CHAPTER 9

Extra Information

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The Business Council for Sustainable Energy cannot accept responsibility for any errors and omissions contained in this information. Specialist advice is recommended in particular for current health and safety requirements.

9.1 Glossary of terms

Term	Description or definition
Absorber area	The net area of absorber receiving solar energy. With an evacuated tube collector the absorber area is the plan area of the array of tubes and does not include the gap between tubes. The area of tube arrays with a parabolic reflector behind the tubes is the area of parabolic reflector.
Absorptance	A measure of the fraction of solar energy falling on a surface that is absorbed into the surface and converted to heat. Typical absorptance factor for absorber plates = 0.9 to 0.95 (i.e. 90 to 95%). The maximum value is 1.0 or 100%.
Active solar heating system	This type of system uses a fan or a pump to transfer hot air or heated water to another place, perhaps to storage of some type. Rocks may be used to store heat from heated air. An insulated storage tank is used to store heated water.
Air eliminator valve	A valve at the highest point in the circuit to bleed air out of the circuit to prevent air locks restricting the flow.
Altitude angle	The vertical angle between the horizontal plane and the sun’s position in the sky, or points along the top of any object that may cause shading on a collector.
Anti-freeze solution	Adding ethylene glycol or propylene glycol to water lowers the temperature at which the water freezes. By adding sufficient glycol to the water in the solar collectors the damage that can be caused by frost is prevented, because freezing is prevented. This is exactly the same technique used in motor cars to prevent damage due to freezing.
Audit	A hot water audit is an assessment of all the uses of hot water in order to come up with a total figure and times for usage.
Azimuth angle	The horizontal angle between true north and the sun’s direction measured clockwise on the horizontal plane.
Boost energy	Energy that is used to boost the temperature in the tank when solar energy is not available.

Cavitation in pumps	The tendency of water within the pump to boil (vaporise) so that bubbles of water vapour form within the pump. Cavitation is likely to cause damage to the pump, cause noise and reduces pumping efficiency. The likelihood for cavitation occurring increases as water temperature increases and, as pressure in the suction side of the pump is reduced. Cavitation is likely to occur in solar hot water systems where the circulating pump has too small a diameter pipe delivering water to the pump, or where there is not enough head of water above the pump, such as in an in-ceiling installation.
Change of state	A substance (fluid) is said to change state when it changes from a vapour or gas to a liquid or changes from a liquid to a solid. Energy input is required to change a solid to a liquid or to change a liquid to a vapour (gas). Energy is released (or removed from the fluid) in changing from a vapour to a liquid or from a liquid to a solid.
Close coupled system	A thermosiphon system where the collector is closely connected to the tank and both are usually on a roof.
Closed loop system	A system where the heat transfer fluid flows in a closed loop from the collector to a heat exchanger in the tank and then back to the collector to be heated again. Often referred to as an indirect heating system.
Cold water shut off valve	A terminator valve sits in a safe tray. If water leaks and starts to fill the tray, the cold water shut off valve, which is spring-loaded, closes the cold water supply. A drain line is not required from the safe tray if a cold water shut off valve is fitted.
Collector area	The same as absorber area.
Commissioning	The process of ensuring that all component parts of a total system function as they should and that the system is adjusted for optimum performance under all normal operating conditions. Commissioning is the last part of an installation prior to hand over to the owner.
Compressor	An electrically driven pump that moves refrigerant around a heat pump circuit to transfer heat.
Condenser	A heat exchanger consisting of either a flat plate with tubes attached or ‘grille’ (like fins and tubes). In a refrigerator, this becomes hot and dumps heat collected from the food to the air outside. This is part of all heat pump systems for transferring heat from the air to water.

Corrosion	Deterioration of metal. The metal combines with other elements to form a salt of the metal. Rust is the corrosion product that results from the combination of iron (steel) and oxygen to form iron oxide.
Corrosion inhibitor	A chemical that can be added to water to prevent metals being corroded, such as rusting of steel. A corrosion inhibitor will also prevent the corrosion caused by dissimilar metals being in contact with each other.
Cross pitch stand or frame	A steel frame used on an east or west facing roof on which to mount a solar system to face the collector to the north.
Diffuse radiation	The component of incoming solar radiation which is scattered by clouds and other gases or particles in the atmosphere.
Direct radiation	The component of solar radiation that comes direct from the sun as parallel rays.
Direct system	The water in the tank is heated in the collectors. There is no heat exchanger.
Discount rate	This factor reduces the value of money spent in the future to what it would be worth if spent today. The market discount rate equals the market interest rate of the most likely alternative investment, typically a bank term deposit.
Domestic hot water (DHW)	The description of hot water that is used for normal domestic tasks – washing people, hands, clothes and dishes. The water used by staff in offices or factories is also called *domestic hot water* although a factory is not regarded as *domestic*. It distinguishes this hot water from hot water used for other purposes such as heating.
EPDM	The acronym for Ethylene Propylene Diene Monome, a flexible rubbery plastic-like material used for roof flashings.
Efficiency of collector	A measure of the fraction or percentage of energy in the heated fluid leaving a collector compared to the incoming incident solar radiation falling on the collector surface area.
Electrolysis	The reaction between two dissimilar metals. It is possible to predict which of the two will be eaten away by the other using the ‘noble metals chart’.
Emittance	A measure of the fraction or percentage of heat re-radiated from the absorber surface

Evaporator	A heat exchanger consisting of either a flat plate with tubes attached or a set of fins attached to a network of tubes. In a refrigerator, it is the plate inside the cabinet at the back that gets cold. It absorbs heat from the food in the refrigerator. Part of all heat pump systems.
Expansion valve	A valve which controls the rate of refrigerant flow through the evaporator in a heat pump system.
Expansion control valve	Also known as **expansion valve**, **cold water expansion valve** or **pressure relief valve**. A valve that releases water when pressure increases in the storage tank.
Fin and tube collectors	A common method of construction of the absorber plate in flat plate collectors. Riser tubes are connected to a top and bottom header pipe. The riser pipes are bonded to a darkened, flat sheet of material that acts as the absorber surface.
Flooded-plate collectors	A less common method of construction of absorber plates. The collector plate is made of two sheets with roll-welded seams joining the two together. Waterways are formed between the welded seams and the water passing through is heated directly by the sun.
Floor heating	Heating of floors (usually concrete) by passing hot water through pipes, or electricity through wires, buried in the concrete.
Floor waste	A drain in a floor such as a toilet, bathroom or laundry. It is usually a concrete floor designed so that the slope is towards the floor waste grate. If water flows onto the floor it drains down the floor waste to outside the building.
Flow switch	A flow switch turns electricity on when there is a flow of water through the switch. In the case of a pressure boosting pump, when water starts to flow through the flow switch it turns on the pump, increasing the pressure. When the tap is turned off and no more water flows, the flow switch turns the pump off. Sometimes flow switches are used as safety devices so that if a pump runs out of water it is switched off.
Forced circulation	Circulation that does not rely on thermosiphon flow but rather is forced by a circulator (circulating pump).
Freezing temperature of water	Water changes state between 4ºC and 0ºC. It changes from a liquid to a solid and with that change, it increases in volume (expands).
Frost damage	The damage that occurs as the result of water expanding when it freezes.

Frost dump valve	A frost dump valve is a valve that opens at low temperatures (usually about 4ºC). Water runs through the valve allowing other water to take its place. If the incoming water is warm enough (it may only be perhaps 7ºC) it will keep the collectors warm enough to prevent freezing occurring.
Frost protection	Techniques used to prevent damage to solar water heaters caused by the expansion of water as it freezes.
Global radiation **(see also irradiance)**	A measure of the solar power at any instant on a surface. It is made up of both direct and diffuse radiation falling on the surface.
Gravity feed storage tank	The tank is usually in the ceiling and the hot water runs to the outlets by gravity. The tank is not pressurised.
Hardness	Water in which soap refuses to lather is called hard. The hardness is caused by calcium salts (calcium chloride) dissolved in the water. It precipitates in water heating devices forming scale.
Heat exchanger	A heat exchanger is a device to transfer heat from one fluid to another without the two fluids mixing. In solar water heaters a heat exchanger transfers heat from a mixture of water and an anti-freeze into the water in the storage tank, heating it. Recognise that it is the heat that is transferred, and there is no mixing of the two fluids.
Heat pipe	A fluid with a low boiling temperature is turned to a vapour by a heat source (the sun). The vapour rises up the heat pipe and gives off its heat to something (water) at a lower temperature and changes back to a liquid.
Heat transfer liquid/fluid	A fluid that carries (transfers) heat from one place to another. In Solar water heaters it is the water itself or an anti-freeze solution that does this job. The fluid in a heat pipe does the same thing.
Hydronic heating	Heating that uses water to carry the heat. A hydronic heating system requires heat emitters that transfer the heat from the water to the air that is to be heated. These heat emitters are commonly panel radiators, fan convectors (a radiator core with a fan that blows air across it), or various finned heaters (such as skirting heaters) which rely on natural convection currents to conduct heat from the water into the air.
Inclination or tilt angle	A measure of the angle of inclination of the collector to the horizontal plane.

Indirect system	A system in which the water in the storage tank is not directly heated in the collectors. It is heated indirectly by a heat transfer fluid (anti-freeze, water, and perhaps corrosion inhibitor). A jacketed system is an indirect system.
Insulation	Insulation is material that reduces the transfer of heat. In the case of insulated pipes the insulation material may be rubber or plastic wrapped around the pipe. Felt fibre material was commonly used and is still available, but nitrile rubber products like ultraviolet (UV) treated Armaflex are now recommended. Insulation comes in long rolls and can be wrapped round the pipe. Insulation is important in reducing heat losses from hot water pipes. Hot water storage tanks are also insulated to reduce loss of heat from the tank.
Integral system	A solar water heater system where the collector is connected directly to the tank with the collector tubes fitting directly into the tank storage area.
Irradiance	A measure of the solar power per square metre of surface area at any instant (International System of units (SI) unit is: kilowatts per square metre – kW/m^2).
Irradiation	A measure of the radiant solar energy per unit of surface area (SI Unit: Megajoules per square metre). The term ‘insolation’ was formerly used but is no longer preferred.
Jacketed system	The hot water storage tank is surrounded by a jacket. The jacket contains an anti-freeze fluid that is heated in the solar collectors. Heat is conducted through the wall of the storage tank into the water inside.
Latent heat	The energy released or absorbed by a material as a result of a change of phase e.g. such as turning water from liquid to gas (absorbing heat) or gas to liquid (releases heat)
Legionnaire’s disease	A disease caused by the presence of Legionella bacteria that breeds in warm water (40°C) systems or cooling towers and air conditioning plant. It can be fatal to humans.
Megawatt hour (MWh)	The amount of energy generated or used over one hour where power output or demand is one megawatt (MW). Equivalent to 1000 kilowatt hours (kWh).
Net Present Value	The difference in total present values (PV) for two options e.g. the PVs of two water heating systems calculated over their lifetimes.

Off peak or controlled tariffs	Electricity tariffs where supply is made available to an electric heating element by the electricity supply company during set off-peak hours, typically for about eight or nine hours.
Open loop system	A system where the heat transfer fluid is water that flows through the collector where it is directly heated and back to the hot storage tank.
Orientation angle	The angle between the direction the collector faces and true north (not magnetic north as read by a compass).
Passive solar heating	In this heating, no energy other than the sun's radiation is required. A passively heated house will have north facing windows to allow the winter sun to enter, masonry (often a concrete floor or internal bricks) to soak up the heat by day and release it by night, and wall and ceiling insulation to reduce the loss of heat. There is no fan or pump required to capture the heat.
Plinth	A concrete slab or step, similar to a paver. A common size is about 450mm x 450mm x 50mm thick. They make an ideal base to go under a hot water storage tank. Most hardware stores or garden shops stock them as stepping stones for paths.
pH	Note that this is written as a small p and a capital H. It is the negative logarithm of the hydrogen ion concentration in a solution. If the solution is acidic there are many H+ ions. If the pH is low (2 or 3 very acidic, 5 or 6 slightly acidic), 7 is neutral. Above 7 is alkaline. Extremely alkaline is 14 (maximum).
Pipe	In this book the word pipe can mean pipe or tube. Strictly speaking, pipe is measured internally and tube is measured externally. To be technically correct we should not speak about copper pipe, but rather copper tube because it is the outside diameter which determines its size. Steel pipe and most plastic pipes are measured according to the internal hole size and so are pipes, not tubes.
Pipe friction	The force or drag of water on the walls of pipes that slows the flow of water through pipes reducing the rate of flow. Pipe friction is increased by increased rate of water flow, reduced pipe size, and length of the pipe.
Potable water	Water classified under Australian Standards as suitable for drinking.

Preheater	A solar system becomes a preheater when the solar collectors provide less than 50% of total hot water demand.
Present Value	The value of a future good or service converted to the equivalent in today's dollars adjusting for the effects of market discount rates and inflation rates.
Pressure/Temperature Relief (PTR) valve	Its purpose is to protect against excessive temperature (>99ºC) and pressure (>1MPa). (Typical pressure setting is 700kPa). If either of these conditions is exceeded, the valve opens and dumps hot water through a drain.
Protective anode	A protective or sacrificial anode is dissolved rather than some other item. Anodes are installed in steel water storage tanks (hot or cold) and are eaten away if electrolysis occurs, rather than the tank.
Pump-circulated or pumped storage systems	This type of system consists typically of a ground-mounted tank and roof collector panels. A small circulation pump is used to pump water through the collectors. A differential temperature controller with two or more temperature sensors is used to control the pump operation.
Pump circulation frost protection	By pumping water from the storage tank through the collectors, freezing of water in the collectors can be prevented if the water in the storage tank is warm.
Radiation	The transfer of heat by its conversion to electro-magnetic waves or photons (tiny packets of energy).
Renewable Energy Certificates (RECs)	Certificates issued under the Federal Government's Mandatory Renewable Energy Target (MRET) scheme that represent 1MWh of renewable energy electricity generation or 1MWh of electricity saved through the use of solar water heaters.
Retrofit	Taking an existing system and changing it, usually upgrading it. In the case of a hot water system, it can be retrofitted by the addition of solar collectors and equipment to convert it into a solar hot water system

Reverse thermosiphon	Reverse of thermosiphoning, i.e. circulation in the direction that is not required. In the case of a solar water heater reverse thermosiphon is the circulation of heated water from the storage tank to collectors resulting in cooling. This happens at night if the collectors are not mounted below the storage tank.
Ring main	A pipe that runs round all the hot water delivery points and has hot water circulating though it so that whenever a tap is turned on hot water is instantly available.
Sacrificial anode	Used in mild steel vitreous enamel lined tanks to prevent corrosion of the tank. Consists of a long aluminium or magnesium rod running along the inside length of the tank.
Safe tray	Another name is a spill tray, or an overflow tray. It is a water collecting tray designed to catch water that leaks out of a hot water storage tank, or a cold water tank such as a header tank. A safe tray is required where the water storage tank is located inside buildings so that water does not cause damage within the building. The safe tray must be drained to the outside of the building and the drain pipe must be visible so that if it does have water escaping it will be noticed.
Saturation index	The saturation index is a number that indicates how readily scale will form. Generally an increase in pH, hardness, and temperature will result in increased potential for scaling.
Scale	The name given to the build-up of mineral deposits within a water heater that is using ‘hard water’. It occurs on electric elements, the walls of storage tanks and solar collectors. It is usually calcium carbonate (limestone) and can be dissolved with acid such as hydrochloric acid.
Selective surfaces	Special coating applied to the surface of the absorber plate to increase its absorptance of solar radiation and more importantly reduce the re-radiated energy from the surface as it heats up.
Sequential freezing	The principle of having freezing occur in sequence in different parts of a collector. First – freezing occurs in the centre of the risers in a solar collector. Second – freezing occurs in the top and bottom of the risers. Third – freezing occurs in the headers. This varies for different manufacturers.

Serpentine collectors	A less common method of construction of absorber plates by a pipe coiling backwards and forwards across the plate. This pipe is thermally bonded to the absorber plate and as the water passes through the pipe it absorbs heat from the plate.
Simple payback time	Calculated as the difference in the installed capital costs of two alternative water heating systems divided by the difference in annual operating costs of each system.
Solar constant	The average power intensity of solar energy outside the Earth's atmosphere, equal to $1367 W/m^2$.
Solar fraction	The proportion of your hot water energy demand at the outlet of the water heater that is provided by the solar collectors, compared to the supplementary or boosting energy that is required to keep the water at a set temperature, typically 60ºC.
Solar radiation (see also irradiance or irradiation)	The spectrum of radiant energy emitted from the outer layers of the sun. It consists of a range of wavelengths of electro-magnetic radiation from ultraviolet to visible light and infrared radiation.
Space heating	The name given to heating a space (or air), as distinct from heating water. A normal house heater is a *space heater*.
Split systems	See pump-circulated systems.
Stainless steels	Stainless Steel comes in various grades, some more resistant to corrosion than others. Grade 316 is commonly used when a relatively high standard of corrosion resistance is required.
Stratification	The formation of layers of water of different temperatures within a storage tank; hot water at the top and getting cooler further down the tank.
Supplementary energy	Energy that is used to boost the temperature in the tank when solar energy is not available (also referred to as **Boost energy**).
Tank	Also referred to as a hot water cylinder or container.
TDS	Stands for Total Dissolved Solids. TDS is measured in mg/L though it was once measured in ppm – parts per million, of salt dissolved in water.

Tempering valve	A tempering valve (or temperature modulating valve) is designed to add cold water to hot water if required to prevent it exceeding a set temperature. Tempering valves are installed to prevent scalding of people using hot water.
Thermistor	An electronic solid-state device to measure temperature.
Thermosiphon	The natural convection of water around a pipe circuit such as between solar collectors and the storage tank above. The heated water in the collector expands and becomes less dense. It therefore rises to the highest point in the circuit, the top of the storage tank. Cold water from the base of the storage tank moves down to replace the heated water.
Tilt angle (see inclination angle)	
Transmittance	A measure of the fraction of solar radiation that passes through a transparent cover such as glass. Typical transmittance factor for low iron glass is 0.92 or 92% and for window glass is 0.87 or 87%. The maximum value is 1.0 or 100%.
True north versus magnetic north	True north is the direction to the north pole. In most places this is a little different to magnetic north, being either to the east or west of magnetic north.
Tube	In this book the word pipe can mean pipe or tube. Strictly speaking, pipe is measured internally and tube is measured externally. To be technically correct we should not speak about copper pipe, but rather copper tube because it is the outside diameter which determines its size. Steel pipe and most plastic pipes are measured according to the internal hole size and so are pipes, not tubes.
Tundish	The opening into a drainage line. The tundish is usually a funnel shaped fitting which collects the water from expansion pipes, etc and carries it away. The tundish incorporates an air-break (a gap) to avoid the possibility of water being drawn back up the expansion pipe.
Vitreous enamel	Vitreous enamel (or glass) is used to line the inside steel hot water storage tanks to prevent rusting of the steel. It is probably the best form of protection in districts where the water is extremely corrosive

Zincalume®	A registered trademark for steel that is coated with a thin layer of zinc and aluminium to protect the steel from corrosion (rusting). Sometimes the zincalume is covered by paint.

9.2 Answers to revision questions

Chapter 1

9.2.1 Answers to questions section 1.1 solar water heating overview

1. A solar hot water system is similar to an electric or gas storage hot water system with some extra bits. What are the four sections of a solar hot water system referred to in the notes?

The four sections of a solar hot water system are:

- *A collector which absorbs thermal energy from sunlight*
- *A storage tank to store the collected heat energy (in water)*
- *A circulation system to transfer collected energy to the tank*
- *A supplementary or boost heater to further heat the water if solar radiation is inadequate to ensure sufficient hot water is available on demand.*

2. Some gas or electric hot water systems are instantaneous and have no storage. They heat the water as it is required. Why must solar hot water systems have a hot water storage tank?

Solar hot water systems require a hot water storage tank because:

- *Solar energy is not available at all times of the day, so energy needs to be stored in the form of hot water*
- *Even if hot water was used when there was sufficient solar energy, the area of solar collectors to instantaneously heat water to a sufficient temperature would be impractically large.*

3. Transfer of hot water from the solar collectors to the storage tank can occur in one of two ways. What are the two ways?

Hot water can be circulated from the solar collectors to the storage tank either by:

- *Natural thermosiphon circulation where the tank is above the collectors, so that the hot (less dense) water can rise up to the tank*
- *Forced circulation with the use of a pump. In this case the tank can be at ground level or elsewhere below the collectors.*

4. Why are evacuated tubes more effective than flat plate collectors in cold climates?

Evacuated tubes can offer benefits in cold climates because the area between the inner absorber and the outer glass tube is evacuated, reducing heat loss from conduction and convection.

5. Heat pumps use refrigeration to heat water. The heat pump transfers heat into the water. Where does the heat come from?

The heat collected by a heat pump water heater comes from the air, which in turn has been heated by direct and indirect solar radiation. This is why they are included as a form of solar water heater.

9.2.2 Answers to questions section 1.2 – economic benefits

Refer to Table 1.2

1a. Darwin is in the north of Australia (latitude 12ºS). What proportion of the hot water can be supplied by the sun using a solar hot water system?

The table shows 92% to 100% of hot water can be generated by heat from the sun in Darwin. In other words – nearly all of it.

1b. Invercargill is the southern-most city in New Zealand (latitude 46ºS). What proportion of hot water can be supplied using a solar hot water system?

51% to 61%, which means that a little over half of the hot water in Invercargill is likely to come from the sun.

1c. Melbourne is in the south of Australia (latitude 37ºS). What proportion of hot water can be supplied using a solar hot water system?

62% to 72%, which means roughly two-thirds of the hot water is heated by the sun.

1d. Why is there such variation between these places?

In northern locations the:

- *water is usually hotter to start off with*
- *air temperature is higher so there is less heat loss from the collectors and storage tank*
- *solar radiation (sunshine) is higher.*

1e. Why is there such variation at any one place? (Darwin 92%–100%, Invercargill 51%–61%, Melbourne 62%–72%)

Variation in a particular place will probably be due to the:

- *difference in the type of collectors*
- *the area of collectors*
- *the size of the storage tank and*
- *the effectiveness of the insulation around the storage tank*

Refer to table 1.2

The table shows two costs: 1. Installed cost and 2. Annual running cost (yearly operating cost).

2a. What type of hot water system is the cheapest to buy and have installed?

An electric hot water system connected to the general (day rate) tariff. $800–$900.

2b. What are the running costs per year for this unit?

$480–$700 a year

2c. Suggest reasons why the running costs in Brisbane are lower than the running costs for the same unit in Melbourne.

There are three possible reasons:

- *Less heat is required to get the water up to 60ºC, probably because the cold water supply is warmer to begin with.*
- *If the cold supply is warmer than in Melbourne less hot water would be required, say to fill a bath or run a shower at a comfortable temperature.*
- *Electricity in Brisbane may be cheaper than in Melbourne*

2d. Now compare these *annual running costs* with the very first solar hot water system on the top of the list (Table 1.2.2). How much money would be saved each year by installing a solar hot water system with electric boosting rather than an electric hot water system (general tariff)? (i) In Brisbane (ii) In Melbourne

Brisbane	*Over $400*	*($480 – $45 or $75*	*=*	*$405 or $435)*
Melbourne	*Over $500*	*($700 – $115 or $175*	*=*	*$525 or $585)*

2e. In order to make electric hot water systems more attractive electricity companies reduce the tariff for units that heat the water during off-peak times (night). How much would be saved by using a solar system (electric boost) rather than an electric hot water system on a night rate tariff? (i) In Brisbane (ii) in Melbourne

Brisbane	*About $200*	*($267 – $45 or $75*	*=*	*$192 or $222)*
Melbourne	*About $200*	*($358 – $115 or $175*	*=*	*$183 or $243)*

2f. Over a 10 year period you will see that the cost of the solar system is less than that of a comparable gas or electric system. What influence will ‘Rule of Thumb 1.1’ have on this figure if a mains pressure gas or electric hot water system has a life of eight to 12 years?

If the electric hot water system has to be replaced after 10 years, the cost of the new hot water system has to be added to the annual cost of the hot water. If the solar system continues without need of replacement it does not have the same increase in annual running costs.

3a. What is meant by ‘payback time’ when talking about a solar hot water system?

It is the time it takes for the savings to pay for the additional cost of the solar hot water system compared with a non-solar system.

3b. Working on simple calculations, what is the payback time for a solar hot water system as shown in Example 1.1?

12 years – this means that in 12 years the savings of the solar system will have paid for the additional cost.

3c. What is the payback time for a system taking into account the longer life of the solar hot water system compared with a gas or electric system as in Example 1.2?

8.8 years – because the cost of a replacement of the non-solar hot water system must be considered, it reduces the payback time.

3d. What other factor was mentioned that results in a shortening of the payback time?

The influence of inflation becomes significant. If energy costs (gas or electricity) increase the cost of running the non-solar system increases to a much greater degree than for the solar system. The payback time for the solar system in proportionally decreased.

3e. Why would the payback time for an LP Gas boosted system be much shorter than for an LP Gas hot water system without solar heating?

The cost of LP Gas is high, so the annual running costs are high for a non-solar LP Gas system. This means that the addition of solar to reduce the use of LP Gas will represent a substantial saving. In Brisbane where LP Gas would cost $700 a year for an all gas system, with about 80% solar contribution the LP Gas usage would be cut to $160 a year. This is a saving of $560 a year. With an installed cost of a solar system of perhaps $3000 more than a non-solar system the payback time is reduced to a bit over five years.

3f. All sorts of extras are possible with some solar systems; mounting frame, frost protection, over temperature protection, high performance collectors, gas boosting, etc.

These extra features may improve the performance of the solar hot water system but they also increase the installed cost. What will happen to the payback time if the installed cost of the system is increased significantly?

If the capital cost of the system is very high the payback time will be very high, possibly so high that the savings will never cover the additional cost before the system eventually has to be replaced.

4. How could energy (gas and electricity) companies make solar water heating less attractive by altering their tariffs?

By providing low cost, attractive tariffs it may discourage people from buying expensive solar hot water systems. This means that in the long term the energy companies will sell more energy.

5. Governments offer rebates to reduce the cost of solar hot water systems. Why do they do this?

The major reason for providing rebates is to encourage the installation of solar hot water systems. The installation of solar water heating systems:

- *reduces greenhouse gas emissions – carbon dioxide from the burning of coal for the production of electricity, or the burning of natural gas*
- *reduces atmospheric pollution from the burning of fossil fuels*
- *If there is less demand for electricity there is a reduced need to build more power stations*
- *Many solar hot water systems are made in Australia. This in turn provides increased employment in Australia.*

9.2.3 Answers to questions section 1.3 – environmental benefits

1. Many purchasers of Solar Hot Water systems buy them because they believe that they represent an environmental benefit. Suggest ways in which the use of a solar hot water system is of benefit to the environment.

A solar water heater uses heat from the sun, a non-polluting form of energy. Heating water by the sun's energy does not produce polluting green house gases – carbon dioxide and other gases. Pollution is reduced.

2. Most Australian electricity is produced from 'fossil fuels'.

a. What does this mean?

b. How does the replacement of electrically produced hot water with solar heated water reduce the production of atmospheric carbon dioxide?

a. Most of Australia's electricity is produced by burning coal. Coal is a fossil fuel. It contains huge quantities of carbon taken from the atmosphere millions of years ago when the plants making up the coal were growing. When coal is burnt it releases carbon dioxide into the atmosphere. Because the carbon (in the coal) was previously locked up and has now been released as carbon dioxide gas, levels of carbon dioxide in the atmosphere are increasing and leading to climate change.

b. If less electricity is needed for the production of hot water, less coal needs to be burnt. Burning less coal produces less carbon dioxide.

3. The graphs (Figure 1.3.2) show annual greenhouse gas released for different types of hot water systems in Brisbane. Compare Electricity Storage New and Solar/Electric.

a. Electric Storage emissions are 4100 kg/year. How many kg/year are produced by a Solar/Electric system?

b. What does the vertical axis of the graph indicate?

c. What proportion of the energy in a Solar/Electric comes from the sun?

a. About 500 kg/year

b. The vertical axis is an indication of the greenhouse gas emission in kg/year produced by various forms of hot water production for the light coloured histogram columns. For the black columns it indicates MJ (of energy)/week for each of the hot water systems; apart from what comes from the sun.

c. In Brisbane approximately 87% of the hot water comes from the sun in a solar/electric system.

4100kg of emission/year from a new electric system. 500kg for a solar system.

This means that the solar contribution of 4100 – 500 = 3600kg equivalent must come from the sun. On this basis, 3600 ÷ 4100 = 0.87 or 87%

4. Look at the graph for Melbourne (Figure 1.3.3).

a. Electric Storage emissions are 7100 kg/year. This is nearly double the figure for Brisbane. How many kg/year are produced by a Solar/Electric system?

b. What proportion of the energy in a Solar (electric boost) comes from the sun?

a. About 2200 kg/year. This is about four times the figure for Brisbane.

b. In Melbourne approximately 69% of the hot water comes from the sun in a solar/electric system.

7100 kg of emission/year from a new electric system. 2200 kg for a solar system.

This means that the solar contribution of 7100 – 2200 = 4900kg equivalent must come from the sun. On this basis 4900 ÷ 7100 = 69%.

5. Now look at the Melbourne graph again (Fig 1.3.3). Look at Gas Storage five-star and compare it with Solar/Gas.

a. Gas storage five-star emissions are 1200kg/year. How many kg/year are produced by a solar/gas system?

b. What proportion of the energy in a Solar/Gas comes from the sun? This is written as a fraction or as a percentage figure, e.g. 1 = 100%, 0.5 = 50%, and 0.1 = 10%. Written as a fraction it is called a ‘solar fraction’.

c. Is the difference between the Solar/Gas (66%) and the Solar/Electric (69%) water heaters significant?

a. Approximately 400 kg/year

b. Approximately 66% 1200 kg/year – 400kg/year = 800 ÷ 1200 = 0.66 written as a fraction.

c. Our reading of the figures from the graphs is only an estimate (an approximation) and to suggest that there is a significant difference between the Solar/Gas and the Solar/Electric based on these figures is quite unrealistic. In other words, in Melbourne approximately 66% – roughly two-thirds of hot water can be produced from the sun. With more efficient solar hot water units this figure can be increased. An increase in efficiency, however, brings about an increase in system cost.

6. Make a comparison between Brisbane and Melbourne and complete the following table showing the MJ/week.

	Electric storage	Gas storage five-star	Heat pump	Solar gas	Solar electric
Brisbane	MJ/wk	MJ/wk	MJ/wk	MJ/wk	MJ/wk
Melbourne	MJ/wk	MJ/wk	MJ/wk	MJ/wk	MJ/wk

a. Electricity is measured in kWh (kilowatt hours). Gas is measured in MJ (mega joules). There are 3.6 MJ in one kWh. Why is the unit for MJ not given as MJ hours?

b. Looking at the chart that you have completed you can see that Melbourne uses more energy to produce hot water than Brisbane does. How much more is not easy to work out from our figures because they are not accurate enough BUT in all cases the figure is greater for Melbourne than Brisbane. Why?

c. What might the ‘solar fraction’ be in <u>Hobart</u> or even further south in <u>Invercargill</u> in New Zealand? You will have to guess as we do not have the figures; but in Table 1.1 we have figures for approximate cost savings. This will probably be the same as the ‘solar fraction’. Take a guess before looking up the table.

d. If you do not know your Geography of New Zealand would you say that Invercargill was north or south of Auckland, simply using Table 1.1?

These figures will only be approximate so if your figures are similar but not exactly the same this is fine.

	Electric storage	*Gas storage five-star*	*Heat pump*	*Solar gas*	*Solar electric*
Brisbane	*800 MJ/wk*	*300 MJ/wk*	*200 MJ/wk*	*100 MJ/wk*	*150 MJ/wk*
Melbourne	*1200 MJ/wk*	*400 MJ/wk*	*400 MJ/wk*	*150 MJ/wk*	*300 MJ/wk*

a. MJ is an amount of energy. If it were petrol it is equivalent to say perhaps one litre.

kW is an amount of power. A kilowatt hour is an amount of energy. If we were to again liken it to petrol the kWh would be the amount of energy produced while petrol is being fed into the motor. After an hour if the petrol produced one kilowatt of power, 1kWh of energy would have been produced. In this case it would be equivalent of 3.6 litres of petrol.

b. The figure for hot water energy usage Melbourne is higher than for Brisbane because:

- *The temperature of water entering the hot water system is higher in Brisbane (see Table 1.4). To reach 60ºC less heat is required.*
- *Less hot water is required. If the cold water is warm then less hot water will be required when hot and cold are mixed, such as for a bath or shower*
- *The air temperature in Brisbane is higher (particularly in the winter months) and the effect of this is that flat plate collectors lose less heat if the air round them is warm. This affects the 'solar fraction'. The solar fraction is the proportion of hot water that comes from the sun compared with the proportion that is heated by gas or electricity. The solar fraction in Brisbane is higher than in Melbourne (see Table 1.4).*

c. The figures show: Hobart 60%–70% and Invercargill 51%–61%

d. With a higher percentage for Auckland we can assume that Auckland is north of Invercargill

7. What do you notice on the Table 1.4 about the number of solar collectors required to produce this quantity of hot water?

The collector area increases for more southern installations. The increase in collector area is to compensate for the colder winter conditions. This of course increases the cost.

8. There are various arguments that people use to discourage the use of solar water heating systems. These are referred to in the notes as 'Non technical barriers to Solar Water Heating'.

Who would be keen to discourage any one from installing a solar water heater, and why would they do this?

- *Manufacturers of non-solar hot water systems might try to sell their systems by discouraging or 'putting down' solar systems.*

- *Retailers or installers who do not understand solar systems and don't know how to install them often discourage customers from considering a solar system.*
- *As a solar system significantly reduces the energy required to heat hot water, one might expect energy companies who make their profits from selling energy to be opposed to solar hot water systems. They can offer cheap tariffs for water heating, and in so doing they make solar hot water less attractive.*
- *People who in the past have had unfortunate experiences with solar (such as frost or vandal damage) may try and put other people off buying a solar hot water system. Having decided that solar is 'no good' they want other people to agree with them.*

9. Table 1.4 shows a column labelled 'Capital Energy'. This is the energy that is required to make/manufacture a solar hot water system. Why is more energy required to make a solar hot water system suitable for use in Melbourne than a system suited to Darwin?

Solar hot water systems in Melbourne require

- *a greater area of collectors than in Darwin*
- *a greater quantity of hot water storage*
- *and although it has not been mentioned yet, frost protection is required in Melbourne but is not required in Darwin.*

All of these add to the cost of solar water heating systems in Melbourne compared to Darwin.

10. A solar hot water system saves energy. How long might it take to save the energy that was required to make (manufacture) the system? Will this vary for different parts of Australia?

As we have seen in question 9 a solar hot water system in Melbourne is far more complicated and has more to it than a Darwin hot water system, so a Melbourne system will take longer to save the energy required to make it. A useful figure, however, suggests that the energy saved in eight months using a solar hot water system is equal to the energy required to make the system in the first place.

Chapter 2

9.2.4 Answers to questions section 2 – solar radiation

1. There are three critical ideas that need to be understood in order to obtain the maximum performance from flat plate solar collectors. Put another way, what needs to be understood when mounting solar collectors for a solar hot water system to give optimum performance? What are the three mounting conditions that must be understood?

The collectors gain the maximum possible energy from the sun when the sun strikes the collector surface at right angles.

- *The collectors should face the equator, north in Australia and New Zealand.*
- *The collectors should be tilted up from the horizontal at the angle of latitude.*

Under these conditions (facing equator; tilted to angle of latitude) the sun will be at right angles to the face of the collectors at midday during the equinox (when day and night are the same length).

- *Shading of the collectors is to be avoided*

2. In the previous question we were discussing optimal or 'best performance' conditions. In most installations these optimal conditions are not able to be provided. Why not?

- *Many houses do not have a roof section that faces true north.*
- *Some roofs do not have enough space on them for a solar hot water system, certainly not on the north face.*
- *Some roofs may have a north facing section big enough for a solar hot water system but this north section may be shaded, either by another building or a tree that cannot be removed.*
- *It is desirable to have the hot water storage near to the point where the hot water is used. This may not be near a north facing part of the roof.*
- *The ideal angle of tilt is the angle of latitude or a little more in southern Australia and in New Zealand. Very few roofs in these higher latitudes (further south) are as steep as the angle of latitude.*

3. Having discovered that very few roofs match the ideal orientation or slope we ask the question of what happens if we do not match the ideal? The simple answer is, there can be significant variation from the ideal and it will not matter all that much. But what are the limits and when does the variation become significant? The way this is answered is using what would be a very common scenario.

Orientation – How far off north would be the maximum that a roof could be for a square or rectangular house?

Tilt (Inclination) – What is the most common roof angle?

Given these two parameters, what effect will they have on the optimal performance? Or put another way, how reduced will be the solar gain by getting away from the optimum?

If the orientation angle is greater than 45º away from north it is likely that another face of the roof would be a better proposition on which to mount the collectors. So we work on a maximum orientation from the optimum of 45º.

The most common roof angle is 23º so we work on that for the tilt.

There is no easy answer to this question that suits all of Australia and New Zealand because it will vary depending on the latitude; however, a common figure is that solar gain is reduced by about 10% if the collectors' orientation is 45*º off north on a 23º pitch roof.*

4. What is the minimum and maximum tilt (inclination) that is acceptable for the mounting of collectors?

- *The minimum tilt (inclination) recommended is 10º. Anything less means that rain will not clean the collectors and adequate thermosiphon circulation will not occur.*
- *The maximum recommended tilt is the angle of latitude plus 10º.*

5. Clearly it is best if the collectors can be mounted in the optimum way but significant variation is possible with very little adverse impact on the collector performance. There will be installations, however, when a special mounting frame will be required. List the situations where a mounting frame may have to be used.

- *Flat roofs – must have a frame in order to tilt the collectors*
- *Reverse pitch – where the collectors are mounted on the side of the roof away from the equator – on the south side of the roof in Australia and New Zealand.*
- *Side pitch – where the collectors are mounted on an east or west facing section of roof.*
- *Although it has nothing to do with orientation, cyclone frames are used in cyclone prone areas.*

6. It is desirable that there be no shading on solar collectors; however, there are times of the day when shading becomes unimportant. What are these times and why is the shading unimportant?

Early in the morning or late in the afternoon the sun will be at an oblique angle to the solar collectors and most of the sun's radiation will be reflected off the glass of the collectors. Shading before 8am or after 4pm does not cause a problem.

7. Why is shading more likely to be a problem in winter than in summer?

The sun is low in the sky in southern Australia and even lower in southern New Zealand even at mid day. With the sun so low it is easier for objects to cast long shadows and these shadows may reach the collectors. This causes a problem. It reduces solar input at a time when solar energy is limited anyway and at a time of the year when hot water demand is probably at its highest. To avoid shading at any time during the 9am to 3pm time zone is critical. Very little water is heated by the sun between sunrise and 9am or between 3pm and sunset in the southern latitudes. These are Standard times of course, not 'summer – Daylight Saving' times.

8. What is the date of the shortest day of the year; the day when the shadows will be their longest?

The shortest day occurs at the 'Winter Solstice', which is 21 June. This is the time to check where the shadows fall because they will be most significant at this time of the year. This is useful knowledge to store away in your memory as it will allow you to make a rapid assessment of new sites. In most cases you can make the assessment without having to use any specialised instruments.

9. Arriving at a house (in Australia or New Zealand) where a solar water heater installation is planned one of the first things that needs to be determined is the location of north. What are the methods that could be used to determine north? Is it true north or magnetic north that we require?

- *If the sun is shining its position in the sky can be used to give a good indication of where north is likely to be. If it is midday (Standard Time) the sun will be close to due north. For other times of the day you can estimate where the sun will be at midday. As all you are doing is trying to decide on which face of a roof the solar collectors are to go, this technique is quite adequate for most installations.*
- *Use a map to decide the orientation of the block of land of the house. The orientation will be given by the north arrow which usually points to the top of the map.*
- *Use a compass to determine magnetic north and then make an adjustment to determine true north. In New Zealand this adjustment can be very significant.*
- *Increasingly vehicles are being fitted with GPS (Global Positioning Systems) which can be used to determine true north.*

10. The angle of tilt of the collectors is usually determined by the slope of the roof. In order to check the slope of the roof a clinometer or level and protractor can be used.

a. If a roof where solar hot water collectors are to be mounted does not face north, but perhaps east or west, what effect does the roof slope have on the installation? Realise that this is not as straightforward a question as it seems. The latitude of the installation has an effect.

b. Suppose the roof is set at a low pitch, say 15º, and is located in Tasmania (latitude 40º), how might you compensate for the fact that in winter solar hot water production would be very poor?

a. In the northern parts of Australia (low latitudes) the sun is reasonably high overhead, even in winter, and so good solar performance will be obtained even if the collectors are not facing north. If the pitch of the roof is low the performance will be improved.

In the southern parts of Australia and New Zealand (higher latitudes) the sun in winter will be at such an oblique angle to the collectors if they are not facing north, that their performance will be very poor indeed. In such cases a side pitch frame will probably be required.

b. There are several options to improve winter performance:

- *On a north facing roof add an extra collector so that the area of collectors is increased.*
- *Tilt the collectors up to an angle of 40º + 10º = 50º using a frame.*
- *You would probably use high performance collectors or perhaps evacuated tubes.*

Chapter 3

9.2.5 Answers to questions section 3.1 and 3.2 – principles of water heating and collectors

1. Solar radiation passes through the transparent surface of solar flat plate collectors and is absorbed on the absorber plate.

a. How does the heat energy reach the water in the collector?

b. Not all of the heat energy heats the water in the collector. What happens to the heat that is not transferred into the water?

c. What purpose does the glass serve in flat plate solar hot water collectors?

d. Modern flat plate collectors use low iron glass rather than window glass used in some older collectors. Low iron glass is more expensive than window glass so why is it used?

e. Solar swimming pool heating collection material does not have glass covering it. Why is glass covering comparatively unimportant for pool heating?

a. The radiant energy from the sun plus the diffuse energy passing through the glass is absorbed by the flat absorber plate. The plate gets hot and heat is conducted through the plate to the water in the tubes (waterways) heating the water.

b. Some of the heat is:

- *re-radiated from the absorber plate and passes out through the glass cover. A ‘selective surface’ reduces this re-radiation or ‘emittance’ to a very small figure*
- *conducted from the plate into the air under the glass. The hot air between the glass and the absorber plate heats the glass and heat is conducted away through the glass into the outside air. If the outside air is very cold (as in winter) a lot of heat is lost this way*
- *conducted through the back and walls of the box of the collector, though this is limited due to the insulation.*

c. The main function of the glass is to prevent the wind cooling the collector absorber plate and removing heat. It also admits solar radiation from the sun.

d. Low iron glass:

- *is much stronger than normal window glass enabling it to withstand hail and other objects hitting it. It may even be strong enough to withstand a person standing on it*
- *has a low co-efficient of expansion so is far less likely to crack than window glass under high temperature conditions*
- *allows more radiant energy to pass through than normal window glass*
- *absorbs less energy than other glass so stays cooler, resulting in keeping more heat staying within the collector.*

e. The glass covering a normal solar collector is to isolate (separate) the hot absorber plate from the cooler outside air. The absorber plate may be 60ºC to 80ºC *or even more at times, and without the glass would lose lots of heat to air which might be between 15ºC to 25ºC.*

As the water being heated for a swimming pool is seldom more than 25ºC to 30ºC little heat is lost to the surrounding air. So the pool heating absorbers (often a plastic type of material) can be unglazed making it very much cheaper than if it had to be glazed.

2. Flooded collectors are able to be used for solar hot water systems where the absorber material is plastic or steel. Why would plastic be unsuitable for fin and tube flat plate collectors?

Plastic is not a good conductor of heat, so it would not readily transmit heat from the absorbing surface several centimetres from the tube.

3. Australian scientists invented the use of 'selective surfaces' for solar hot water systems. Why is a selective surface so much better than just plain black paint for the plates (fins) of solar collectors?

Black paint and selective surfaces both absorb radiant energy very well. Once the surface gets hot black paint re-radiates the heat, whereas the selective surface does not. This re-radiation is called 'emittance'. The emittance for black paint is high (95%) and selective surface low (5%).

4. Why are evacuated tube collectors cylindrical? Why aren't flat plate collectors made with a vacuum between the absorber plate and the glass cover?

Removal of air results in reduced pressure inside. The atmospheric pressure outside presses on the outside surface and is no longer balanced by the pressure of air on the inside. A cylinder is able to withstand this pressure on the outside. A flat glass surface on a flat plate collector, however, would flex down (and break) and the bottom of the box would flex up and crumple if the space between was evacuated.

5. What is a 'heat pipe'?

A heat pipe is a sealed tube that transfers heat, up the pipe but not down the pipe. The liquid inside the pipe is usually at a reduced pressure that allows it to boil at a lower than normal temperature. The vapour rises up the pipe to a cooler place giving up its heat (latent heat) to the water it is heating. The vapour condenses and runs back down the tube where it is reheated and turns to a vapour again.

9.2.6 Answers to questions section 3.3 – tanks

1. Hot water storage tanks are much the same whether they are for solar hot water systems or electric or gas storage systems. They all consist of an inner tank in which the hot water is stored and an outer case. Between the inner and outer cases is insulation designed to reduce heat loss from the stored hot water.

a. What materials are commonly used for the inner hot water storage tank?

b. Suggest a reason why the insulation is thicker at the top of a Solahart hot water storage tank than at the bottom as shown in the small inset in Figure 3.3.1

c. The outer case must be able to withstand various environmental factors. What are these factors that might otherwise damage the hot water storage tank?

*a. Gravity feed tanks are made from **copper** or **plastic**.*

*Mains pressure tanks are made of **mild steel lined with vitreous enamel** or **stainless steel**.*

Some special mains pressure tanks are made from copper or plastic material enclosed in a mild steel sleeve so that the copper and plastic can withstand the increased pressure.

b. The hottest water rises to the top of the tank and the thick insulation is to retain as much heat as possible. If the water at the bottom of the tank is very hot it is desirable to lose heat which is why the insulation at the bottom of the tank is thinner.

c. The outer case is made to protect the inner tank, the electric or gas boost components and the insulation from:

- *Mechanical damage – during installation and once the tank is in use*
- *The adverse effect of Ultra Violet light which will cause the insulation and the plastic insulation in the boost wiring to deteriorate*
- *Interference by children or adults who may adjust the settings of the boost system.*

The outer case of a balanced flue gas unit serves as a passage way between the balanced flue inlet and the burner unit. Once lit, it is important that the casing door be replaced so that the balanced flue function is restored.

2. What does the word ‘potable’ mean when used to describe water?

Potable water is water that is fit for human consumption

3. Hot water storage tanks are nearly always cylindrical. Why?

A cylinder is able to withstand high pressures. Where the pressure is significant the top and bottom of the cylinder is hemispherical so that the ends can withstand the pressure without damage.

4. Most non-solar hot water storage tanks are cylinders, standing on end. Close coupled solar storage tanks are cylinders which are mounted horizontally.

a. Why are the tanks mounted horizontally?

b. What problem does this present in terms of stratification?

c. Suggest why a person with a close coupled solar hot water system may find that their hot water is a lot cooler in the morning than it was when they went to bed.

a. The horizontal tank is less visible and more easily installed on a roof than a vertical tank.

b. Horizontal tanks have less distance between the hot and cold layers of water within the tank. The stratification within the tank is more easily disturbed (broken up) so diffusers are installed at the top and bottom of the tanks to reduce the disturbance of the layers of water within the tank when water is drawn off.

c. Because the hot and cold water in a close coupled tank are close together heat is conducted from the hot layers to the colder layers. This conduction occurs through the water and through the metal walls of the tank. Of course some heat will also be lost through the insulated walls of the tank.

5. A standard 315 litre hot water storage tank is likely to contain 340 litres of water. Why do we call the tank a 315 litre tank and not a 340 litre tank?

The 315 litre figure represents the quantity of water that can be drawn off (at a set rate) before the temperature starts to fall. After 315 litres have been drawn off the temperature of the hot water falls as a mixture of hot and cold water is delivered. Once 340 litres have been drawn off the water being delivered will be about the same as the incoming cold water, unless some heating has occurred while draw off takes place.

6. What is a heat exchanger and why are they commonly used in solar water heating systems?

A heat exchanger transfers heat from one lot of water to another without the two lots of water actually mixing. In solar water heaters this allows the collectors to be filled with water containing an anti-freeze solution. The heat from the collectors is transferred to the water in the storage tank, but the anti-freeze solution and the potable water do not mix.

If the water in the storage tank is corrosive or builds up scale this would not be good to have in the collectors. A heat exchanger allows pure water to be circulating through the collectors and kept separate from the water in the storage tank.

9.2.7 Answers to questions section 3.4 – close coupled systems

In the 1980s the close coupled hot water system became the ‘standard’ solar water heating system. It was easily recognised. It was easily marketed. It was reasonably easily installed. All the customer had to decide was, ‘Do I buy one or not?’

1. What are the features, dimensions, etc. of a standard close coupled solar hot water system?

The average or standard close coupled solar hot water system has:

- *A 300 litre mains pressure hot water storage tank*
- *4m^2 area of collectors*
- *Some method of boosting water temperature if there is inadequate sunshine.*

2. What fittings are normally included?

- *A series of valves on the cold supply line – isolating valve, perhaps a strainer and pressure reduction valve, non return valve, perhaps an expansion valve.*

- *The hot water storage tank will include a PTR (Pressure Temperature Relief) valve.*

- *Pipes to connect the collectors to the tank.*

- *Straps and fittings to attach the tank and collectors to the roof.*

3. What are the positive features of a horizontal close coupled tank?

Being long, the weight of the tank is carried on several rafters or roof trusses.

It does not have to be fitted into a roof cavity.

Being low, the tank is stable on the roof and not as obvious as a vertical tank would be outside.

Any leaks in the tank or fittings will usually not penetrate the house roof.

4. In what situations can a close coupled solar hot water system be installed when other types of systems can't be installed?

A building without a ceiling space (cathedral ceiling construction) may have a close coupled system installed. An alternative is a pump circulated system with the storage tank at ground level.

5. Close coupled solar hot water systems can use direct or indirect heating. What is the difference?

*The potable water from the hot water storage tank in a **direct** system is the water in the collectors.*

*The water (or anti-freeze solution) in the collectors is isolated from the potable water in the storage tank. It heats the potable water **indirectly** from the collectors.*

6. Starting at the isolating valve, list the fittings and valves that get the cold water to the hot water storage tank.

Fittings and valves required are an isolating valve, line strainer, non-return valve, pressure reducing (limiting) valve and expansion valve.

7. What is the purpose of the diffusers on the cold supply into a horizontal hot water storage tank?

The diffusers in the top and bottom of the hot water storage tank are designed to keep the velocity of water low to reduce the stirring up of the water. Stirring the water will break up the stratification of different temperature layers of water. Instead of the tank having distinct layers of hot water at the top and cold water below the hot and cold are mixed so that there is a tendency to have a tank of warm water.

8. Why is a heat dissipater unit included in some solar water heaters? What type of storage tanks might have a heat dissipater?

The heat dissipater is designed to get rid of excess heat. So if water in the tank exceeds a set temperature (say 75ºC) heat is released into the atmosphere. This is important for vitreous enamel-lined tanks.

9. Why is there such an enormous difference between the 13MJ/hour gas rate for the boosting unit in the close coupled system and the instantaneous gas heater which may have a gas rate of 200MJ/hour?

The 13MJ heater has a long period of time to heat the water, probably several hours, as there is a store of hot water. It does not matter if the rate of heating is slow. With the instantaneous hot water system it has to heat the water as the water is used, which requires much more energy over a short period of time.

10. Why is the all plastic Solco solar hot water system not available as a mains pressure unit?

The plastic is not strong enough to withstand the high pressure, particularly when the plastic gets hot. It would be likely to stretch, bulge and eventually burst.

9.2.8 Answers to questions section 3.5 – pump-circulated systems

1. What types of collectors are suitable for use with pump circulation systems?

Flat plate collectors or evacuated tube collectors. In the past serpentine collectors were used with pump circulated systems but these are no longer marketed in Australia.

2. Is there any difference between the collectors used in a pump circulation system and a close coupled system or a remote (in-ceiling tank) system?

No. Most manufacturers use the same flat plate collectors for either system. However, most evacuated tube collectors are not suited to thermosiphon circulation so must have a circulating pump.

3. Suppose a family of six people has a 400 litre hot water storage tank. How many $2m^2$ collectors would you recommend be used in conjunction with that tank?

With the rule of thumb of $2m^2$ of collectors for 150 litres of storage $6m^2$ of collectors, that is three collectors would seem appropriate. In New Zealand or Hobart the area may even be extended to $8m^2$ and in Darwin it might be reduced to $4m^2$.

4. Why is a circulating pump required in some solar systems?

Hot water rises by natural convection currents. If the solar collectors are higher than the storage tank circulation will not occur by natural convection (thermosiphon flow) so a pump is required to bring the hot water DOWN to the hot water storage tank.

A circulating pump may also be used when the collectors are a long way from the storage tank.

5. What does the circulating pump do? How is the pump controlled?

The circulating pump increases the pressure across the pump pushing water around the circuit. It is usual to install the circulator in the cold pipe to the collectors so that it forces water through to the collectors and back to the storage tank.

If the circulator was installed on the hot return line it is likely that bubbles of air generated in the collectors would cause the pump to stop circulating water due to an air lock. If the water was very hot it might vaporise (boil) within the pump causing 'cavitation'. Again the water would stop circulating and cause damage to the pump. Pumps should not be allowed to run dry.

The pump is turned on when the sun is shining using a timer or photovoltaic (solar electric) cell or photovoltaic module. The most usual control method, however, is a differential temperature controller. It switches the pump on whenever there is water in the collectors that is hotter than the water in the bottom of the hot water storage tank.

6. The circulating pump is often called a 'circulator'. Why is it not just called a pump? Is there any difference to any other pump?

It is called a circulator because it is designed just to circulate water.

Sometimes other types of pump are used but the solar hot water circulator is generally a ***small centrifugal pump****. Like any centrifugal pump it must have water in it to pump water – it must be primed. The circulator is designed to move volumes of water against a comparatively low head. The circulator does not develop much pressure – the UPS 25–60 can produce only six metres (60 decimetres) head on the highest speed with a very low flow of water. On lower pump speeds the head is less, perhaps only two or three metres. It draws comparatively small quantities of power. The more water that flows, the lower the pressure.*

7. An electric storage tank is used as the hot water store for many pump circulation systems, whether the electric boost element is used or not. Some systems adapt other tanks for use as the hot water storage tank. List the characteristics of:

a. stainless steel, and

b. vitreous enamel-lined mild steel mains pressure storage tanks?

Stainless steel tanks

- *Because of the cost of stainless steel, stainless steel tanks are usually made of quite thin gauge material. So the maximum pressure they are able to withstand is often lower than for vitreous enamel-lined mild steel tanks.*
- *Normal stainless steel tanks do not handle the combination of high temperatures and salty water at all well.*
- *Boosting may be electric or gas.*
- *Protective anodes are not used.*

Vitreous enamel-lined mild steel tanks

- *The vitreous enamel lining withstands the corrosive effects of salty water better than stainless steel.*

- *A protective sacrificial anode installed in the tank reduces the corrosion of the steel in the tank.*
- *Boosting may be electric or gas*

8. The valves on the cold water supply to a pump circulation solar system are the same as for a close coupled solar hot water system. There are, however, two other valves not normally part of a close coupled system;

- The air eliminator valve. Where is this located and what is its function?
- The non return valve associated with the circulating pump. Why is it installed?

*The **air eliminator valve** is designed to release air that is generated within the solar collectors as the water is heated. By preventing air being pushed down the pipe from the solar collectors to the storage tank, the likelihood of air blocking the pipe (an air lock) is reduced.*

The air eliminator valve is important for low power circulators which develop only a small pressure. With more powerful circulators some installers do not use air eliminators, but there is a potential problem of turbulence in the storage tank running circulators on higher speeds. The result is a mixing of the hot and cold water within the tank.

Non-return valve associated with the pump – this is installed so that when the pump is not operating the pipeline to the collectors is closed. This prevents reverse thermosiphon flow of hot water from the storage tank to the collectors where heat is lost (at night or on cold overcast days) and back down the cold line. This could cool the entire contents of the storage tank if the hot connection from the solar collectors was at the top of the storage tank.

9. Other fittings that are required to go with the circulating pump controller are the pockets (tubes sealed at one end) for the sensor probes. The sensor pockets are often made on site from small diameter copper tube (often 10mm outside diameter). Where are these positioned and what is their function?

*A pocket is installed in the **top header of the collectors**. The sensor in this pocket will detect water temperature and when higher than the temperature in the tank will turn on the circulator pump. This sensor might also provide frost protection, turning on the circulating pump in frosty weather to maintain a temperature above 0ºC to prevent the water in the collectors from freezing.*

*A sensor is located at the **bottom of the hot water storage tank**. If the water temperature is less than the collector header the pump turns on. If the water has reached a maximum temperature, say 65ºC, the sensor might switch off the pump to prevent further temperature rise in the water in the tank.*

All differential temperature sensor controllers are not the same and not all have these features.

10. The differential temperature sensors are not the only temperature sensors in the system. What other temperature sensors are there?

There are thermostats that detect the temperature of the hot water and switch the boosting (gas or electric) on if the water is too cold and off when it is hot enough.

11. What advantages do pump circulation systems have to offer?

- *They offer the benefits that go with a vertical rather than a horizontal storage tank; less break-up (mixing) of the stratification layers of hot and cold water and less heat transfer from the hot to the cold layers.*
- *The customer may not want the storage tank on the roof.*
- *The installer may not want the storage tank on the roof.*
- *There may not be a large enough roof space for collectors AND a storage tank.*
- *The roof pitch may be too low for a storage tank to be placed inside the ceiling space.*
- *There may be no ceiling space.*
- *The roof may not be strong enough to carry the weight of a hot water storage tank full of water*
- *It may be possible to avoid an unsightly frame.*
- *The storage tank and the collectors may be a significant distance from each other.*
- *Mounting the storage tank on the ground allows a large storage tank to be used.*
- *The cost of hiring a crane to lift the storage tank onto the roof (particularly if it is two storeys) can be avoided.*
- *Small diameter connecting pipes between the storage tank and the collectors can be used.*

9.2.9 Answers to questions section 3.6 – remote solar systems

1. Describe the features of an in-ceiling gravity feed hot water system, without solar collectors attached.

- *The hot water storage tank is made of thin copper sheet. The top and bottom of the tank are flat sheet silver brazed to the walls around the edge.*
- *The hot water storage is surrounded by insulation – either rockwool, fibreglass or polystyrene beads, about 50mm thick.*
- *Around that again is a galvanised or zincalume sheet steel casing that provides the tank, the insulation, and the electrical components with protection.*
- *A header tank is attached to the top of the casing. It contains a float valve and controls the supply of cold water to the tank.*
- *A vent from the top of the tank to the header tank means that the water in the tank is at atmospheric pressure. We call this 'open vented'.*
- *A pipe runs from the header tank to the bottom of the hot water storage tank entering through the case and the insulation. This is usually 25mm outside diameter.*
- *The tank will have an electric element in the bottom of it and a thermostat to turn off the electricity when it is up to temperature.*
- *The tank will sit within a safe tray so that in the event of leakage or overflow the water will be caught and will drain away through a pipe to the outside of the roof space.*

2. How would you convert such a hot water system to a solar system?

- *If there were connecting nipples (20mm or 25mm) on the side of the tank the solar collectors could be connected to these nipples using 25mm copper tube.*

- *The top of the collectors would have to be 300mm below the bottom of the storage tank.*
- *The 25mm copper tube would have to be well insulated.*
- *If there were no solar or stove connections you may have to install some.*

3. Supposing the bottom of the storage tank was not 300mm or more above the top of the collectors. How would it be possible to use the tank?

- *The tank may be able to be raised higher in the roof space.*
- *The collectors may be able to be located lower on the roof, or lower down the wall of the house, or at ground level.*
- *An anti-reverse circulation valve might be able to be used.*
- *The pipes, however, must slope up to the tank at a slope of at least one in 20.*

4. If you were selecting a tank especially for the job it might be possible to have a tank with both the cold and hot solar connections (flow and return) near the top of the tank. Such a tank is made by Rinnai Beasley. Why is it so important to have the solar collectors lower than the connections on the storage tank?

If the collectors are at much the same height as the tank connection nipples there would be two undesirable effects:

The water in the collectors would get very hot but the movement of hot water into the tank by thermosiphon circulation would be very slow. Much heat would be lost through the glass of the collectors.

When night came and the collectors cooled, the cool water would flow in through the bottom connection of the storage tank. Hot water would leave the top connection on the tank, enter the collectors and cool down. By morning the tank would not have hot water below the top tank connection nipple.

5. It is most important that the pipe slopes uphill (however slightly) from the collectors to the storage tank. Why?

When water is heated any air dissolved in the water turns to air bubbles. These bubbles must be able to rise to the tank and escape through the vent. If this does not occur the bubbles will block the pipes causing an air lock and water circulation will cease.

9.2.10 Answers to questions section 3.7 – heat pumps

1. A heat pump hot water system has been described as being like a normal household refrigerator in reverse. What is meant by this?

A refrigerator transfers heat from inside the cabinet to the outside of the cabinet. A solar water heater transfers heat from outside the storage tank to the water inside the storage tank.

2. Where does the thermal energy that heats the water in the storage tank come from?

The thermal energy for most heat pump units now comes from the air. Early heat pump units had evaporators on the roof in the sun so heat for these units came from the sun, the rain and the air.

3. Is there any difference in the plumbing for a heat pump system than for an electric storage hot water system?

There is no difference in the plumbing of a heat pump or an electric storage hot water system.

4. Is there any difference in the electrical connection between the heat pump system unit and the electric or peak storage system?

Yes. The heat pump requires only a 10 amp GPO (general power outlet) and is plugged into that power point. The electric unit has to be hard wired with its own circuit coming from the main switch board or sub board.

5. Why would someone consider installation of a heat pump instead of:

- a mains pressure electric storage hot water system?
- a solar hot water system?

A mains pressure electric storage hot water system?

- *The mains pressure hot water system running on mains electricity will be very environmentally polluting if the power generator burns coal. A heat pump system will reduce that electricity usage (exact saving depends on where it is installed).*
- *If the electric hot water storage system is on the day rate or general tariff the cost to run it will be about two to 3½ times the cost of running a heat pump unit.*

A solar hot water system?

It is possible that the solar hot water system might not be suitable due to:

- *insufficient space on the roof or an unsuitable roof*
- *visual or vandalism issues making solar impossible*
- *inability to access sunshine such as in a shaded location or high rise buildings*
- *portable dwellings where frequent movement makes solar unsuitable.*

6. Why do manufacturers speak about the ‘Co-efficient of Performance’ in relation to heat pump water heaters? What does it mean?

- *Manufacturers use the Co-efficient of Performance (COP) to specify the ability of their heat pump water heater to transfer heat from the air to the water in the tank. The COP is the amount of heat that can be transferred divided by the electrical energy that is used.*

Chapter 4

9.2.11 Answers to questions section 4.1 – boost heating

1. What conditions make it necessary to boost hot water temperatures by means other than solar?

- *Cool or overcast conditions that result in insufficient hot water being produced.*
- *Periods of high demand, such as when additional people are in the house.*
- *Storage tank capacity or collector area being inadequate.*

2. The amount of boosting of hot water by a source of energy (electricity, gas, solid fuel) other than solar energy will be determined by what factors?

- *Temperature of the incoming water*
- *The required temperature (thermostat 'set' temperature)*
- *The volume of water to be heated; daily usage patterns*
- *The solar contribution – the amount of heating that the sun is able to do.*

3. If the boosting is electric, the time of heating and the tariff will determine the position of the heating element in the storage tank. Explain. Figure 4.1.4 shows details in diagrammatic form.

If the boosting is using off peak tariff (cheap – night rate) electricity, the element should heat one day's supply of hot water. The element is likely to be near the middle or bottom of the tank.

If the boosting occurs at any time during the day or night (expensive – general tariff) it is logical to have the element near the top so that only the top (perhaps 20%) of the tank is heated leaving the sun to heat the rest.

What would be the most logical position for the heating element in a tank where there is no off peak tariff and the power is available for boosting at any time during the day or night.

The element should be placed close to the top, just far enough down so that there would be enough hot water for any one draw-off.

4. Why is natural gas a preferred method of boost heating a solar hot water system, rather than electricity?

The green house gas emissions from burning natural gas are far less than the emissions that result from electricity produced by the burning of coal, particularly brown coal.

5. Electronic ignition for lighting gas hot water boosting units reduces the quantity of gas used compared with a pilot light that burns a small quantity of gas all the time. What are the disadvantages of an electronic ignition unit that prevents it being used on standard gas hot water storage systems?

An electronic ignition system costs more than a pilot light system.

An electronic ignition requires electricity for it to operate. This usually means involving an electrician, which increases the cost of the installation. To overcome the cost of the electrician, Bosch has produced an instantaneous gas hot water system that generates its own electricity when water is drawn off, using a miniature micro hydro generator.

6. How is the temperature of the hot water controlled? What is the name of the temperature control device that turns gas or electricity on or off?

A thermostat controls the supply of gas to the burner, or electricity to the heating element. Some gas hot water boilers have modulating thermostats/burners and as the water approaches the set temperature the flame on the burner is reduced. This is not common on storage hot water systems, but is common on instantaneous/continuous units.

9.2.12 Answers to questions section 4.2 – uncontrolled heat source

1. What is meant by the expression 'uncontrolled heat source'?

A heat source that is not thermostatically controlled – domestic solar and solid fuel are generally without thermostatic control.

2. The expression comes from the Australian Standard for plumbing installations. What is the number of this standard?

AS3500.4

3. Why do we talk about 'solid fuel' rather than just saying 'firewood'?

The name 'solid fuel' includes firewood, but it also includes coal, briquettes, bagasse (from sugar cane), peat, etc. Thus solid fuel includes domestic fuels other than gas, oil, or electricity.

4. Numbers of country people whose only source of hot water was a solid-fuel fired cooker have had a solar collector added to their hot water system. Why did they bother when the cooker made enough hot water?

In summer with the cooker operating the house was even hotter than it would otherwise be. It was a relief when solar became an option to provide hot water on hot days. The combination of solar with a solid fuel cooker was logical with hot water from non-fossil fuel sources all year-round.

5. There is an extremely important safety rule relating to solid fuel hot water installations. What is it?

The solid fuel boiler must be OPEN VENTED.

6. What does 'open-vented' mean and why is it so important?

The boiler must be vented to the atmosphere. This means that if it boils the steam must be able to escape. This prevents a build-up of pressure and the possibility of an explosion. PTR valves are NOT an acceptable alternative.

7. If valves were installed between the boiler and the storage tank they could be closed off to do maintenance on the boiler, without having to drain the storage tank. Why are valves not permitted on these pipes?

If the valves were closed inadvertently (perhaps by a child at play, or an adult who did not know what he/she was doing) a build-up of pressure could result in a dangerous explosion. It has happened.

8. Why is it inappropriate to use plastic pipe for connecting a solid fuel cooker to a hot water storage tank?

Most plastic pipes are not able to withstand the high temperatures associated with boiling water.

9. Why is it inappropriate to connect a solid fuel boiler to a vitreous enamel (glass) lined hot water tank, even if the system is open-vented?

Vitreous enamel does not cope well with temperatures over about 70ºC. It starts to dissolve. Expansion of the steel tank also results in stresses, causing damage to the vitreous enamel.

10. Why might an owner of a hot water system want mains pressure for his hot water supply?

Many houses have been built with small diameter (15mm) hot water pipes that would deliver water too slowly if the hot water supply was not at mains pressure.

11. Can he/she have a mains pressure hot water supply if he/she has a solid fuel boiler acting as a booster?

Yes, but the system is more costly than a gravity-feed tank in the ceiling. A heat exchanger of some type is required. For this reason many installers will say that it is not possible to have mains pressure and solid fuel heating.

12. A person is considering installing a solid fuel room heater as a booster for a solar water heater. What advice would you offer?

One common piece of advice is simple: Don’t do it.

This is a simplistic view, but people with solid fuel heaters (as distinct from cookers) are sometimes disappointed by their heater’s hot water performance. The heater needs to be well matched to the quantity of hot water used.

Because a wet back (boiler) takes heat from the fire it may result in an increase in smoke production and detract from the heater’s performance, so many heater manufacturers will no longer sell heaters with wet backs. From past experience, they have found wet backs to be more trouble than they are worth.

Chapter 5

9.2.13 Answers to questions section 5.1 – the need for controls and protection

1. List the issues that would be responsible for shortening the life of any hot water system. It may or may not be a solar water heating system.

The following factors will reduce the life of any hot water system that incorporates a storage tank.

- *Pressure – stress on the tank is caused by high pressures, so the higher the pressure the greater the vessel is stressed; the greater the stress the shorter its life.*
- *Temperature – high temperatures speed up chemical reactions, including the chemical reactions that corrode that storage tank.*
- *Dissolved chemicals – the higher the concentration of dissolved salts (chemicals) in the water, the faster the storage tank will be corroded.*
- *Water usage – the greater the quantity of hot water that is drawn off the greater the variation in pressure and temperature and this variation varies the stress, shortening the life of the unit.*

In summary – long life for hot water storage tanks will occur when the water quality is good (with little dissolved salts), the pressure is low, and temperature is low (though it must be at least 60ºC) and use is limited.

2. List the factors that might represent a risk to people's safety.

- *The main factor that is likely to threaten a person's safety is high water temperature. Scalding requires very little time. The higher the temperature the faster that scalding will occur.*
- *Water in excess of 100ºC but under pressure will turn to steam when it comes out of a tap and is at atmospheric pressure.*
- *High pressure can also represent a danger in that water may be splashed into places or onto people unexpectedly.*

3. What are the reasons that it is undesirable to have water boil in solar hot water systems?

- *The higher the temperature the faster the rate of deterioration of the storage tank and all the other components.*
- *Vitreous enamel-lined steel tanks should not exceed temperatures of about 70ºC.*
- *Boiling water is potentially very dangerous to people.*
- *A tank full of near boiling hot water if emptied through the PTR valve will be replaced by a tank of cold water, leaving limited hot water available.*

4. What techniques can be used to prevent this happening?

- *Prevent water getting too hot in the first place, such as by using a blind.*
- *Prevent the very hot water entering the storage tank either using a Sunstat valve or having a circulating pump turn off.*

- *Remove excess heat from the storage tank with a heat dissipater. The TPR valve will lift off its seat when the temperature reaches 99ºC.*

9.2.14 Answers to questions section 5.1.1 – valves

5. Why is an isolating valve included on the cold water supply to any hot water storage tank?

If there is a problem with the hot water system, it can be shut off using the isolating valve and the remaining cold water system is unaffected. The hot water system (storage tank, heater and associated delivery pipes) can now be worked on.

6. A duo valve is commonly used in place of a simple isolating valve. What is the difference between the two?

A duo valve is a combined isolating valve and non-return valve. The non-return valve prevents water flowing back out of the hot water storage tank into the cold supply line.

7. A line strainer is not always installed on the cold supply to a hot water storage tank. Under what conditions would it be advisable to install a line strainer?

Where water is regarded as clean and pipes are clean there is little need for a strainer; however, where a pressure limiting valve is fitted a strainer is desirable. The pressure limiting valve has fine tolerances and any grit would be likely to damage the valve or cause it to seize and not operate.

8. In some states it is mandatory for any new house installations to include a pressure limiting valve on the cold water supply line that enters the property. What is the pressure setting of this valve?

A common maximum setting is 500kPa

9. What are the reasons for installing a Pressure Relief/Expansion Valve on the cold water supply to a hot water storage tank, even though there will be a PTR (Pressure Temperature Relief valve) installed at the top of a mains pressure hot water storage tank?

When water is heated it expands. In a closed storage tank this expansion must be accommodated and a Pressure Relief valve (also called an Expansion valve) allows water to escape as pressure builds up. Located on the cold supply it is cold water that escapes not hot water, so this saves wasting water that has been heated. If there is mineral dissolved in the water, having cold water escaping from the Pressure Relief valve means that the valve will last longer before needing to be replaced than if hot water escapes from the PTR valve.

10. When installing a Pressure Relief/Expansion valve we must know its pressure setting and the pressure setting of the PTR Pressure Temperature Relief Valve. How do we find out what their settings are and how do the settings affect our choice of the two valves?

The aluminium tags on the valve have the pressure settings written on them. The setting of the PR (Pressure Relief) valve on the cold supply line must be lower than the PTR (Pressure Temperature Relief) valve at the top of the hot water storage tank, otherwise expansion would occur from the PTR valve not the PR valve. AS3500 has the details.

Clearly both valves (PTR and PR) must be rated to a pressure greater than the supply pressure (after passing through any pressure limiting or reducing valve).

11. Why is it that in time a float valve will always leak if it is not maintained?

Eventually the rubber washer that seals the valve will become worn and no longer seal. The constant moving of the piston within the valve will create wear within the valve. When this happens proper alignment no longer occurs and the valve will no longer completely seal.

12. What is the purpose of a tempering valve? Why is one installed?

The tempering valve is designed to prevent people being scalded by excessively hot water. It does this by mixing cold water with the hot water when the incoming hot water exceeds the set temperature. The set temperature is commonly about 45 to 50ºC.

13. A hot water circulator/circulating pump does not require very much power to simply circulate the water in a solar hot water system between the storage tank and the collectors. What effect does the low power rating of the circulator have on the water circulation?

The circulator being low powered means that:

- *It requires very little electricity to run it. It is not a big energy user.*
- *It moves the water through the system comparatively slowly, particularly if the pipe diameters are small (10 – 15mm)*
- *It creates a comparatively small pressure difference across the pump. This means that it does not have the ability to blow air out of the collectors or connecting pipe work.*

14. Why is an air vent valve required if a low power circulator is installed?

If the circulator does not have the ability to push air out of the pipes an air vent is installed at the highest point, allowing air to escape and preventing an 'air lock'.

9.2.15 Answers to questions section 5.2 – frost protection

1. Why does water cause damage when it freezes?

It expands – increases in volume. In so doing it stretches the container that is holding it, if the water fills the container.

2. What is the temperature at which water freezes?

0ºC.

3. Which parts of Australia and New Zealand require frost protection?

Any places that are subjected to frost; this will include most of southern Australia, parts of inland Australia and most of New Zealand.

4. Some districts may only get a frost every second or third year, and even then it will only be a light frost. Explain whether frost protection is required in such an area.

It is recommended that frost protection be installed wherever frosts occur*; however, if the frosts are genuinely very light, frost protection might not be required.*

5. What is the reason for <u>not</u> including frost protection on a solar hot water system if the district where it is being installed has no frosts?

Frost protection:

- *Adds to the cost of a solar water heater*
- *Reduces the efficiency of a solar hot water system, compared with one with a heat exchanger frost protection system*

6. What is now the most usual method of preventing frost damage in solar water heaters?

The most usual system is to use an anti-freeze solution in the collectors. A heat exchanger is required to transfer the heat from the anti-freeze liquid to the potable water.

7. Why is a heat exchanger necessary with a frost protection system that uses an anti-freeze solution?

The anti-freeze solution must not mix with the potable water. The heat exchanger transfers heat, while keeping the two liquids separate.

8. When using an anti-freeze to prevent freezing in solar hot water collectors it is usual to use a mixture of anti-freeze and water. What determines the amount of anti-freeze to use?

The likely temperature determines how much (proportion or percentage) anti-freeze is required compared with the amount of water. A chart is used to determine the percentage of anti-freeze and the percentage of water.

9. The use of either frost dump valves or a pump circulation frost protection system will protect collectors in the same way. What do both of these systems of frost protection have in common?

Frost dump valves and the circulating pump bring water with temperature above freezing into the collectors, keeping the temperature high enough to prevent freezing.

10. Why is a system that drains the collectors of water during frosty periods an ideal frost protection system?

Without water in the collectors there can be no freezing problem.

9.2.16 Answers to questions section 5.3 – corrosion protection techniques

1. In what everyday activity could someone notice and describe that water is ‘hard’?

Difficulty of getting soap to lather is the first indication that most people have that the water is ‘hard’.

2. pH is a measure of acidity or alkalinity and is represented by a number. Water that is neither acidic nor alkaline would have a pH of….? (a number). Strongly alkaline water would have a pH of perhaps ……? Strongly acidic water might have a pH of …?

Neutral (neither acid nor basic/alkaline) is pH 7

Strongly alkaline water may have a pH of 10. It would be most unusual to have water from a natural source with a pH higher than this. Strong solutions of caustic soda (NaOH) may have a pH of 12 or 13.

Acidic water from natural sources may have a pH 5 but concentrated acid may have a pH 2.

3. Will hard water have a high or a low pH? Will it be acidic or alkaline?

Hard water will have a pH of perhaps 9 or 10.

4. Hard water contains high concentrations of the element calcium. What problems does this pose for water heating systems?

The calcium is dissolved in the water, but it precipitates onto heating elements or other heating surfaces in hot water systems to form scale. The scale reduces the heat transfer from the heating surface. This means that the surface gets hotter than it would without the scale and may overheat. Scale can cause electric heating elements to burnout or distort. In regions where the water is hard it is common to use larger electric elements to reduce the intensity of heat (spread it over a larger area).

5. Electrolysis is the reaction between two metals when they are in damp contact. The table of noble metals shows how metals will react with each other. Magnesium is on the top of the list. Explain what happens when it is used as a protective anode in a steel hot water storage tank.

Rather than the steel being corroded away, the magnesium is eaten away. We call the magnesium anode a 'sacrificial anode'. It is sacrificed, to protect the steel.

6. Copper is on the bottom of the list. What does this tell us about copper and its likelihood of corroding through electrolysis when in moist contact with other metals?

It tells us that when in moist contact with other elements copper is less likely to corrode than the other metals.

7. How does this explain why copper hot water storage tanks have a long life when the water supply has few dissolved salts in it?

It tells us that copper is less likely to be corroded than all the other elements on the list. This is why copper pipes and copper hot water storage tanks have such a long life.

8. If a copper tank was likely to have water with large quantities of dissolved salts in it, would a protective anode help prevent corrosion, or are protective anodes only for steel tanks?

Copper hot water storage tanks do have protective anodes installed in them when it is known that the water is likely to be corrosive.

9. Heat transfer fluids in solar hot water systems are likely to perform two functions. What are the two functions?

The fluid transfers heat and it may have:

- *an anti-freeze, and*
- *a corrosion inhibitor incorporated into it.*

10. Some large hot water storage tanks have two sacrificial anodes installed in them. Why should the anodes always be of the same type; made of the same materials and not different materials, for example one aluminium and one magnesium?

If there were two anodes in the tanks of differing materials one anode would corrode the other.

11. Under some circumstances it is mandatory to have an expansion relief valve (also known as a pressure relief valve) on the cold water supply pipe.

a. Under what conditions is it mandatory?

b. Why is it that the normal Pressure Temperature Relief valve cannot do the job and the second valve is also required?

a. An expansion valve is required where local regulations require it, or a manufacturer specifies it.

b. The PTR valve can do the job but is likely to fail very quickly if it has to handle hot, highly mineralised water. The PR valve (expansion valve) has only cold water that will result in far less deterioration.

12. Often people think that stainless steel is not affected by corrosion. This is not true. Under what sort of water conditions would it be unwise to install a stainless steel tank?

Where water is highly mineralised (salty), it is inadvisable to use stainless steel for hot water.

Chapter 6

9.2.17 Answers to questions section 6.1 – installation assessment

1. Why is it important to ask a prospective customer a number of questions before advising on installation of a solar water heater?

A hot water system must provide for the customer's needs, and asking the customer some questions will enable these needs to be determined. If the hot water system is to be a solar system then access to sunshine, the direction and slope of the roof, as well as the possibility of shade, all need to be determined.

2. Why is it often a good idea to speak to more than one member of a household in order to get a better understanding of hot water usage?

In question 1 we decided that the hot water system must meet the customer's needs. It is quite likely that one person in a household will have a very different view to another as to what the needs are for the entire household. By talking to the second person you are likely to get a better idea of the quantity of hot water required.

3. Describe situations where a solar water heater would be an inappropriate form of water heating.

In some situations there will be no or little sunshine available for the production of solar heated water, perhaps because of shading by clouds, trees or other buildings. The system would not work!

Sometimes the volume of hot water required varies significantly throughout the year. A caravan park is a good example. It is not logical to set up a solar hot water system to provide for the time of maximum demand if it is only for a few weeks each year. The size of the hot water store would need to be very large (and costly) and probably for much of the year the water would be overheated as little is being used. At the time of high demand a large area of collectors would be required. Again at times of low use overheating of the hot water would be likely to be a problem.

It would be more logical to have a solar system to provide enough hot water for the average times of the year and use some other method of boosting the water temperature during times of high demand.

In this second case (variation between hot water requirements at different times of the year) the installation of a solar water heater may be possible but not logical or economic.

4. Regardless of whether a hot water system is a solar system or not, some efficiency in system and installation design can avoid wasting water and wasting hot water. Explain.

- *Placing the points of hot water usage close together when designing a new house will result in less cold water having to be drawn off before the hot comes through.*
- *Placing the hot water system close to the point of greatest use reduces the water that has to be drawn off before the hot water is available.*

- *Large diameter pipes hold more water than smaller diameter pipes. So if there is a long run of pipe between the hot water system and the point of use small diameter pipes will waste less hot water than larger pipes BUT there must be enough pressure.*
- *The installation of a circulating pump (perhaps as a ring main) at distant points will reduce water usage but not hot water usage.*

By getting the views of more than one person you are more likely to ensure that the hot water system will suit the whole household.

5. Suppose that you determine that a family will use about 220 litres of hot water a day. What size solar hot water storage system would you recommend? Why will it depend on where in Australia or New Zealand the installation is to be undertaken?

In districts where most days are sunny and warm (northern Australia) a storage tank of about 300 litres capacity would be common. In districts (southern Australia and New Zealand) where a sunny day would be likely to be followed by an overcast day a larger storage tank would be desirable and a tank of about 400 litres would be more appropriate.

6. What is meant by the ‘efficiency’ of solar collectors? How does this affect the number of collectors in an installation?

The efficiency is a measure of the collector’s ability to convert the energy from the sun into hot water. A collector that produces more hot water or water at a higher temperature would be regarded as more efficient than one that produced less hot water at a lower temperature.

Another way of expressing the efficiency is as a percentage or ratio – the proportion of energy coming in from the sun compared with the proportion of energy going into the water being heated.

Energy in = Energy into the water + Losses from the collector (through the glass or through the rest of the casing)

7. Some manufacturers make more than one type of solar collector. How might two different flat plate collectors be made (constructed) so that they have differing efficiencies, but still have the same surface area?

Flat plate collectors (2m tall x 1m wide) with perhaps seven riser tubes will be less efficient than collectors with a greater number of riser tubes.

Collectors with black paint on the absorber surface will be less efficient than collectors with a selective surface.

8. How could the use of a simple timer make a heat pump water heater more efficient?

If the timer is set so that the water is heated during the warmest part of the day, the heat pump will use less electricity to heat the water in the tank than if it runs during the coldest part of the day (or night).

9. What is meant by a <u>retrofit</u> solar hot water installation?

A retrofit solar installation means:

- *connecting solar collectors to an existing hot water storage tank, or*
- *installing a solar hot water system as a pre-heater to an existing hot water system.*

10. Why is a standard mains pressure gas storage hot water unit not suitable to be retrofitted as a solar system using the storage tank as the only hot water store in the system?

Standard mains pressure gas hot water systems have two characteristics that make them unsuitable for connecting collectors to them directly:

- *The capacity of the storage tank is generally too small (90 or 135 litres are common).*
- *More importantly – when ever any hot water is drawn off the thermostat turns the gas on and immediately heats the cold water that has entered the tank. This prevents the solar collectors being able to contribute to heating the water.*

11. Rheem has a system using a 270 litre gas storage tank as the only water store as part of a solar system. How does this system differ from the normal gas storage system with solar connected directly to the storage tank?

- *The capacity is much larger than most average gas storage hot water systems.*
- *The heating of the water is controlled by a time clock and the gas boosting only occurs at the end of the day IF the water in the tank is not up to temperature.*

12. Explain how the temperature differential controller works in a pump circulation solar hot water system.

The temperature differential controller switches on the electric circulating pump whenever the temperature of the water in the collectors is higher than the temperature of the water in the bottom of the storage tank. This brings the hot water from the collectors to the storage tank.

Some temperature differential controllers also have a frost protection circuit that turns on the circulating pump in frosty weather to prevent the water in the collectors from freezing.

Some controllers will not continue to pump if the temperature of the water in the bottom of the hot water storage tank exceeds 70ºC.

13. Why is a ring-main installed in buildings such as motels, large office buildings, hospitals, etc?

A ring main is installed to ensure that hot water is delivered almost immediately when a hot tap is turned on. It is installed when the points of use are a significant distance from the hot water system.

14. Why is the minimum temperature setting for hot water systems 60ºC?

Legionella bacteria are likely to develop in warm water that is below this temperature. Legionella bacteria can cause disease in humans – Legionnaires disease.

15. If you were about to install a mains pressure hot water system in a district with very hard water how would you decide what protective anode to install?

Sources of information that would allow you to make a choice of which anode to install:

- *The local water supply authority would be able to provide a water analysis and may even suggest the most suitable anode.*
- *It is possible that the local plumbing wholesaler would know which anode to use.*
- *The Australian Standard AS3500 provides a list of recommendations.*
- *The best source of advice is going to be the hot water manufacturer.*

16. If a plastic rainwater tank is found to have acidic water, what might you expect the pH to be? What might you add to the water to make the water less acidic? What would be the pH of the water if it was neither acidic nor alkaline? (Refer back to Section 5 for details).

It would be unusual for rainwater to be more acidic than pH 5 or pH 6.

Adding lime would increase the pH of the water. The acidity would be reduced as the acid dissolved the lime.

pH 7 is neutral – neither acidic nor basic (alkaline).

17. What is the difference between a quotation and a contract?

A <u>quotation</u> is an offer by a supplier/installer to supply something (either goods and or service). If the quotation is accepted by the customer it should be signed and dated by both the customer and the person offering the goods and/or service. It then becomes a <u>contract</u> – an agreement by the supplier/installer to supply the goods and/or service and the customer to pay for the goods and/or service.

9.2.18 Answers to questions section 6.2 – installation

1. Why do close coupled systems (tank and collectors on roof) make for an easy installation? What drawbacks are there and what can be done to make the installation as easy as possible?

- *Assembling the various components on the roof (as distinct from within the ceiling space) is comparatively easy. Many houses have no ceiling space or a ceiling space that is too small for the installation of a tank.*
- *The requirements in additional knowledge and skills to install close coupled systems are far less than for the in-ceiling systems that they replaced.*
- *All the special fittings required for the installation are supplied with the unit. Other pipe and fittings required are what are carried by a normal plumber.*
- *There is no circulating pump required, keeping the cost of the installation low.*
- *Often the storage tank is not large enough for the needs of the users, but a larger storage tank on the roof would be too heavy.*
- *Getting a heavy storage tank onto a roof means using special equipment to lift the tank into position.*
- *If the roof is not suitable (direction of slope or pitch) a support frame may be required.*

2. Why have on-ground mains pressure storage tanks recently become more popular solar hot water installations than close coupled systems?

Roof safety is a significant issue and with the storage tank on the ground there is not the difficulty and cost of getting a heavy tank onto the roof as is the case with a close coupled system. The question of the roof being strong enough to carry the weight of the tank is not an issue.

3. What makes an in-ceiling installation a slower and more difficult installation than some other installations?

An in-ceiling tank installation requires:

- *A place in the ceiling space where the tank is supported over a wall or walls.*
- *Space for the tank; often roof trusses are too close together for a tank to fit between them.*
- *A stand to support the tank.*
- *A safe tray (often called a spill tray) and a drain pipe from it.*
- *The opening up of the roof if it is an existing house.*
- *The tank must be above the collectors.*
- *The connecting pipes between collectors and storage tank are usually 25mm diameter or larger, not a standard size for most plumbers.*
- *Ensuring that there is a slope upwards all the way from collectors to the storage tank takes time and requires adequate support within the roof space.*
- *Insulation with 25mm thick walls is required – again something few plumbers carry as standard equipment.*
- *The roof flashing for pipes passing through at an angle close to the same slope as the roof is difficult.*

4. Treated (preserved) pine timber should never be used to mount solar collectors on a roof. What type of timber is recommended as being suitable?

Timber is not recommended. Where exposed to weather the timber will suffer deterioration (rotting and cracking) and timber is also likely to accelerate rusting of steel roofs.

5. Why should collectors be kept covered while being installed until they are filled with their normal operating water or anti-freeze fluid?

Without water in them, uncovered collectors are likely to get too hot. This may damage the collector and/or result in the glass cracking.

6. When should a safe tray be installed under a hot water storage tank?

In any situation where leakage of water from the hot water storage tank might cause damage. This means inside ceiling spaces or within a house where the floor does not have a floor waste.

7. Some plastic safe trays have ribs (with spaces between them) to support the tank sitting in the tray. Flat galvanised or zincalume steel trays have timber between the tank and the tray. What is the purpose of the ribs and the timber?

Separating the base of the storage tank from the safe tray prevents the base of the storage tank from getting wet. A storage tank that is constantly sitting on a bed of water will quickly corrode. A safe tray that is constantly wet is will also corrode. With air spaces underneath, any water that has collected can drain away and the tray can dry out.

8. What type of solder would you use to solder a drain pop into a zincalume safe tray?

Zincalume cannot be soldered. Silicon should be used as the sealant.

9. Why it is important that if a cold water cut off valve (Terminator) is used it must sit right on the base of the spill tray?

If the 'Terminator' does not sit flat on the bottom of the safe tray it may not switch off the supply of cold water as the water level builds up in the safe tray. If this happened water may spill over the sides of the safe tray.

10. Why is it recommended that solar collectors slope slightly up to the outlet where the hot water leaves?

When water is heated air is released. These air bubbles must be able to escape to prevent an air lock developing. To escape, the bubbles must rise to the outlet and be carried away with the hot water leaving the collectors.

11. Why must solar collectors be lower than their storage tank connections for a thermosiphon system?

Hot water rises. So water heated in the collectors rises to the storage tank by natural convection currents. This is also known as thermosiphon flow or thermosiphon circulation. The tank must be higher than the collectors for this to occur.

12. Some manufacturers recommend 20mm copper tube to connect collectors to a storage tank. Others recommend 25mm. When might you use 20mm, when might you change to 25mm or an even larger diameter, for a remote thermosiphon system?

20mm copper tube may be suitable to connect collectors to a storage tank when:

- *There is only one collector*
- *The collectors and the storage tank are horizontally close together*
- *The vertical distance between the collectors and the storage tank is great – the collectors are much lower than the storage tank.*

13. Why is copper tube and not plastic pipe recommended for solar hot water installations?

The water temperature in solar collectors can exceed 70ºC (the maximum recommended temperature for many plastic pipes) and may even exceed 100ºC.

14. The suggested thickness of insulation on copper pipe between collectors is 25mm (insulation 25mm + pipe 25mm + insulation 25mm = total diameter of 75mm). The recommended insulation on hot water delivery pipes is 12mm minimum. Why is there a difference between these two recommendations?

When the sun is shining there will be hot water travelling through the pipes between collectors all day. To reduce the heat losses from these pipes the thicker insulation is recommended. When water is drawn off only intermittently, less insulation is specified as the heat loss becomes less significant.

15. Why is it a good idea to have pipes connecting collectors and an in-ceiling storage tank set between the ceiling rafters if possible, and then coming vertically up to the connections at the tank? There are three good reasons; however, it is often not possible to have the pipes installed in this way and have the collectors lower than the bottom of the tank.

- *Pipes at ceiling level are less likely to be damaged than pipes at knee or waist height as people move through the roof space.*
- *Pipes running straight down from the tank connections provide a natural heat trap and reduce heat loss from the pipes.*
- *If the pipe runs are long, expansion has to be accommodated and the right angles allow for the expansion.*

16. Sunlight has a damaging effect on some plastic and rubber materials. What can be done to reduce this damage?

Try and use UV stable products or cover the material with a metal cover or cover it with at least two coats of suitable paint.

17. How would you connect solar collectors to a ground-mounted electric 315 litre storage tank if the tank has only two connections?

- A hot water outlet at the top, and
- A cold water inlet at the bottom.

The installation would be a pump-circulation system. The water would be drawn out of the bottom cold water connection and then the heated water from the solar *collectors injected back through the same connection using an injector elbow or five way connector.*

18. Why would you <u>not</u> weld additional nipples for a solar connection onto a steel mains pressure tank?

Welding additional nipple onto a steel mains pressure tank would damage the vitreous enamel lining of the tank. Rusting would occur at this point, adding rust to the hot water and causing the tank to fail and leak.

19. Why is it that in frost prone districts it is important that cold water pipes as well as hot water pipes be insulated where they are exposed to outside air temperatures?

The water in cold water supply pipes is as likely to freeze as the water in hot water pipes, so where they are exposed to air that is likely to be below 0ºC the pipes should be insulated to reduce the likelihood of the water in the pipes freezing.

20. If installing a PTR (Pressure Temperature Relief valve) and a PR (Pressure Relief valve/Expansion valve) on a solar hot water system where would you install each valve?

As with any hot water storage tank the PTR valve is installed at the top of the storage tank. This is where the hottest water will be. The PTR valve must actually be located within the water in the tank, not in a pipe some distance from the tank.

21. Why would you install two valves (PTR and PR) and what purpose would each valve serve? Where would each valve be installed?

The PTR (Pressure temperature Relief) valve would be installed at the top of the hot water storage tank. It would open releasing water if the water was too hot or if the pressure was too high.

The PR (Pressure Relief/Expansion valve) is installed on the cold supply so that as water in the storage tank expands when heated, cold water, not hot, runs to waste. This saves wasting hot water and increases the life of the PTR valve.

22. A ground-mounted hot water storage tank sitting on a concrete verandah has an intermittent trickle of water running across the verandah from the PTR (Pressure Temperature Relief) valve drain pipe. This leaves the verandah wet and slimy. How might you install the system to prevent this water running across the verandah, yet leave the storage tank in the same place? There are several ways this could be done.

- *Cut a 100mm diameter hole in the verandah under the expansion pipe outlet, through to the ground and fill it with coarse gravel. The expanding water can drain away through the gravel.*
- *Run the expansion pipe through the verandah or under the verandah so that the water does not run across the verandah. This might be quite some job if undertaken AFTER the verandah concrete has been poured and the hot water storage tank installed.*
- *Install a PR (Expansion) valve on the cold supply in a position not on the verandah. It is possible to install the PR valve several metres from the storage*

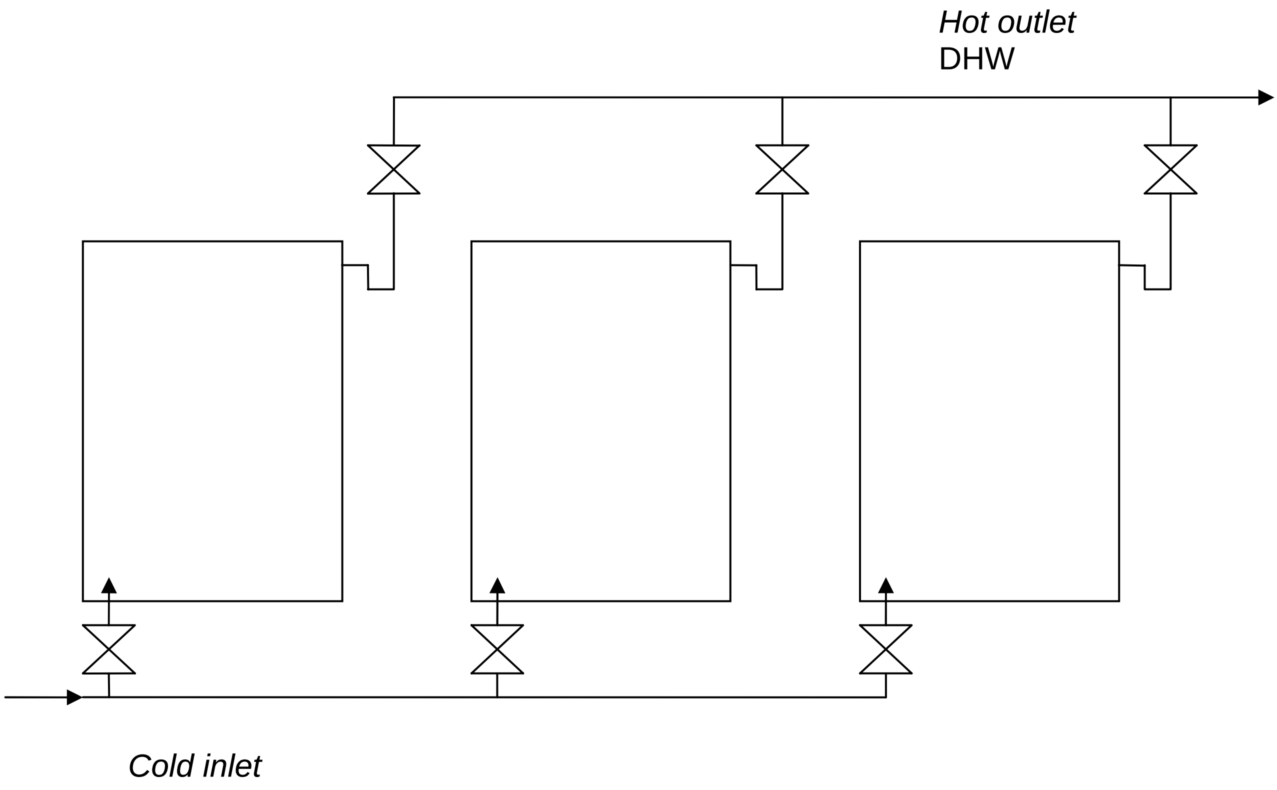
tank. If installed this way water would not leave the PTR valve under normal operating conditions.

23. A gravity feed hot water storage tank with a mains pressure coil installed in it is able to supply water to hot water outlets (taps) above the tank. A gravity-feed tank with a pressure pump and flow switch on the delivery pipeline to increase the pressure cannot be connected to outlets above the storage tank. Why not? What is the difference?

A pressurising pump activated by a flow switch will only switch on once water starts to flow through the switch. For water to flow out of a gravity feed tank it must run downhill. In other words the pump only builds up the pressure after the water starts to flow.

24. When connecting several solar collectors or several hot water storage tanks together, the flow of water should be diagonally across the collectors or the tanks – in the bottom of the first in the row and out the top of the last in the row. Why? Draw a diagram to show how you would connect them.

This ensures even pressure across each of the storage tanks.



25. When connecting several hot water storage tanks together it is important that each tank have an isolating valve on the cold line and the hot line. Why is a valve needed on both lines and not just the cold line as with a single hot water storage tank?

If one hot water tank is to be taken out of service (removed) a valve is required to stop cold water or hot water flowing from the disconnected pipes.

26. Explain how you would flash a tile roof for pipes penetrating the roof for an in-ceiling gravity feed storage tank as part of a remote solar hot water system. A diagram might help.

Remove a tile or several tiles to enable the copper tube (probably 25mm diameter or more) and its 25mm thick insulation to go through the roof.

Cover the insulation with a sheath (perhaps round down pipe) to protect it from the weather.

Install a lead or lead coated flashing over the covered pipe and the hole created by the removal of the tile (use a non-lead flashing if water is being collected for drinking).

27. Suppose an en suite bathroom is 30 metres away from the hot water storage tank. Why would it be logical to install a tempering valve for the en suite close to the en suite rather than beside the hot water storage tank?

With the <u>tempering valve fitted at the hot water storage tank</u> a mixture of hot and cold (tempered) water will run along the line to the hot tap when it is turned on. The further it goes the more likely it is to cool off so that by the time it reaches the en suite it may be quite cool. It is quite possible that regardless of how long the hot water is allowed to run, the water reaching the en suite is never hot enough due to heat loss along the way. Also a lot of water will be wasted waiting for the hot water to arrive.

With the <u>tempering valve fitted near the en suite</u> despite heat being lost along the way from the hot water storage tank, the water reaching the tempering valve will be hotter. Less water will be wasted waiting for the hot to arrive, and the water delivered from the tap is more likely to be hot enough to be satisfactory.

28. How might you check to see if the water from a hot water service was reaching the required 60ºC?

Use a thermometer. Probably the best place to test the water is by lifting the PTR valve and checking the water leaving it.

29. Suppose you have installed a solar hot water service. What would be the minimum that you might do by way of <u>commissioning</u> it before handing it over to the new owner?

- *Lift the PTR valve to release air and any dirt.*
- *Open all hot water taps to ensure that all air has been cleared from the system.*
- *Clean out all strainers on: tempering valves, sink and trough diffuser aerator outlets, cold water inlet to hot water system, washing machines, dishwashers, flickmaster valves, and any other places where strainers may have had a build-up of muck as the result of the installation.*
- *Ensure that the level of anti-freeze (where appropriate) is satisfactory.*
- *Ensure that the solar collectors are heating the water if it is a sunny day, and that there is no air lock.*
- *Check that the boost heating system functions as it should.*
- *Explain to the owner how the system works and anything that is specific to the particular installation. Leave a contact name and phone number for any queries.*

30. Would checking of the operation of a tempering valve be regarded as part of commissioning a newly installed hot water service?

If the installation of the tempering valve was part of the installation of the new hot water service it should be checked to ensure that water is being delivered at the set temperature.

Chapter 8

9.2.19 Answers to questions chapter 8 – solar hot water for space heating

1. What is the difference between an *active* and a *passive* solar house heating system?

An <u>*active*</u> *heating system requires a pump or a fan to bring heat (hot water or hot air) from the collectors into the building or storage.*

A <u>*passive*</u> *system is one in which no energy is required other than from the sun to get the heat into the building. In Australia, windows facing north allow heat into the building. The heat is often stored in a concrete floor or other heat absorbing materials in the house, simply by the sun shining on that surface.*

2. What is required to produce an active solar hot water house heating system?

- *Collectors – to absorb the heat energy from the sun.*
- *An energy (heat) transfer system – the transfer medium is commonly heated water or heated air.*
- *A heat store – a large insulated hot water tank for hot water systems OR rock piles for hot air systems are common.*
- *Heat distribution system – for hot air this will be ducts, for a water (hydronic) system it will be pipes.*
- *Heat emitters are required for a hot water system – a device to get the heat from the water into the air of the building. The heat emitter may be the floor or it may be hydronic panel radiator heaters, or other heaters.*

3. In winter in southern Australia what is the likely hot water temperature produced by flat plate solar collectors?

The temperature of the water will be determined by the volume of hot water required. For a solar hot water system from which a tank of hot water is removed each day the temperature of the water on a cool, very sunny day might reach 40ºC or 45ºC. For a system from which no hot water is being drawn off, it is possible to have a water temperature of 60ºC or 70ºC.

In the context of house heating where a significant quantity of heat energy is required, it is likely that only low temperatures (perhaps 30ºC to 40ºC) will be achieved unless a huge area of collectors is installed.

4. Is increasing the number of flat plate solar collectors going to increase the water temperature of water in a hot water storage tank to the 75ºC or 80ºC required for a normal hydronic heating system?

Possibly, but it is unlikely. As temperatures inside the collectors rise, heat losses through the glass also rise if the surrounding air is cool or cold.

5. A flat plate solar water heating system operating in a southern Australia winter raises water temperature from 15ºC to 35ºC. It is going to capture far more heat than one raising water temperature from 40ºC to 60ºC. Why?

*Raising the water temperature from 15*ºC *to 35ºC will capture more heat energy than raising it from 40 to 60*ºC*. The difference between the lower temperature inside the collector compared with the outside air temperature (perhaps 10ºC to 15ºC) means that there will be less heat lost through the glass of a flat plat collector, than if the water temperature in the collectors is higher.*

6. What are the disadvantages or difficulties of using water at low temperatures for space heating?

It would seem logical on this basis (question 5) to use low temperature water for heating; however, for hydronic heaters to transfer low temperature heat to the air inside a building they would have to be enormous. Huge panel radiator heaters would be required, which might occupy the entire area of one or more walls. Such heaters would be expensive, unsightly and impractical, even if they were manufactured.

Floor heating is the other option and while low temperature water suits this form of heating, it is not an efficient form of heating. Heat is lost downwards into the ground, and heat is wasted on warm days heating a building that is getting sufficient warmth into it anyway.

Annex 2.1

9.2.20 Answers to questions annex 2.1 extra detail on frost protection

1. It is unusual for collectors to be damaged by the first frost that they experience. Why is this?

Although the water expands when it freezes, some of the water will expand out of the collectors and into the storage tank. The water that does freeze and expand within the collectors is likely to stretch the pipe a little, but probably not enough to burst the header or riser tubes. Repeated stretching, however, will eventually result in the tubes splitting.

2. In districts where frosts are rare, but do occur sometimes, it can be tempting for a salesperson to sell a solar hot water system without frost protection, rather than with frost protection. Why?

It reduces the cost of the system. This may often result in a sale over a supplier who provides frost protection.

3. Manufacturers of solar water heaters are keen to develop an alternative to anti-freeze techniques for frost protection. Why?

Anti-freeze frost protection adds significant complexity and cost to a solar system. It also reduces efficiency. If a different method of frost protection can be achieved with lower costs, this is desirable.

4. List the factors that determine how many frost dump valves would be used in an installation that uses frost dump valves for frost protection.

- *Temperature of incoming water*
- *Anticipated ambient air temperature*
- *Pressure of the water*
- *Area of collectors to be protected.*

5. Why is an all plastic solar hot water system unlikely to be damaged by frost?

An all plastic system stretches sufficiently to accommodate the expansion of the water when it freezes.

6. It is usual for anti-freeze to be added to the water in collectors at about 25% concentration. To approximately what temperature would this provide protection?

The table shown does not go to such low temperatures, but about -35ºC would be the approximate figure.

7. There are probably no parts of Australia or New Zealand that get this cold (question 6). Why is such a high concentration used?

This concentration covers all situations in all districts and provides for some dilution or loss of anti-freeze solution.

8. A heat pipe relies on a ‘change of state’ of liquid to a vapour or a vapour to a liquid. Explain why this is significant in transfer of heat.

In changing from a liquid to a vapour (such as when water is boiled), significant quantities of heat need to be applied to the liquid. Roughly 500 times as much energy is required to change 1kg of water to 1kg water vapour (steam). Conversely when a vapour changes to a liquid huge quantities of heat energy are given off.

9. What is meant by a direct heating system and an indirect heating system?

A direct solar system heats the potable water in the collectors. An indirect system uses a heat exchanger and the water being heated is not in the collectors.

10. A heat exchange coil in the bottom of a storage tank is usually quite short. It heats the water in the tank surrounding and above the coil. By comparison a mains pressure heat exchange coil in the upper part of a tank that heats the water passing through the coil must be much longer. Why?

Heating water in a storage tank usually happens over an extended period of time so a coil in the bottom of the tank does not need to be as long as a coil that heats the water passing through it as it is used (such as a mains pressure coil in the top of the tank).

9.3 Government solar water heater incentives

9.3.1 Australian Federal Government Renewable Energy Certificates

When a client installs solar water heating they subsequently use a lot less electricity or gas to heat their water and are therefore contributing less to greenhouse gas emissions. Through the implementation of the Mandatory Renewable Energy Target (MRET) the owners of such systems in Australia are entitled to create Renewable Energy Certificates or RECs for short. One REC is equivalent to saving one megawatt hour (MWh) of electricity, where a megawatt hour represents one megawatt of electrical power used for one hour. For a 2.4 kilowatt electric element, 1MWh is roughly 400 hours of electricity use.

RECs are an environmental credit, a form of currency like shares on the stock market and are tradable through a point of sale discount with the solar water heater retailer or an agent or emissions trader such as Green Bank or through a point of sale discount (POS) with the solar water heater retailer.

The price of RECs has been volatile in recent times due to changing supply and demand in the market and this has seen fluctuations in the value of RECs. That price instability has exposed some retailers to substantial losses when giving POS discounts so some now refer the client directly to agents to trade their RECs. As a rule of thumb most solar water heaters and heat pumps can create 30 RECs per unit and the price of RECs over the last two years has ranged from $36.00 to as low as $11.00 in September 2006. RECs are essentially a commodity and like all commodities are subject to vagaries of the marketplace and to the politics of greenhouse gas emissions, carbon accounting and climate change.

The process of trading the RECs is relatively simple. The RECs are created on an electronic registry administered by the Officer of the Renewable Energy Regulator (ORER) in Canberra. The client completes the REC Assignment Form and sends it to an agent such as Green Bank where it is processed; it is then approved by ORER and released from the registry. The agent then pays the client for the environmental credits via direct deposit into their nominated bank account or by cheque if preferred. If all the necessary information is supplied the process will take three to four weeks. There is a twelve month ‘sunset clause’ on the creation of the RECs for solar water heaters from the date of installation, after which time they cannot be created. These are some installation details that need to be provided:

- Model and brand
- Serial number of the tank or heat pump
- Installation date
- Certificate of compliance or proof of purchase

Once payment has been made to the client, the RECs then become the property of the agent, who can then on-sell them to an electricity retailer or company who has a liability under the MRET scheme to purchase a certain number of certificates.

An agent is an authorised person registered with the Office of the Renewable Energy Regulator to register Renewable Energy Certificates under the Mandatory Renewable Energy Target scheme.

The above information has been supplied by Fiona O'Hehir at Green Bank Australia Pty Ltd. Fiona is a registered REC Agent and is happy to take calls on 03 9723 9500 or 0409 176 167.

9.3.2 Australian state government rebates

Different State Governments have recognised the environmental benefits of solar water heaters, and have provided rebates to assist customers to cover part of their higher capital costs. Several states and territories have provided these rebates in the past, but since details can vary with time, readers are encouraged to find information at the website www.solartraining.org.au.

9.4 Technical standards and other references and resources

9.4.1 List of Australian/New Zealand Standards

Standards are available in Australia for purchase from:

SAI Global Limited

GPO Box 5420

Sydney, NSW, 2001

Phone: 131 242 from within Australia

+61 2 8206 6020 from overseas

mail to: sales@sai-global.com

Or by visiting:

Sydney

Unit T, 10-16 South St, Rydalmere, NSW 2116

Melbourne

19-25 Raglan Street, South Melbourne VIC 3205

Perth

165 Adelaide Terrace, East Perth WA 6004

Brisbane – Preferred reseller

SDS Express, Ground Floor, Mineral House, 41 George St, Brisbane QLD 4001

New Zealand

In New Zealand the Standards are available from Standards New Zealand

Private Bag 2439, Wellington 6140

www.standards.co.nz

0800 782 632

snz@standards.co.nz

The Standards are available in the traditional printed book format or on-line allowing you to be right up to date and with access to ALL standards.

The following standards all have relevance to this course, some to a greater extent than others. As Standards are updated periodically, the current applicable Australasian Standard may have superseded the number shown.

AS 1056	Storage water heaters
AS 1056.1 : 1991	Part 1: General requirements
AS 1056.2: 1985	Part 2: Specific requirements for Water Heaters with Single Shells
AS 1357	Water supply – Valves for use with unvented water heaters
AS 1357.1: 2004	Protection valves
AS 1357.2: 2005	Control valves
AS 1361: 1995	Electric Heat Exchange Water Heaters
AS 1375: 1985	Industrial Fuel Fired Appliances
AS 1571: 1995	Copper – Seamless tubes for air conditioning and refrigeration
AS/NZS 2712: 2002	Solar Water Heaters – Design and Construction
AS 3000: 2000	Electrical installations (Australia & New Zealand Wiring Rules)
AS 3142 – 1986	Approval and Test Specification – Electric Water Heaters (superseded)
AS/NZS 3500	National Plumbing and Drainage Code
AS/NZS 3500.0: 2003	Part 0: Glossary of Terms
AS/NZS 3500.1: 2003	Part 1: Water Supply
AS/NZS 3500.4: 2003	Part 4: Hot water supply systems
AS 3565: 2004	Meters for water supply
AS 3666: 2006	Air handling and water systems of buildings
AS 3666: 2006	- Microbial control, Design, Installation & Commissioning
AS 3666: 2006	- Microbial control, Operation & Maintenance
HB 263 – 2004	Heated water systems – Handbook
AS 5601 – 2004	Gas Installations
AS 3498 – 2003	Authorisation requirement for plumbing products
	Water Heaters (all types)
AS 4032.3 – 2004	Water supply – Valves for the control of hot water supply temperatures

AS4234 – 1994	Solar Water Heaters – Domestic and heat pump – Calculation of energy consumption
SAA MP 52 – 2005	Manual of authorisation procedures for plumbing & drainage products
AS 4552 – 2005	Gas fired water heaters for hot water supply and/or central heating
AS/NZS 4692.1:2005	Electric water heaters – Energy consumption, performance and general requirements
AS/NZS 4692.2:2005	Electric water heaters – Minimum Energy Performance Standard (MEPS) requirements and energy labelling
AS 3814 – 2005	Industrial & commercial gas fired appliances & equipment
SAA HB 9 – 1994	Occupational health and safety
AS 1470 – 1986	Occupational health and safety

In New Zealand the installation of solar water heating systems is regulated by the New Zealand Building Code, Clause G12 Water Supply. Demonstrated compliance can be by way of Acceptable Solution G12/AS2.

9.4.2 Other resources

Books

Plumbing Industry Commission/Australian Standards 2004 *Heated Water Systems* – a particularly useful easy to understand small book of 28 pages filled with useful diagrams.

Berrill T. (Ed) 2000, *Solar Water Heating Systems Resource Book*. Brisbane North Institute of TAFE, Available from www.qtw.com.au.

Berrill, T. (2004), *Comments on Sustainable Housing Code,* Qld Sustainable Energy Industry Development Group, QUT.

Ekins, P. (1992), *Wealth beyond Measure – An Atlas of New Economics*, Gaia Books, London.

Foster, J. S. (1989), *The Solar Technology/Electricity Utility Interface in Queensland – Solahart and SEQEB*, Solar 89 Conference Proceedings, ANZSES, Sydney.

Foster, J.S. (1991), *Acceptance of Solar Water Heaters by New Householders in Queensland*, ISES Solar World Congress proceedings, Denver, Colorado.

Gilchrist, G. (1994), *The Big Switch – Clean Energy for the 21st Century*, Allen and Unwin, Sydney.

Jolly, P. & O'Sullivan, R. (1989), *The energy required to manufacture renewable energy technologies*, Proceedings of ANZSES Solar 89 Conference, www.anzses.org.au.

Lloyd, Dr. C.R., (1999), *Renewable Energy Options for Hot Water Systems in Remote Areas*, World Renewable Energy Congress, Murdoch University, Perth, WA.

Saddler, H. (1981), *Energy in Australia, Politics and Economics*, Allen and Unwin, Sydney.

Simpson, R. (1989), *Air pollution in Brisbane*, Institute of Applied Environmental Research, Watson and Ferguson, Brisbane.

Berrill, T., Burton. R. et al. (2000), *Solar Water Heating Systems Resource Book, Brisbane North Institute of TAFE* (available from www.qtw.com.au).

Berrill, T. (2006), Compiled from reports to Queensland Govt. (DLGP) by consultants MMA (2004) and to the Victorian Govt. (SV) by consultants GWA (2005) regarding sustainable housing code development and operating costs of water heaters (tberrill@powerup.com.au).

BMT & Associates (2006), *Indicative Elemental Estimate – Basix Energy 40*, Property Depreciation and Construction Cost Consults, Sydney.

G. Wilkenfeld and Associates (GWA) (2005), *Estimating Household Water Heater Energy Use, Running Costs and Emission, Victoria*, Report to SEAV.

Australian Greenhouse Office (2004), *Minimum Energy Performance Standards (MEPS) for Heat Pumps – Report No. 2004/17*, National Appliance and Equipment Energy Efficiency Program.

McLennan, Magasanik & Associates (MMA) (2004), *Social, Economic and Environmental Implications of Proposed Energy Efficiency Amendments to BCCs City Plan House Code*, Report to Brisbane City Council.

Solwatt Program (2005), S*preadsheet for the analysis of the performance and life cycle cost of solar systems vs. alternatives* (available from tberrill@powerup.com.au).

Duffie, J.A. & Beckman, W.A. (1991), *Solar Engineering of Thermal Processes*, John Wiley and Sons, New York

Lee, T, Oppenheim, D, Williamson T.J. (1996), *Australian Solar Radiation Data Handbook*, available from Aust. & NZ Solar Energy Society (www.anzses.org).

Monsour, P., Berrill, T. et al. (2003), *Introduction to Renewable Energy Technologies*, Brisbane North Institute of TAFE (available from www.qtw.com.au).

Nunez, M. (1990), *Satellite estimation of regional solar energy statistics for Australian capital cities – Meteorological Study No. 39*, Canberra, Australian Government Publishing Service.

Phillips, R.O., (1992), *Sunshine and Shade in Australasia*, Australian Government Publishing Service, Canberra.

Films

Solahart Consumer and Installation – DVD – This is specific to Solahart showing two programs. One (9 minutes) provides answers to objections that potential customers might have. The second (24 minutes) provides installation instructions for Solahart units. It is indexed so that only part of the total program can be selected. 2003.

Rinnai Beasley – DVD 1990s vintage but shows

1. The installation of Silver Bullet close coupled system.
2. Also shows the installation of an *in-ceiling gravity feed tank* system. This is probably the only video to show how to go about an in-ceiling installation.

Each of the two programs runs for 15 minutes.

Restricted Water Supply for Electricians video – produced by Victorian Plumbing Industry Commission and National Electrical Contractors Association. The video shows valves associated with the installation of hot water services. The quality is not particularly good and using a Rheem video would probably be better. About six minutes. 1996.

Domestic Solar Water Heating – video – CSIRO this is an old film but establishes quite clearly the basic principles of solar water heating. 10 minutes.

Solar Hot Water Myths and Realities – video – Victorian Plumbing Industry Commission. 16.5 minutes. Reasonably recent (2005). Installation overview: seven minutes. It uses a modern style of presentation that may appeal to younger installers.

Plumbers, Purlins, Parachutes – video – a roof safety video produced in the 1990s for the Plumbers Gasfitters Employees Union and the Master Plumbers Association produced by Open Channel and Bechtel Australia.

Alright at Height – Video – British – roof safety film, well presented and useful but it is set on major building sites, not domestic. It does, however, present the major safety issues that need to be considered. 18 minutes (2000).

Powerpoints

See resources section at: www.solartraining.org.au.

Internet web sites

The internet provides access to some of the most varied and up to date sources of information. It must be recognised that most solar hot water manufacturers' web sites are designed to sell a product first and foremost. The provision of information is another function of the website and often the information provided is selected to direct consumers to a specific product based on their requirements. Given these considerations the sites of the manufacturers on the list in Section 9.9 will provide up to date information.

There are several state agencies throughout Australia with valuable information on solar water heaters. These and other links can be found at www.solartraining.org.au.

www.solartraining.org.au

Solar Training web site – includes links to different training organisations, regulators, and other resources.

www.greenhouse.gov.au/index.html

Australian Greenhouse Office, including links to "Your Home' Technical Manual and solar water heater rebate information.

www.solarindustries.org.nz

New Zealand Solar Industries Association has information on the New Zealand solar water heating industry. Lists accredited suppliers and their approved installers, process for accreditation and guidance notes for installation.

www.solarsmarter.org.nz

New Zealand government maintained site for information on government programmes.

9.5 Installation check list

Installation check list and quotation/contract

The check list is used to ensure that all aspects of an installation are covered. If used as a quotation it means that both installer and customer know exactly where they stand; what is covered and what is not covered. If the customer is happy with the quotation it is signed by both supplier and customer and it becomes a contract. If the supplier is not the installer, it must be made clear who accepts responsibility under the conditions of the warranty. Some companies will only permit their own trained installers to undertake an installation.

If installing in an existing house, it is very important that the supplier makes it very clear to the customer where the boundaries for the work stop. When installing in an existing house there will be a number of aspects that only become obvious once the work has started. These should be drawn to the attention of the home owner as soon as discovered. If the work boundaries have been clearly set out it will not be an issue of the installer's responsibilities.

When installing on a new building it is easy to get other trades to do things and they are often accommodating. If something subsequently goes wrong, however, there is often a dispute about who did what and whose responsibility it is. As the system supplier it is the installer's responsibility to ensure that any work requested of another trades person is fit for purpose. A similar issue arises if the home owner offers to do things that subsequently fail. As the professional and the one responsible for successful installation and system operation the installer must check that any work undertaken by the home owner is fit for purpose.

On a new building it is not unusual for parts of the system to be installed while cranes and scaffolding are available, and then final connection and commissioning is left to a later time. In this situation the supplier needs to ensure that other people do not interfere and remove collector covers for example. Also the supplier may leave it to other trades to extend the pipework or specific structural work. If the supplier is a subcontractor then the respective responsibilities between the trades is usually clear. When the supplier is dealing directly with the home owner then the supplier has a responsibility to ensure that the home owner clearly understands what the supplier will and will not do.

In each of these situations it is very easy to end up in a dispute. Generally it has arisen because the supplier has not taken enough care to properly outline in writing what they will and will not do.

Name of the supplier...
Address...
Telephone...email...
Name of supplier representative..
Installer...
Address...
Telephone...email...
Name of person for whom system is to be installed (customer)...................................
Customer address..
....
.
Telephone...email...
Address of installation...
....
.

<u>Building and usage details</u>
Number of people using system...
Number of bedrooms...
Number of bathrooms...
Position of main points of use relative to the storage tank...............................metres
Anticipated daily hot water usage...litres

<u>Water details – cold supply</u>
Water supply authority..
Water pressure..................kPa
Is there a pressure reducing valve at meter?.....................
Is a pressure reducing valve to be installed?.....................
Water quality...pH
TDS (Total Dissolved Solids)...........................mg/L
Hardness..mg/L

Valves

Isolating valve
In-line strainer or filter
Non-return valve
Pressure-limiting valve
Expansion valve

<u>Proposed Solar Hot Water System</u>

Type of system proposed:

Close coupled on roof, mains pressure
Ground-mounted tank, mains pressure pump circulation
Gravity feed in-ceiling tank

<u>Storage tank</u>

Storage tank draw off capacity...litres
Brand of tank...model
Boost heating (circle)
Natural Gas LP Gas Electricity Solid Fuel (type of unit)
Boost heating rating.......................Kilowatt.................Megajoule
Boost connection requirements

Electricity – is an adequate supply available?
Gas – is supply available? Do the existing pipes need to be increased in size?

Boost details (position of electric element/s, instantaneous gas in line)
Protective anode – Is the standard anode suited for the water supply?
Select appropriate anode.
Expected solar contribution (kWh pa)
Expected annual supplementary heating (kWh pa)
Expected electricity for circulating pump (kWh pa)
Supplementary heating controller type
Supplementary heating controller settings
PTR (Pressure Temperature Relief Valve) required for mains pressure system
Will a safe tray be required? Yes/No
Will a tank stand or mounting block (concrete plinth) be required?

<u>Collectors:</u>

Number of collectors................................Approx. area................................
Brand..Model...

<u>Connection of collectors</u> to storage tank:

Close coupled – is kit supplied?
Pump circulated system
Circulating Pump..........................brand.....................model
Pump controller............................brand.....................model
Sensor connections
Power supply for circulating pump
Pipe diameter between circulating pump and collectors
Air escape valve?
In-ceiling storage tank
Distance between collectors and storage tank.............metres
Connecting pipe diameter..mm
Is the bottom of storage tank at least 300mm above collectors Yes/No
If ‘No’ – what provisions are to be made to prevent reverse thermosiphon?
Is the gradient between collectors and storage tank connections at least 1:20?

Is the insulation on these pipes at least 25mm thick?

Connection between storage tank and solid fuel heater (where appropriate):
Is a wet back or boiler planned for boost heating?
Will the heating unit be a cooker, room heater, or independent boiler?
Is the gradient between the boiler and the tank up hill all the way so that air bubbles escape into the tank?
Is a heat trap fitted to prevent reverse thermosiphon flow?
Is a drain valve fitted at the lowest point?
Are there any valves installed on the flow and return lines between the boiler and the storage tank in contravention of AS NZS 3500?

Frost protection

Is the district frost prone, and, if so, what method of frost protection is planned?

Roof

Type of roofing material: Tiles Steel Other
Orientation of roof on which collectors/unit will be mounted (circle below or azimuth):
North Northeast East Southeast South Southwest West Northwest
Pitch of roof....................degrees
Will a mounting frame be required? Yes/No
Will any additional supports be required? Yes/No
Details? Yes/No
Work to be undertaken by property owner or other trades...
....
....
....
....
Will any repairs or restoration be required to the roof prior to the installation of the system?
What roof penetrations will be required?
What method of fixing to the roof will be used?
What flashings are planned?
If rainwater is being collected, are non-lead flashings being used?

Domestic Hot water

Will a balance feed tank, cold water supply connection on head tank or other provision need to be made where cold water supply is at different pressure to the hot water pressure?
Details..
....
....
If a gravity-feed tank, do the hot delivery pipes slope up to the tank all the way from the hot water outlets so that air can escape?
Is the hot water delivery pipe 20mm in diameter? Yes/No
If not what provision will be made to ensure adequate supply?
Are the hot water pipes insulated with at least 12mm think insulation?
Is a tempering valve to be installed?

<u>Installation</u>
Labour..
Travel..
Crane hire..

<u>Materials</u>
Is a Building Consent to be obtained by installer or owner?
Items or possible contingencies not listed above..
....
....
....

Materials	$
Installation	$
Building Consent (to be obtained by installer)	$
Additions to bring the installation to compliance standard:	
List: Supply and installation of tempering valve	$
Supply and installation of pressure limiting valve at the main meter	$
Supply and installation of additional insulation on hot water pipes	$
Other	$
Subtotal	$
GST	$
Total	$

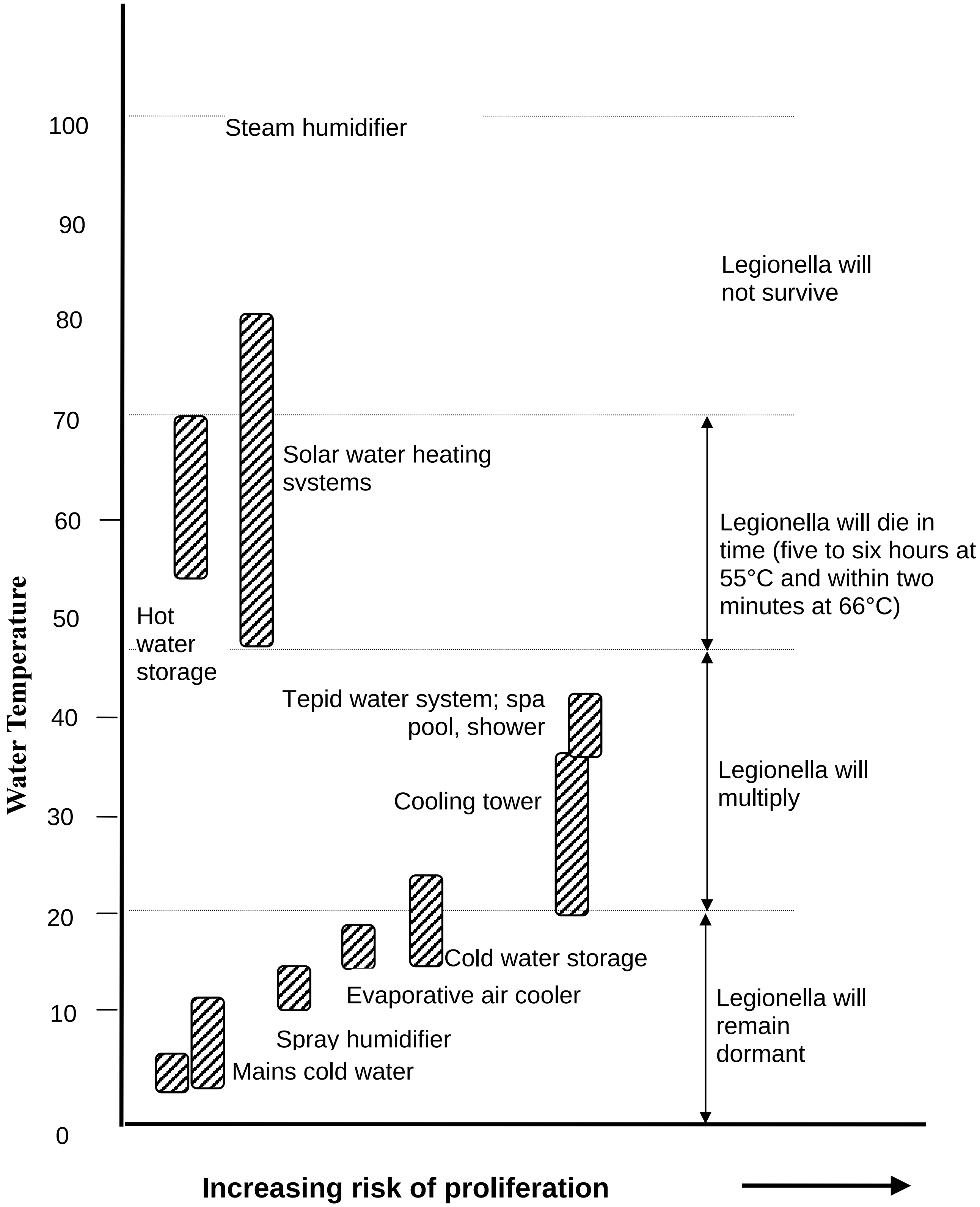
Conditions (add any additional comments or information, access, removal of trees/vegetation, etc.)
Date of installation...
Warranty details..
Warranty exclusions..
Payment details:
Name of supplier....................................Signature of Supplier....................................
Date...
Name of installer....................................Signature of Installer....................................
Date...
Name of customer.................................Signature of Customer..................................
Date..

9.6 Significant water temperatures

0°C	Water freezes at sea level
4°C	Although cold water is heavier than hot water, cooling water below 4ºC will reduce its density
8°C	Approximate minimum ambient water temperature in Australia (Melbourne – winter). This temperature is used in sizing water heaters for that state.
13°C	1) Approximate average water temperature in Melbourne
	2) Approximate minimum water temperature in Sydney
20°C–45°C	Legionella bacteria flourishes
24°C	Approximate maximum ambient water temperature in Australia
35°C–38°C	Bathing temperature for infants
38°C–40°C	Bathing temperature for children
40°C–42°C	Bathing temperature for adults
Above 45ºC	Legionella bacteria cannot survive
55°C–60°C	Washing up temperature
57°C	Thermostat setting for booster elements in dual element heaters
60°C	Normal setting for domestic gas water heaters
68°C–70°C	Maximum setting for domestic gas thermostats
77°C	Temperature required in the sink for sanitising purposes
82°C	Maximum thermostat setting for thermostats in heavy duty water heaters
82°C–92°C	Temperature at which the energy cut off device will operate on fixed setting thermostats
87°C–95°C	Temperature at which the energy cut off device will operate on adjustable thermostats
93°C–95°C	Temperature at which a TPR valve subjected to normal working pressure will start to dribble
99°C	Nominal thermostat setting for Lazer boiling water units
100°C	Boiling point of water at sea level

9.7 Legionnaire's disease temperature table

Relationship between the proliferation of **legionella** and the temperature of water systems when systems are in use and when other growth factors are present.



9.8 Occupational health and safety considerations

9.8.1 General

Further information for this section will be available from the website, but safety issues for solar water heater installation would include all of the following:

- responsibilities
- protective clothing, hats, safety glasses, welding masks, gloves or gauntlets, sunscreen, etc
- fire precautions
- hot work equipment
- portable timber and metal ladders, scaffolding
- safety signs
- heavy lifting
- pipeline colours and identification (add lilac for non-potable water)
- roof safety – perimeter fencing, safety harnesses.

9.8.2 Lifting

This van was specially fitted with a lifting platform. It was originally a taxi for wheelchairs but here makes an ideal vehicle for lifting heavy equipment to van floor level.

It operates using electricity from the battery of the vehicle.

An alternative is a ramp, but either way a hand truck or trolley is required.

Photo: Andrew Blair

Figure 9.8.1 – Using a Lifting Platform

9.8.3 Roof safety

Refer to the video/DVD for further information

Swinburne library reference:

363.11969ALR-C All Right at Heights

Plumbers Purlins and Parachutes

Figure 9.8.2 – Roof Safety harness

Photos Dux Hot Water solutions

Figure 9.8.3 – Roofers with safety harness and lanyard

The perimeter fence is on the top of scaffolding round a double storey house during construction. Arranged as it is here, it not only reduces enormously the likelihood of a fall, but also provides a work platform for the roof plumbers.

Photo: Andrew Blair

Figure 9.8.4 – Perimeter fencing

Figure 9.8.5 – Roof safety on the cheap

By law this builder was required to provide perimeter fencing, which he did on the most visible parts of the building, but not on the back where it could not be seen from the road. Who is likely to pay the price for the cost cutting? – Why, the roofers of course.

The perimeter fencing is designed to be used again and again. It is quickly and easily attached and removed.

Photos: Andrew Blair

Figure 9.8.6 – Method of attachment of perimeter fencing

Installers should be aware of relevant workplace Occupational Health and Safety requirements within their state. Legislation, Regulations and Codes of Practice cover areas that need to be addressed. Particular attention should be paid to 'Working at Heights' requirements, but other areas that need to be addressed are lifting and potential overheating of uncovered collectors during installation (see **Section 6.2.2 Getting collectors and tank onto a roof**). A risk assessment or Job Safety Analysis (JSA) should be done to minimise risks, and proper safety equipment utilized. For more information and links to relevant agencies, refer to the website.

9.8.4 Working on roofs – safety harnesses

There are different types of Personal Protective Equipment (PPE) that are available to protect people working at heights. These are typically:

- fall arrest, or
- travel restraint systems.

As stated on the 'Worksafe Victoria' web site, 'fall arrest equipment is personal protective equipment and should not be selected unless other systems, which provide a higher level of fall protection, such as scaffolding or elevating work platforms, are impracticable'.

Fall arrest systems include inertia reels and lanyard systems. These often provide some form of energy absorption in the safety line should a fall take place. It is very important that the anchor point is chosen correctly to minimise the distance of a fall, and to ensure that the line is not exposed to snagging on obstructions or bending around an edge. This can result in safety system failure.

Travel restraint systems physically prevent the user from reaching an unprotected edge. Obviously the restraint should be of suitable length to ensure this.

Some information will be specific to particular fall arrest systems, so installers should consult safety equipment suppliers for details of operation and maintenance of their systems. Fall prevention such as safe working procedures and suitable barriers are the first priority for working at heights. These are outlined in Codes of Practice such as from Worksafe Victoria:

See www.workcover.vic.gov.au/wps/wcm/connect/WorkSafe.

The Business Council for Sustainable Energy cannot accept responsibility for any errors and omissions contained in this information. Specialist advice is recommended in particular for current health and safety requirements.

9.8.5 Care and maintenance of safety equipment

9.8.5.1 Introduction

Safety systems may consist of a number of different items of equipment that are constructed from one or more of three types of material. These three groups of materials are:

Kernmantle rope

Webbing

Metal fittings (steel and alloy)

Each item of equipment has been designed and manufactured for extreme strength and durability in order to ensure total reliability.

As with all equipment, however, the performance of any safety system over an extended period of time depends upon thorough and regular care and maintenance.

9.8.5.2 Kernmantle rope and webbing

Kernmantle rope is different to traditional laid rope in that it is braided rather than twisted. This makes it stronger, more durable and less prone to stretching. Kernmantle rope consists of an outer protective sheath – providing approximately 25% of the rope's strength – and an inner core which provides the main strength of the rope. The fibres of the rope are polyamide and run for the full length of the rope.

Webbing is a flat, woven, synthetic alternative to rope. It is comprised of many thin strands of polyamide fibre that run for the full length of the piece. It is extremely strong and durable and is commonly used in harnesses and anchor strops where it is important to spread the load of tension over a wider area than is possible with rope.

9.8.5.3 Damage to rope and webbing – what to look for

Damage to webbing and rope can be caused by a number of factors. Here are the most common causes of damage, and what to look for as indicators of damage.

General surface abrasion This occurs through contact with abrasive surfaces, such as rough cement finishes, and is distinguished by fluffing of the surface of the rope/webbing. This occurs through normal use and causes minimal damage, but you must ensure that there is no area that receives more of this attack than others. When this occurs the result is Local Abrasion.

Local abrasion This can be caused by continual general abrasion in one place, or more commonly by passing over a relatively sharp edge while under tension. The damage ranges from concentrated fluffing, which requires careful monitoring in the future, to actual destruction of the integrity of the rope/webbing. In the case of rope this is indicated by penetration of the sheath to expose the core. Whenever this damage is seen, or even suspected, the rope/webbing **must be retired immediately.**

Either general or local abrasion may affect the stitching on harnesses, so it is important to pay special attention to those areas.

Chemical attack While very hardy, both rope and webbing are susceptible to attack by a range of harsh chemicals – in particular solvents, acids (batteries), oxidising agents and petroleum products. It is advisable to avoid contact with any chemical. Chemical attack is indicated by discolouration and local softening of rope/webbing. In extreme cases the surface fibres can be rubbed off as powder.

Heat Rope and webbing affected by excessive heat – such as from soldering, welding, etc – becomes brown and brittle. In extreme cases it will break when flexed, or may even burn through. **Any heat damage greatly reduces the strength of the fibres.**

Sun Whilst stabilised against ultra violet radiation, rope and webbing will gradually weaken and discolour if left in the sun for an extended period. Normal day-to-day use will not quickly result in damage, and annual servicing by the supplier will pick up any problems.

9.8.5.4 Damage to rope and webbing – what to do

Cuts, nicks, burns, chemical degradation, reduction in width or thickness, or severe damage to weave pattern must be treated seriously. It must be checked by the suppliers before being used again. Most often it will need to be replaced.

Whenever damage is suspected – stop using the equipment.

It is your life that you risk. Always err on the side of caution.

9.8.5.5 Care of rope and webbing

When in use, excess lengths of rope should be stored so as to avoid excessive contact with dirt, etc. When setting the system up, avoid placing rope or webbing over sharp edges or obvious wear points, or protect the rope/webbing from those situations. When not in use, all equipment must be stored in the barrel to prevent damage from tools, chemicals and sunlight.

To **clean** rope or webbing, first wipe off excess dirt, mud, dust, etc with a damp sponge. Next use a mild solution of household detergent in water and lather the rope, webbing or harness. Finish by rinsing with fresh water and drying as much as possible with a clean cloth.

For heavy dirt or grease deposits it may be necessary to use a stronger detergent solution and a scrubbing brush. Again, finish by rinsing and drying.

9.8.6 Metal fittings on safety equipment

The metal fittings in the system include buckles and D-rings on the harness, snaphooks on the lanyard, karabiners and the specific system fittings. Each fitting is extremely strong and resistant to damage. Damage is most likely to occur through hard knocks on sharp or solid objects, through corrosion, and through wear of moving parts from abrasive particles.

9.8.6.1 Damage to metal fittings – what to look for/what to do

Structural damage Burrs, sharp edges, distortion and cracks indicate damage. If minor, burrs are little problem. Sharp edges, however, can damage rope and webbing, whilst distortion, and particularly cracks, indicate major damage.

Corrosion All metal fittings are corrosion resistant, but will become more susceptible with age. If stored and maintained well there will be little problem. Any unit that is severely corroded must be retired.

Wear of moving parts Check snap gates, screw locks and return springs for ease of movement and to ensure no sideways play. If movement is restricted the unit should be serviced. Do not lubricate.

Whenever damage is suspected – stop using the equipment.

It is your life that you risk. Always err on the side of caution.

Pitched roof safety systems – safety rules

1. One person only per safety system.
2. Always anchor both ends of the system.
3. Non-fixed anchor systems should weigh 600kg minimum.
4. Always conduct a final check of complete system.
5. If you suspect damage to equipment – don’t use it!

9.8.6.2 Typical warnings for water heaters

IMPORTANT

Scalding occurs at 50°C. This appliance is capable of providing hot water at above this temperature

All installers must advise users and customers of the potential hazard of scalding in accordance with the relevant Australian Standards including AS/NZS 3500.4

This appliance is not suitable for Pool or Spa Heating

This is a water heating apparatus only and the final fitness of water delivered is dependent upon the quality of water supplied to this system.

This water heater is designed for the supply of hot water to a domestic household premises which has been constructed to the appropriate local and national codes and regulations.

All work must be carried out in accordance with Local, State and Federal Occupational Safety, Health and Welfare Regulations, in particular the requirements for safety whilst manufacturing, working at heights and on roofs.

Installers must be completely trained in:

1. Height Hazard Assessment

2. Working at Height Procedures

3. Assessment/Use/Wearing of correct height safety equipment (harnesses etc.)

4. All other relevant safety factors specific to the work to be all to suitable Occupational, Health and Safety Regulations/Codes.

WARNING

Where straps, frames etc are secured to roof timbers all fittings must be of an appropriate type to suit the type of timber. Inadequate or inappropriate fixings may result in straps becoming unsecured and the installation of the solar hot water system becoming unsafe.

9.9 Solar water heater manufacturers and distributors

9.9.1 Australian suppliers

Company	**Web site**	**Telephone**
Apricus Australia	www.apricus-solar.com.au	1300 730 165
Aquamax	www.aquamax.com.au	03 9556 5555 1800 676 000
Chromagen	www.chromagen.com.au	1300 367 565
Conergy	www.conergy.com.au	1300 551 303
Dux Hot Water	www.dux.com.au	1300 365 115
Earth Two Solar	www.earthtwosolar.com.au	03 9763 6311
EcoSmart Hot Water	www.ecosmart.com.au	133 326 (133 eco)
Edwards	www.edwards.com.au	08 9351 4600
Endless Solar	www.endless-solar.com.au	1300 730 707
Entrend Australia Pty Ltd	www.solarlord.com.au	1300 133 782
Hills Solar	www.hillssolar.com.au	1300 363 385
Linuo Australia		03 9462 1427
My Solar		08 9261 1823
Quantum Energy Technologies Pty Ltd	www.quantum-energy.com.au/	02 9699 7444 1800 644 705
Rheem	www.rheem.com.au	132 552
Rinnai	www.rinnai.com.au	1300 360 343
Solahart	www.solahart.com.au	02 9684 9100
Solar-Mio	www.metaldynamics.com.au/metaldynamics.htm	02 6040 6666
Solco	www.solco.com.au	1800 454 161
Stiebel Eltron	www.stiebel.com.au	1800 153 351
Sunplus CPC Solar	www.sunpluscpc.com.au	1300 653 872

9.9.2 New Zealand suppliers

A list of New Zealand suppliers and their approved Installers is available on the New Zealand Solar Industries Association website (www.solarindustries.org.nz).

9.10 Credits – photos, diagrams, tables

Sources for photographs, figures and tables are acknowledged at relevant locations throughout the book. Particular thanks to:

Project participants

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Jenniy Gregory

Peter Rorke, Peter Cruttenden

Solar Water Heater manufacturers

Chromagen

Conergy

Dux

Edwards

Endless Solar (Hills Solar)

Quantum

Rheem

Rinnai

Solahart

Solco

Stiebel Eltron

Thermocell Ltd

Other companies

Anoguard, Green Bank Australia, Reliance Manufacturing Company (RMC), Solar-Mio

Organisations

Plumbing Industry Commission (Victoria)

Solar Industries Association New Zealand

Work done by the former Solar Energy Industries Association of Australia (now amalgamated into the Business Council for Sustainable Energy), especially Andrew Blair, Ray Prowse and the late Ross Horman, is gratefully acknowledged.

9.11 Special tools

There are probably few special tools that are required for the installation of a solar hot water system, that are not used for general plumbing.

Drum and hose

One useful piece of gear is a drum with a tap and hose for the transfer of anti-freeze into the collectors of a heat exchange solar water heater.

Charging the collectors and jacketed tank with anti-freeze solution

In this photo the hose and the drum are shown but there is no tap which is a useful addition, but not essential.

The drum allows a mixing of the anti-freeze concentrate and water.

The anti-freeze solution is fed in through the hose connected to the bottom of the collector.

A ‘pump bucket’ is another option for this task.

Figure 9.11.1 – Charging the collectors and jacketed tank with anti-freeze solution

Spanners

Some brands of collectors are connected by screw connectors and spanners with wide jaws do not fit into the space. Either narrow jaw shifting spanners or fixed jaw spanners may be required.

Never use ‘Stilsons’, ‘Footprints’, or other pipe wrenches for tightening brass fittings. The jaws chew into and damage the brass. The jaws also have the effect of closing when pressure is put on them and often this results in the nut to which they are applied being forced ‘out of round’.

Oil can

A drop of oil on threads that are being tightened (compression or conetight fittings), or copper tube in a compression fitting, will result in them being able to be tightened without binding and twisting the tube as it is tightened.

A drop of oil on the moving parts of tools such as shifting spanners, stilsons, pliers, tube cutters, etc. will keep them easier to use and reduce the rusting that would otherwise occur.

Tools for measuring orientation and collector inclination

Every solar system installer should have the tool shown in Figure A1.3.3 in Annex 1.3 to properly assess the site (or roof) orientation and pitch angle to see if these provide adequate solar radiation access. The combination tool shown includes a compass for measuring orientation from magnetic north and a clinometer (also called an inclinometer) for measuring angles from the vertical. These instruments are also useful for assessing whether or not shading of the collectors is likely to occur due to nearby trees or buildings. This is dealt with in **Annex 1.3** of the book.