed AS/NZS 2712:2007?
- Are storage tanks used in the system NZ MEPS (AS/NZS 4692.2) compliant?
- Have building consent costs been included in the proposal?
- Are the collectors to be installed facing true North?
- Are the collectors to be installed at a slope between 30 – 60º?
- Will all pipework be properly insulated, with insulation UV protected where appropriate?
- If a boiler is used, is it appropriately sized relative to the required load. (This is particularly important for integrated system designs).
- Has the supplier provided adequate time for system commissioning and client training post installation?
- Does the contract require remedial works if the system performance is less than expected?

FLOW CHART FOR CHECKING THE DESIGN OF LARGE SCALE SOLAR WATER HEATING SYSTEMS.



Explanation Notes:

1 Integrated systems are where the auxiliary heating is integrated into the solar circuit system. Usually this means the same tank is used to receive the water from the solar collectors as is used for auxiliary heating. There are, however, many other variations possible, particularly with commercial systems. System design and control is much more critical to the performance of the system, and the performance of the system should be determined by thermal modelling software (eg TRNSYS).

2 Preheat systems are where the solar circuit is separated from the auxiliary heating circuit. The most common example is where the solar collectors preheat water in a tank (or tanks), that is then used to supply the cold water inlet for a boiler, califont etc. When correctly designed, they are effective at reducing the amount of heating required by the auxiliary heating system. The performance of the system can be determined by either RETScreen™ or TRNSYS™ software.

3 New Zealand has a number of regions with hard water conditions. A useful check to see if this is an issue in a particular area is to consider if the domestic kettles are affected by a build-up of scale. Where these conditions exist, systems must be closed circuit (indirect). Open circuit (direct) systems have cost and complexity advantages over indirect systems, however care must be taken to ensure that a build-up of precipitate within the collector does not occur as it will lead to collector failure in time.

4 Glycol is often used in closed circuit solar systems to prevent freezing and help prevent boiling of the system. Glycol often also contains corrosion inhibitors as well as the glycol itself. Systems that use glycol will need the glycol replaced every few years. Systems frequently operating at high temperature will require more frequent replacement of the glycol as it degrades more rapidly under these conditions. Ensure that a service program is established that will include the replacement of the glycol.

5 Frost protection on smaller systems is often achieved by the use of the pump to circulate warm water from the hot water cylinder through the panels at night to stop them from freezing. This is not recommended for larger systems, as the panels effectively act as radiators under these conditions and large heat-losses are incurred particularly if using flat panels. The use of drain-back system design is preferred in colder locations.

A "Drain Back" frost protection system is usually a closed circuit system with an additional drain-back tank between the pump and the collectors. The pump transfers the solar fluid through the collectors when the pumps run. When the pump stops, the solar fluid drains back into the drain-back tank. This system prevents damage to the collector during freezing conditions and complications during stagnation conditions.

6 Over-temperature control is an importance part of the design of larger solar systems due to the quantity of heat collected. A temperature pressure relief valve (TPR) on either the collector bank or the storage tank is not recommended as the primary means of over-temperature control unless the ratio of collector area to load is low. TPR valves on collectors tend to be unreliable (leading to constant water discharge when they fail) and TPR valves on cylinders can waste a lot of water. Solutions are the use of properly sized pressure vessels to stabilise the system under stagnation, heat dissipater systems, and drainback / draindown systems. Drain-down systems (as opposed to drain-back systems) should only be used where the risk of overheating and freezing is low to prevent excess water consumption.

7 The performance of most collectors designs decreases when multiple collectors are joined in series. This is because the ability of the collector to efficiently heat the preheated water from the previous collector declines with each additional collector. Evacuated tube collectors are not as sensitive to this issue as flat-panel collectors, and can therefore have more collectors joined in series. In general, flat-panel collectors should be parallel connected and evacuated tube collectors in limited series connections.

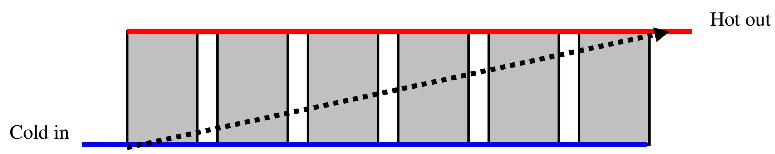


Figure 1. Parallel – Recommended

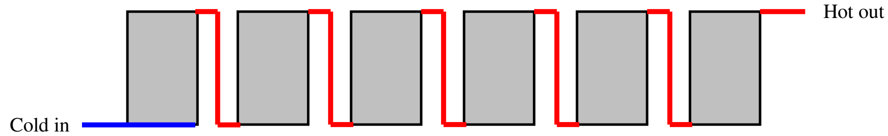


Figure 2. Series – Not Recommended

8 The Tichelmann Principle refers to a method for balancing the pressure loss and flow within a bank of collector panels. The flow should move in a constant direction across all connected collectors simultaneously. Flat panel collectors connected in serial do not conform with this principle as the flow alternates between up and down between subsequent collectors. The collector inlet should be in the opposite corner to the collector outlet within a row of collectors, and between a bank of collectors. The figure below shows this principle for flat panel collectors installed in parallel, and for evacuated tube collectors installed in both series and parallel. Some collectors, particularly heat-pipe evacuated tube style collectors, are less sensitive to multiple serial connections than other types.

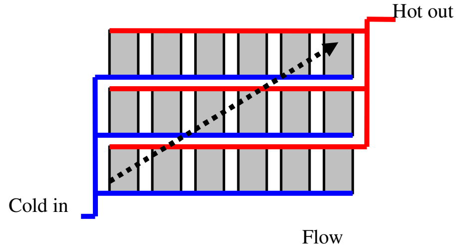


Figure 3. Flat panel installation

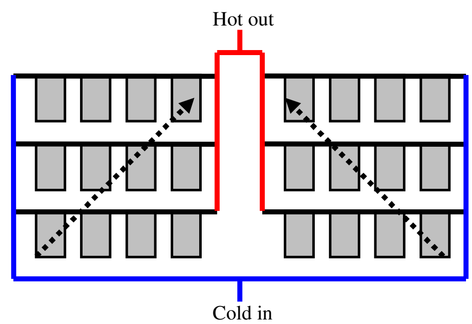


Figure 4. Evacuated tube installation

9 A balanced flow should primarily be achieved through the way the system is plumbed, using the 'first in, last out' principle. This ensures the backpressure across each row of collectors, as well as through each collector, is as even as possible. Should this be insufficient, then the use of balancing valves can be used. Balancing valves can be difficult to set up accurately, and it is likely with time that the system flows will become uneven. Systems with an uneven number of collectors on different circuits should be avoided.