CHAPTER 4

Boost Heating

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4. BOOST HEATING

4.1 The need for boost heating

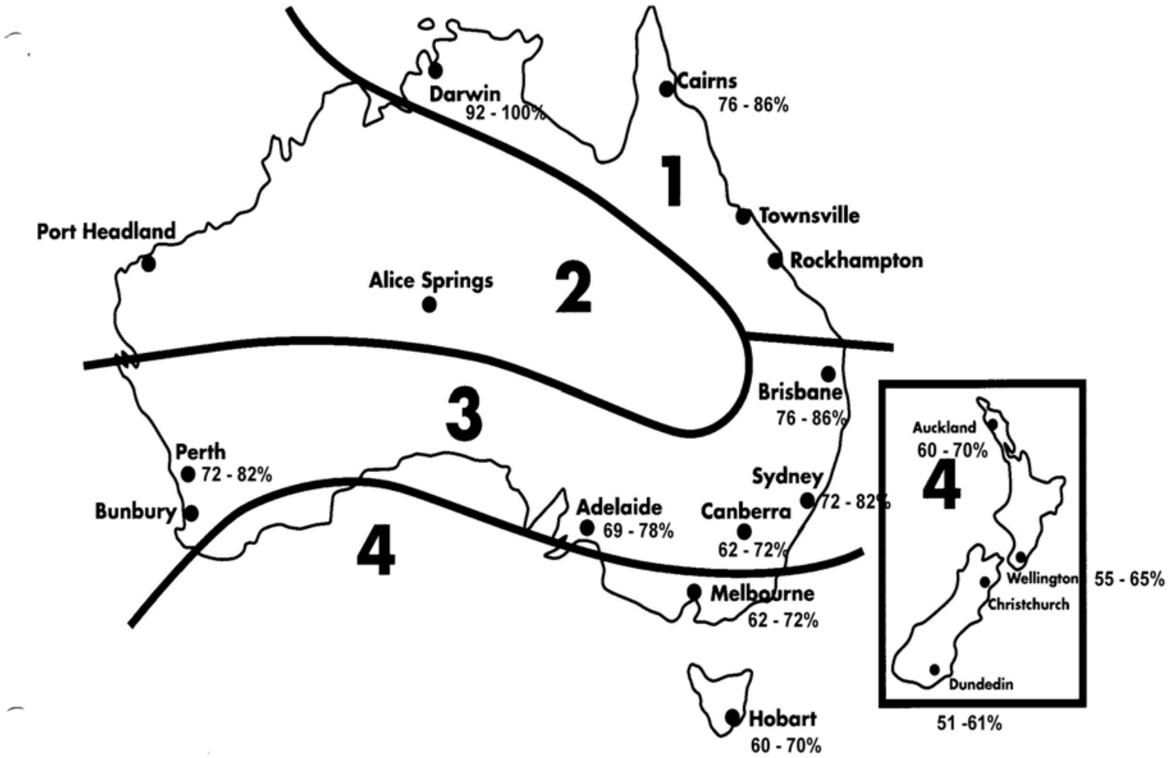
What this section is about

This section will provide you with an understanding of:

- the necessity for boost heating
- the alternative methods of boost heating commonly used
- booster control methods
- the methods to optimise the solar contribution and minimise boosting requirements.

The need for boost heating

Figure 4.1.1 shows the anticipated solar contribution to water heating for a well-designed system in various locations across Australia and New Zealand. This assumes a hot water demand of around 200 litres per day and a booster temperature set at 60ºC.



Map: Courtesy Solahart

Figure 4.1.1 – Anticipated solar contribution for various Australian and New Zealand cities using modified figures from Australian Standard AS NZS 3500

As can be seen from this figure, the standard recommended size of solar water heater will not provide all the energy requirements to produce hot water year-round. Note that in Victoria, where solar water heaters are one option for new homes to comply with five-star regulations, zone 4 is treated as covering all of Victoria. For Renewable Energy Certificate allocations, the above zones apply.

The proportion that the solar collectors supply depends on:

- the quantity and temperature of hot water required
- climatic conditions of irradiation, air temperature and cold water temperature
- the efficiency of the solar collector and storage tank
- the efficiency of the booster
- how efficiently the system is managed by the users.

The most likely period for boosting is during very cloudy days or those with cloud and rain, but this depends on geographic location and hot water demand. Table 4.1 shows the temperatures achieved in the storage tank on an average June day in Brisbane and Melbourne due to the solar energy alone and the solar plus booster input (set to a maximum of 65ºC). In Brisbane, the solar input alone achieves 61.6ºC so little boosting is required. This is due to the higher solar input and higher cold water temperature, and lower hot water demand. By contrast, in Melbourne the solar achieves 32.9ºC, so the booster has to raise the water temperature by an additional 30ºC. This is because the solar input is much lower, the cold water temperature is lower and the demand for hot water is higher.

Table 4.1 – Solar input and water temperature rise in storage tank (boost energy and solar input estimated from SCF program)

	Brisbane	**Melbourne**	
Solar input	33.3	20	MJ/day
Booster input	2.4	27	MJ/day
Volume of water	167.0	200	Litres/day
Cold water temp.	14.0	9	deg C
Tank water temp.	61.6	32.9	deg C – due to solar only
Tank water temp.	65.0	65.1	deg C – due to solar + booster

Often, users of solar systems accept that the booster does not need to heat water to 60ºC or greater every time and regulate boosting accordingly. For example, most people are comfortable showering when the water temperature is in the range 40ºC to 45ºC, so boosting will be necessary only to enable comfortable showers. For most other applications, lower temperatures are often acceptable, provided that the temperature is not too low, too often. **Water should be heated to at least 60ºC if it is to be stored.**

This precaution must be taken so that **legionnaire's disease** does not develop in the stagnant parts of the tank. Although this is an exceedingly rare occurrence in water heating systems, legionnaire's may develop and multiply if the water temperature is kept below 50ºC for extended periods. Hence, it is advisable to use a booster to raise the temperature above 60ºC regularly (e.g. at least once every 24 hours) to keep the system safe.

The amount of hot water provided by the booster is generally not the full capacity of the storage tank. This keeps the solar contribution to the optimum level, and the amount of fuel consumed by the booster and running cost to a minimum.

Time of use of hot water, lifestyle and boost heating

As the sun is only available during the day, system users are advised by solar manufacturers to have their showers, wash their clothes etc first thing in the morning. This allows the sun to reheat the replacement cold water that has entered the tank before the electrical booster comes on at night. By comparison, heavy usage of hot water in the evening means that the first heat source to be activated as the water temperature in the tank falls is the electric element or gas boost heater. However, this may not fit all people's preferred showering time. A typical pattern of hot water demand is shown in Figure 4.1.2 (below). As can be seen from this graph, more hot water is used in the evening for showers, as well as kitchen and laundry needs.

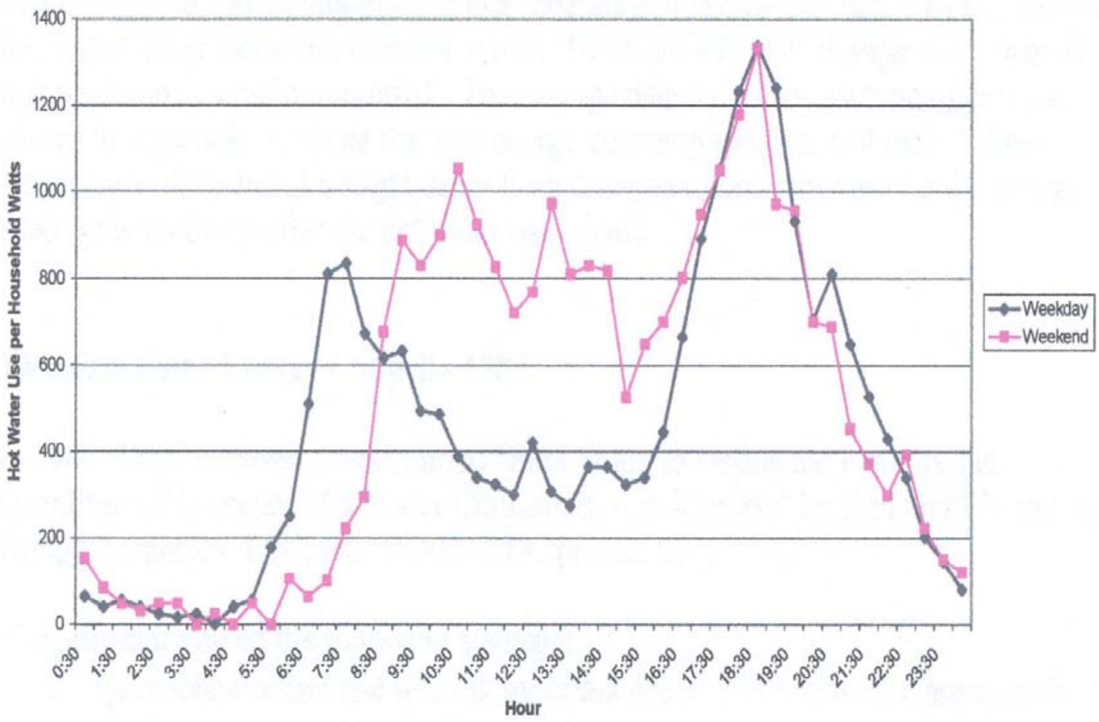


Figure 4.1.2 – Hot water demand in Victorian homes

In warmer climates where little boosting is required or with systems that are well managed by the users, this is not a problem as users who shower in the evening will leave the booster off or manually control the boosting time to a minimum before showering. This means the solar collectors can do plenty of heating the next day as the water in the tank has cooled.

However, some people don't wish to manually limit boosting time as they find it inconvenient, even though this can be done with a simple timer. Merely letting the thermostatic control of the booster operate does not optimise the solar contribution. This problem has been addressed with the smarter boost controllers now available and these are described in detail below.

Types of boost heating options

A decision needs to be made regarding the type of booster that is used. Not all the options will be available, so often the choice will be made for you. If available the options are:

- electric – off-peak or day rate tariffs
- gas
- solid fuel heater (vented systems only).

Electric – off-peak or controlled tariffs

Where off-peak tariffs are available, an electric heating element is supplied by the electricity supply company during set off-peak hours – typically for about eight or nine hours. For example, these periods can be 9pm to 6am (SE Queensland) or 11pm to 7am (Victoria). In some states, controlled tariffs are available that offer more hours per day but at a higher cost; e.g. for up to 18 hours per day but at 50% higher cost. Electric element sizes commonly used are shown in Figure 4.1.3.

1.8kW at 240 volts and 7.5 amps	2.4kW at 240 volts and 10 amps
3.6kW at 240 volts and 15 amps	4.8kW at 240 volts and 20 amps

Figure 4.1.3 – Common electric boost element sizes

The supply authorities have minimum requirements for both the wattage and the size of the hot water tank to qualify for off-peak electricity rates. These requirements vary from state to state, but typically require a minimum tank of 250 litres capacity and a 2.4kW element. The standard size of solar systems for an average home of three people and 170 to 200 litres of hot water per day is a 300 litre tank, a 2.4kW element and two or three collectors, depending on climate and system orientation. This additional storage capacity of one half-day to a full day's extra capacity above the daily demand gives some reserve capacity to carry over from sunny days to cloudy or rainy days. This gives the solar collectors the opportunity to make their maximum contribution.

One limitation of using the off-peak tariff is that the booster element will not able to be turned on during the day if more hot water is required; i.e. at times of high water usage and low solar radiation. In some electricity supply areas, the off-peak tariff is available for hot water boosters for some systems during non-off-peak times.

The booster used in many solar water heating tanks is an immersion type of element that has a ‘sickle’ or curved shape. This can be positioned in the storage tank to provide varying amounts of boosted hot water. For example, if off-peak tariffs are used, particularly in colder climates, then the sickle is curved down to increase the volume of boosted water to about 85%. Some manufacturers alter the orientation of the ‘sickle’ element or use straight elements in mild to warm climates to alter the amount of boost heating. This restricts boost heating to the top 50% of the tank.

Off-peak boosting is relatively cheap – typically 5.5 to 7.5 cents per kWh (2005 costs) plus a minimum monthly charge. However, in warmer regions where solar contributions of 85% or greater are easily achievable, then off-peak tariffs can be no cheaper than day rate because so little electricity is being used and the off-peak tariff will impose a minimum charge per month or quarter (three-month period) that must be paid regardless of how little electricity is used. For example, in Brisbane where a typical solar system gives a solar fraction of 86%, the minimum charge for off-peak would be paid for eight months and the total yearly boosting cost would be $47. By comparison, if day rate electric tariff was used, the cost would be only $53 (based on 2005 costs).

Electric – day rate or continuous supply (storage)

Day rate boosting implies that the booster is available at all times of the day and will be charged at day rate tariffs. This is much higher, often in the range of 14 to 15 cents per unit of electricity (i.e. per kilowatt hour). This means that the client should virtually never run out of hot water, but they will pay for it. The booster element will be set to come on at a predetermined, lower temperature setting to give the system a chance to recover, with input from solar radiation.

Location of the booster electric element

To avoid running out of hot water, the booster must be sufficiently far down from the top of the tank to heat all the water that is likely to be required before the booster is able to reheat the water above it. If the booster has a low electric power rating or low gas heating rating, then the amount of water it heats will need to be greater than if a higher rated heater is used.

If the water is heated with off-peak electricity, the tank must be large enough to hold an entire day's hot water above the electric element. This means the booster must be able to heat one day's hot water during the off-peak heating time. This is the reason why the storage tanks must be larger when on off-peak tariffs. This larger tank size comes with a disadvantage as it has a larger surface area and heat losses are greater. Figure 4.1.4 shows the ideal location of the electric boost element and the solar collector connections to the storage tank for different tariffs.

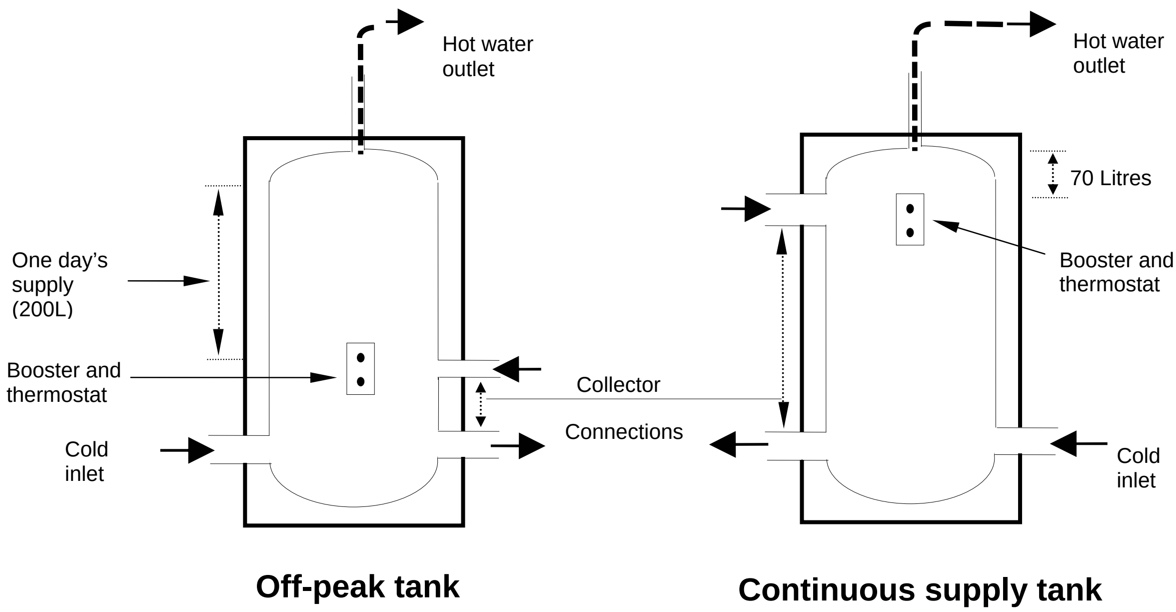


Figure 4.1.4 – Ideal location of the electric boost element and the collector connections to the storage tank for different tariffs.

Electric – day rate (instantaneous)

Another option is to use an in-line instantaneous electric heater, but this can be an expensive option. In this case, the solar heater acts as a pre-heater; there is no booster in the solar system itself. The water leaving the solar system then enters the instantaneous heater and is boosted if necessary. The advantage of this is that only the quantity of water required to be boosted will be boosted. The disadvantage is that the electricity costs 14 to 15 cents per unit (kWh).

Effect of electric boosters on the electricity grid

It should be noted that the use of any day rate (i.e. continuous supply) electric water heating may add to the peak load if it operates at peak power demand times. This increases losses of the electrical transmission system and may increase greenhouse gas emissions compared with electricity supplied during off-peak times.

Time of use electricity tariffs

Time of use tariffs are where the price per unit of electricity is charged at different rates during the day to follow the different cost of generation. Two or three different prices per unit may apply depending on how the supply company divides up the day. Typical options are to:

- charge two prices – one for peak periods and one for off-peak periods
- charge three prices – one for peak periods, one for intermediate period (called shoulder) and one for off-peak periods.

These tariffs are becoming the preferred option for electricity supply companies and governments because the full cost of electricity can be charged at any time of the day.

Metering of electricity

All electricity is metered. Day rate meters are already installed in all homes. Off-peak or time of use tariffs will require extra meters if not already on the premises. This adds an additional cost for the meter and its connection.

Natural gas or LP gas (storage)

Natural gas burns five times cleaner than black coal per unit of energy delivered and even more so than brown coal (6.4 times). Natural gas or LPG is therefore much less harmful to the environment. The gas burner can be located:

- in the storage tank, whether that is on the roof with the collectors in a close coupled system or in a conventional gas fired water storage cylinder in a pump-circulated storage system
- in-line after the solar storage tank; in this case, the solar heater acts as a pre-heater with no booster in the solar system itself.

Gas burners now use electronic ignitions to minimise gas use and thermostatic control. However, just like electric booster thermostats, the thermostat does not take any account of the type of day and will therefore switch the burner on even if there is still the whole of the solar day in which to boost the temperature using solar radiation. Smart controllers are helping to overcome this problem to maximise the solar contribution.

If natural gas is unavailable, LP gas (LPG) is another option. In particular, people living with stand-alone power supply (SPS) systems usually aim to reduce their overall electrical load as the cost of power is much higher and it makes little sense to use this expensive power for heating tasks when solar or gas can do it at lower cost. Thus hot water boosting, cooking, space heating and the back-up generator for the SPS systems can all be LP gas powered.

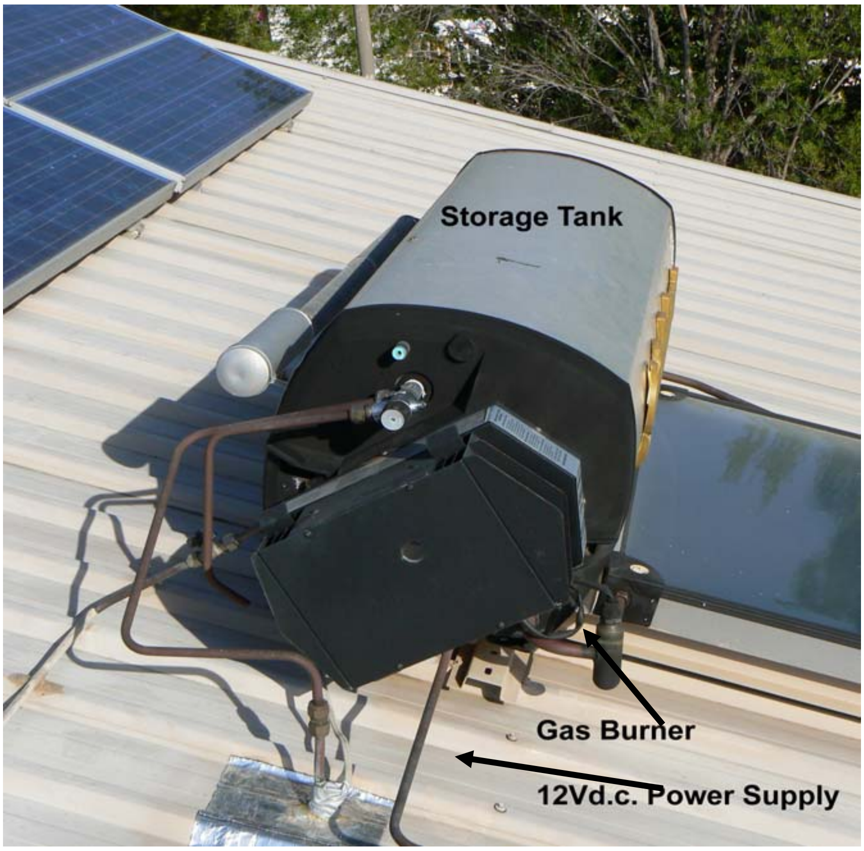


Photo: Courtesy Trevor Berrill

Figure 4.1.5 – Tank-mounted gas booster

LP gas is generally about two to three times dearer than natural gas. Under some tariff structures, the more LP gas that is used, the lower the price per litre of that gas. So, if a fossil fuel is required, a larger cylinder of LP gas, filled regularly by the gas suppliers, will probably provide the cheapest and cleanest energy supply for back-up to the solar system and other uses.

Natural gas or LP gas (instantaneous)

In instantaneous gas-boosted units, the solar system does not normally have a booster at all, but acts as a pre-heater for the gas burner. If the water entering the gas system is already at a suitable temperature, the burner will not ignite. This means that only the water needed is heated and that such a system is therefore more efficient.

Slow combustion heaters and stoves

On properties where there is access to solid fuel, slow combustion heaters can provide the required supplementary heating. In many rural areas properties have dead timber readily available on site. If timber has to be purchased at normal retail prices in urban and metropolitan areas, the cost of slow combustion boosting may be significant.

Slow combustion boosters are deemed to be uncontrolled energy sources and must be installed to the requirements of AS NZS 3500.4. An uncontrolled energy source may produce sudden surges in the pressure of the water. It must be open-vented to cater for these surges and therefore will be a low-pressure system with the header tank lower than the open vent. These requirements are shown in Figure 4.1.6.

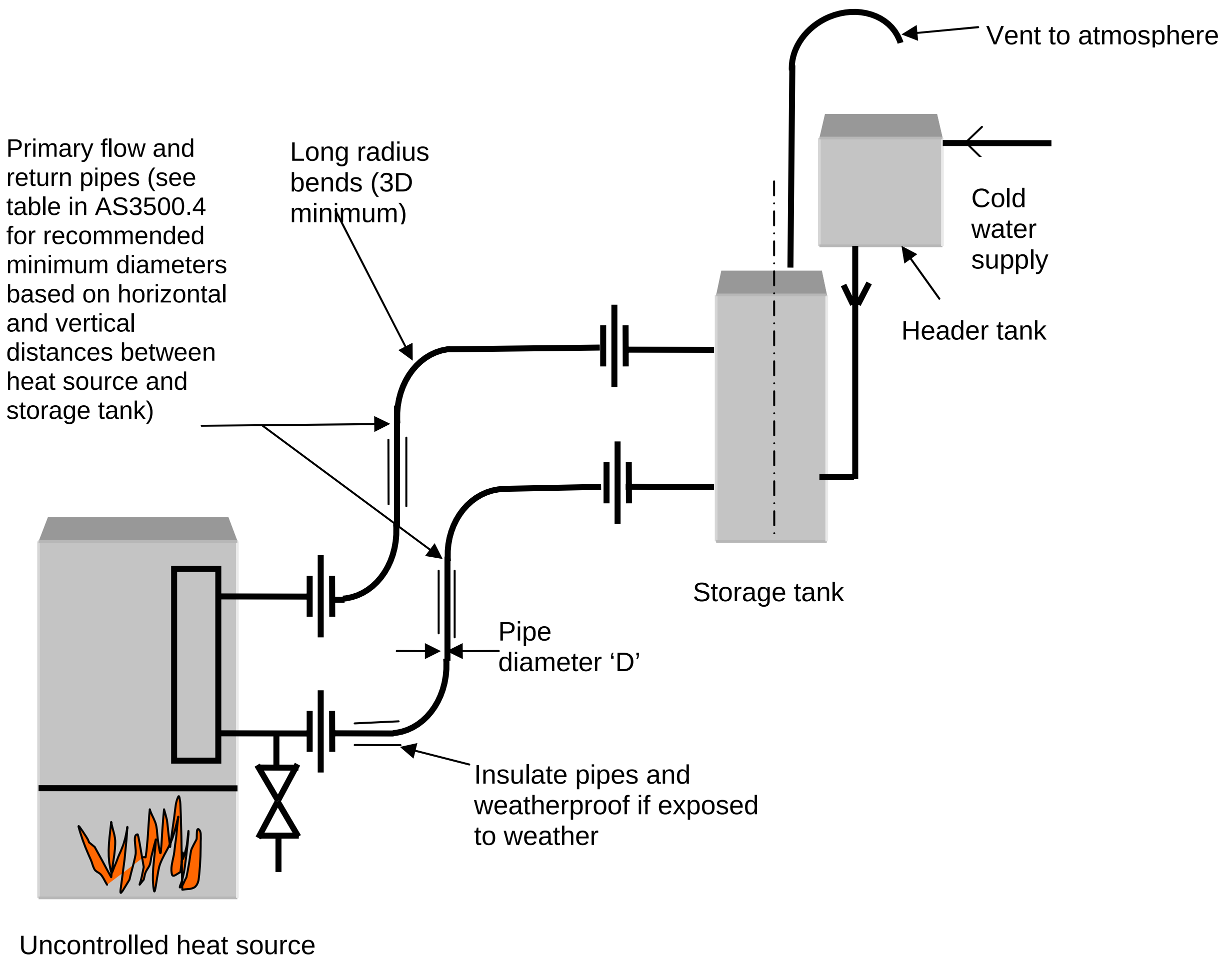


Figure 4.1.6 – Installation of slow combustion booster

Control of boosting

Boost heating can be controlled by:

- thermostat only
- thermostat plus manual or timer-based override
- smart electronically programmable controls.

Thermostats only

Thermostat only systems do not allow optimisation of the solar contribution as the thermostat may switch the booster on after hot water is used and before the solar collectors have a chance to reheat the water. Hot water passes through the collectors and little or no heat is added.

Thermostat plus manual or timer-based override

A manual override switch can be added to allow the user to turn the booster off before the water temperature in the tank above the booster reaches its preset temperature (typically 60ºC). However, this relies on the user remembering to switch off the booster.

A better solution is for the user to set the period of boosting with a timer. This allows the user to reduce or increase the boosting time according to weather conditions, expected demand in the coming hours and present tap water temperature. This system works well and users quickly get a feel for the appropriate boosting time. A manual override switch is still incorporated in this arrangement. This adds a little to the capital costs but saves on wasted boosting energy.

Smart electronically programmable controls

The ideal solution with full convenience is for an intelligent controller to:

- be programmed to only boost to preset temperatures during each hour or so of the day with the temperatures being set low or to zero during daylight hours to avoid boosting. These controllers are already available.
- learn the pattern of use of hot water in the home and to program itself using smart or ‘fuzzy’ logic. These controllers are currently under development.

An example of the first type is the ‘Solarit’ controller for pump-circulated systems. This allows the user to pre-program the temperature for each two-hour period of the day. Solahart’s ‘Optimiser’ controller can use a pre-programmed algorithm.

Key points

- All solar water heaters will require boost heating at some time unless:
  - the user accepts cold water occasionally, which might be acceptable in Darwin but not Brisbane or Melbourne
  - the system is substantially oversized – this is expensive and stresses the tank and collectors more due to more frequent overheating.
- In Australia, solar systems are generally sized to provide between 60% and 90% of the total hot water demand. This means that boost heating will be used nearly all winter in cold climates, or on very cloudy and/or rainy days in warmer climates.
- Boosting of water temperature in solar systems can be done by:
  - electricity
  - gas – natural and LPG
  - solid fuel heaters.
- Boosters can be mounted:
  - in the storage tank to heat some proportion of the tank
  - in-line after the storage tank to heat just the quantity of hot water that will be used. This is the most efficient option.
- Boosting is best controlled via timers/manual override or smart controllers to allow the solar collectors to do as much heating as possible during the day to maximise the solar contribution.

Section 4.1 questions

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

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

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.) 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?

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

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?

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?

4.2 Connection to an uncontrolled heat source

What this section is about

A normal hot water service (gas or electric) reaches a set temperature (minimum 60°C) and then the electricity or gas is shut off. Heating stops. The source of heat is controlled.

An **uncontrolled heat source** (solar, firewood, coal, etc) continues to provide heat even when the water being heated has reached a satisfactory temperature.

In this section we look at uncontrolled heat sources and how they can be used to boost the temperature of water in a solar hot water system.

By the end of this section you should have an understanding of the words:

- solid fuel
- boiler and wet back
- open vented (and what that means)
- direct and indirect heating
- heat exchanger.

Solid fuel

Solid fuel is the name given to fuels such as firewood, wood chips, paper, sawdust pellets, sugar-cane residue (bagasse), black coal, brown coal, briquettes, peat, animal manures and straw.

The main solid fuels used domestically in Australia and New Zealand are fire wood and coal.

In Australia and New Zealand solid fuel is used because it is cheaper than LP gas or electricity. Often firewood is available to householders from their own properties and the only cost is that of collecting the wood.

Photos: Andrew Blair and Philippa Noble

Figure 4.2.1 – Coal and firewood are common sources of solid fuel in New Zealand and Australia

Heaters and cookers

Solid fuel heaters and cookers may have a *boiler* (sometimes called a *wet back*) in the firebox so that the fire heats the water in the boiler.

Solid fuel cookers will provide hot water whenever the fire is alight. In the summer time the sun heats the water with solar collectors, and often the cooker is not used, because it makes the house too hot. A heater operating only in winter can heat the water at a time when the sun does not provide enough heat.

This cooker uses firewood to heat water in winter. In summer the sun heats the water through the solar collectors.

Photos: Andrew Blair

Figure 4.2.2 – Cooker providing water heating in winter

The room heater provides winter heat for the house and hot water. The pipes from the boiler in the heater are connected to the hot water storage tank through the brick wall behind the heater.

Figure 4.2.3 – Wood heater with boiler coil

The boiler in this heater is a simple single coil of 25mm diameter copper tube. Unfortunately the coil reduces the quantity of firewood that can be fitted into the firebox.

Free hot water

Many owners of heaters or cookers say that they are getting free hot water, because after all the heater or cooker would be running anyway. To suggest that the hot water is free is not quite correct. More wood or coal has to be used in a heater if it is heating water as well as the room. A cooker has to burn more fuel if it has to heat water as well as do the cooking.

Some heater owners have found that with a boiler in their heater, the room heating performance is so reduced that the heater will no longer do its job properly. Cookers on the other hand are usually designed to provide enough heat for both cooking and hot water.

Boilers

The boiler (wet back) may be a small rectangular tank made of copper, stainless steel, steel or cast iron. The cast-iron boilers are sometimes lined with vitreous enamel in order to prevent rusting. The boiler may simply be a coil of copper tube as shown in the heater on the previous page. In both cases the boiler is usually located within the firebox so that the flames lick up against it.

The boiler in this cooker (left) is located at the back of the firebox and appears as a flat metal surface. The connecting pipes are not shown as they go out through the back of the cooker.

Photos: Andrew Blair

Figure 4.2.4 – Boilers (wet backs)

This (right) is a boiler (wet back) from a room heater. The wet back is purchased as an optional extra. The cast iron section conducts heat to the water in the 25mm diameter copper tube.

Flue Jacket boiler

Another option is to use a water jacket instead of the first section of flue.

Heat going up the flue heats the water in the jacket.

These stainless steel flue jackets are placed directly on top of the heater flue spigot, and then the normal flue is inserted into the top of the jacket.

Note the hot water connecting nipples.

Figure 4.2.5 – Flue jacket boiler

Pros and cons of installing wet backs in solid fuel room heaters

At first glance the idea of installing a heater with a wet back to provide hot water in winter and solar collectors to provide summer hot water may sound a good system.

However, heaters with a boiler present manufacturers with a problem:

1. Do they make the boiler big enough to provide all the hot water required in the autumn and spring when the days are mild and the nights are not cold but cool enough that the heater is lit? At no stage is the heater burning strongly so it needs a large boiler to make enough hot water.

2. Or do they make a smaller boiler? In the middle of winter when the weather is cold the heater is burning strongly for most of the day and night, so a small boiler will produce enough hot water.

If they go for option 1 it is likely that with a large boiler the water will boil in winter. Not only is the noise of the water boiling (a loud banging sound) annoying, in time it is likely to damage the storage tank and connecting pipe work.

If they go for option 2, a small boiler, then in overcast weather in autumn and spring the boiler will not make enough hot water.

Either way the heater manufacturers are likely to have dissatisfied customers, so currently most heater manufacturers do not offer heaters with a boiler.

Boilers in heaters result in a cooler fire (because the boiler takes heat away from the fire) and cooler fires are more likely to smoke. A smoking heater is less likely to pass the rigorous testing to which all Australian heaters are subjected.

Heater tests are expensive, and if a heater has a boiler in its firebox, a separate test must be conducted. This is an expense that few heater manufacturers are prepared to pay considering that few boiler heaters would be sold.

Installation of a boiler

The connection of a solid fuel boiler to a hot water storage tank has some similarities to connecting solar collectors to a storage tank (refer to AS3500.4, section 7.3):

- The heat source must be below the storage tank so that the hot water can rise to the storage tank. This natural circulation by convection currents is called ‘thermosiphon flow’.
- It is possible to use a circulating pump if the storage tank is lower than the boiler, but provision must be made for the steam to escape if the pump fails, and a pumped system is best avoided.
- The hot flow pipe from the boiler must have an uphill gradient all the way to the storage tank so that any air bubbles (released as the water is heated) can escape into the storage tank.
- The connecting pipe work must be copper tube, not plastic.
- The storage tank must be copper (or stainless steel, though this is not usual), not plastic or vitreous-lined enamel. The enamel starts to

dissolve if the temperature of the water is too high. High temperatures also set up stresses between the expanding steel and the enamel lining.

- The whole system must be 'open-vented'. This means that the boiler must *not* be able to develop pressure. If the boiler boils, the steam generated must be able to escape into the atmosphere. This is the most important single safety requirement. PTR (pressure temperature relief) valves must not be used. Boilers must not be connected directly to mains pressure hot water storage tanks.
- There must be no valves between the boiler and the storage tank.
- When connecting a solid fuel boiler *and* a solar system to a hot water storage tank, it is advisable to use two separate pairs of nipples. This way the circulation of one system will not interfere with the other system. Never use the same pair of pipes for the stove and solar collectors up to the storage tank.
- Most domestic boilers produce about 3kW maximum; many produce less. The normal copper tube size to connect boiler and tank is 20mm diameter. If the boiler and the storage tank are a significant distance apart (perhaps 10 metres or more) then 25mm tube is used. It is best to use at least 25mm tube for solar connections. If there is very little height difference between boiler and tank a larger pipe diameter is necessary.
- The copper tube should be well insulated between the boiler and the storage tank.
- Hard drawn copper tube is preferred rather than annealed tube.
- For large boilers, larger diameter copper tube is used. The size is determined by the capacity of the boiler in kW, the vertical difference in height between the boiler and the storage tank, and the length of the pipe run. As a general rule, however, for 3–10kW boilers use 25mm tube, 10–20 kW use 32mm tube, and 20kW or over, use 40mm tube. These figures assume a boiler at floor level, a storage tank in the ceiling and a distance of no more than 10 metres between the boiler and the tank. Consult the boiler manufacturer or supplier for recommended pipe sizing.
- A valve to prevent boiling hot water reaching the bathroom hot water outlets is essential. A valve that mixes cold water with the hot water may have various names: a tempering valve, a thermal mixing valve or a temperature modulating valve. In order that the valve operates properly, the hot and cold pressure must be equal.
- Any piping that is not protected by a tempering valve should be copper tube, not plastic pipe.

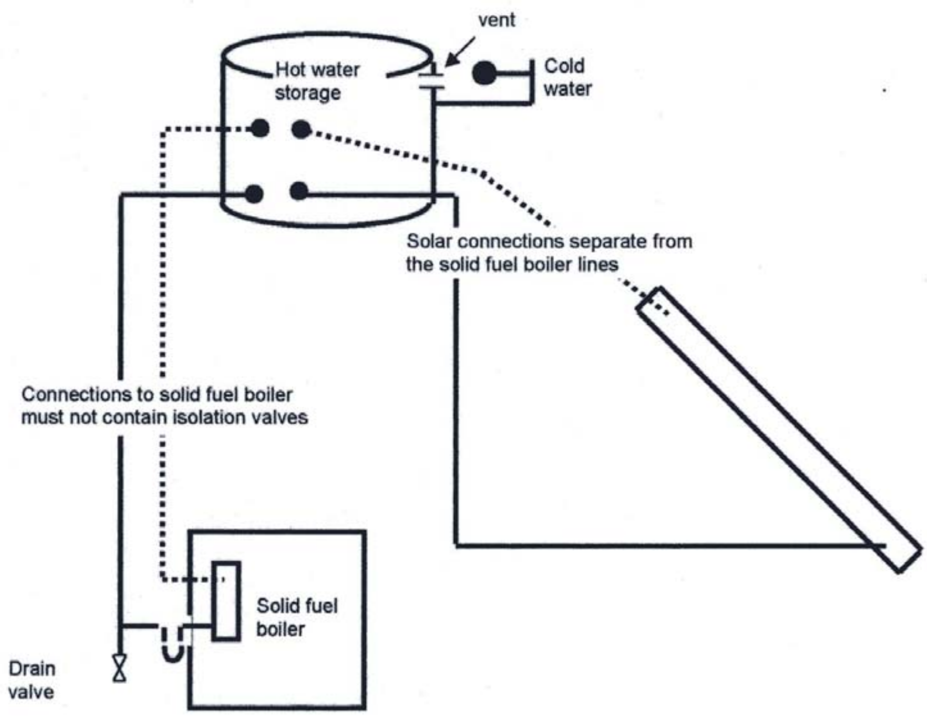


Figure 4.2.6 – Typical connection for solid fuel and solar system

This is a typical connection that includes a solid fuel boiler and solar collectors connected to a gravity feed (in ceiling) copper storage tank. Notice that the solar and boiler are connected at the tank independently of each other.

Figure 4.1.6 (earlier in chapter) shows how a small boiler such as in a heater or cooker is connected to a hot water storage tank.

AS NZS 3500.4 (Section 7.3) includes a chart that shows recommended pipe diameters based on two distances (X and Y). This shows that the further the storage tank is:

- horizontally (X) from the boiler, the greater the diameter of the connecting pipe needs to be
- vertical (Y) above the boiler, the smaller the diameter of the connecting copper tube can be. It does not matter if the connecting pipes are larger diameter than specified, but they must not be smaller.

The same applies with the connection of solar collectors to a remote storage tank. With greater horizontal distance (X), pipe diameters must increase. With greater vertical distance (Y), the smaller the diameter can be.

Circulation is achieved by thermosiphon flow (natural convection currents) due to cold water being denser than hot water. The cold water falls and the hot water rises. The greater the temperature difference, the greater the rate of circulation. Pipe friction slows the rate of flow of water through the connecting copper tube, and the longer the tube, the greater the pipe friction.

Pipe sizes recommended to connect a boiler to a storage tank are found in AS NZS 3500.4:

- The greater the distance between the boiler and the storage tank, the greater the pipe diameter required.
- The greater the heat output of the boiler the greater the pipe diameter required.
- The smaller the vertical distance between the boiler and the storage tank the greater the pipe diameter.

Mains pressure hot water systems and an uncontrolled heat source

It is commonly said, ‘You cannot have a mains pressure water storage and a solid fuel boiler.’ This is only partly correct. It would be better to say, ‘You must not connect a solid fuel boiler *directly* to a storage tank under mains pressure.’

Most copper hot water tanks are gravity fed. A small supply tank is attached to the side of the storage tank. The tank must be higher than all of the hot water outlets, including the shower, so that hot water flows downhill under gravity to each outlet.

An alternative is a 7.5 metre header tank. This is a copper tank with a separate supply tank able to be set up to 7.5 metres above the storage tank. These are fairly rare in Australia now but are commonly used in New Zealand. In this case, a vent pipe must run from the top of the storage tank above the supply ‘head tank’. If the system boils steam can still escape from the vent pipe.

Storage tank with mains pressure coil

The most common way to provide mains pressure hot water with a boiler connected to the storage tank is to have a mains pressure coil in the tank.

A coil of copper tube inside the tank is surrounded by the hot water in the tank. Cold water enters the bottom of the coil and is heated by the surrounding water as it passes through the coil. The pressure within the coil can be ‘mains pressure’, which means that the hot water can be delivered to outlets above the storage tank.

The mains pressure coil has disadvantages:

- If the water passes through the coil too quickly it will not be adequately heated. A maximum flow rate of about 12 to 15 litres/minute is a common recommendation. It is usual to install a valve to restrict the rate of flow on the cold water supply to the coil.
- The water coming out of the coil will be cooler than the water in the tank once it has started to flow. The temperature difference between the water in the tank and the water coming out of the coil may be 10ºC or 15ºC; but it does depend on how fast the water flows through the coil.
- As hot water is drawn off, the temperature of the water being delivered slowly falls as heat is taken from the water in the tank.
- It is best to use an over-sized tank to provide for a greater store of hot water. Mains pressure coils are well suited to a constant source of heat such as a solid fuel boiler.

These techniques are not particularly common, but they demonstrate that it is possible to have a supply of high-pressure hot water while still retaining an open-vented boiler water system. It is common to refer to these systems as *mains pressure* hot water systems. In each case, the heat exchanger separates the waters which are at two different pressures.

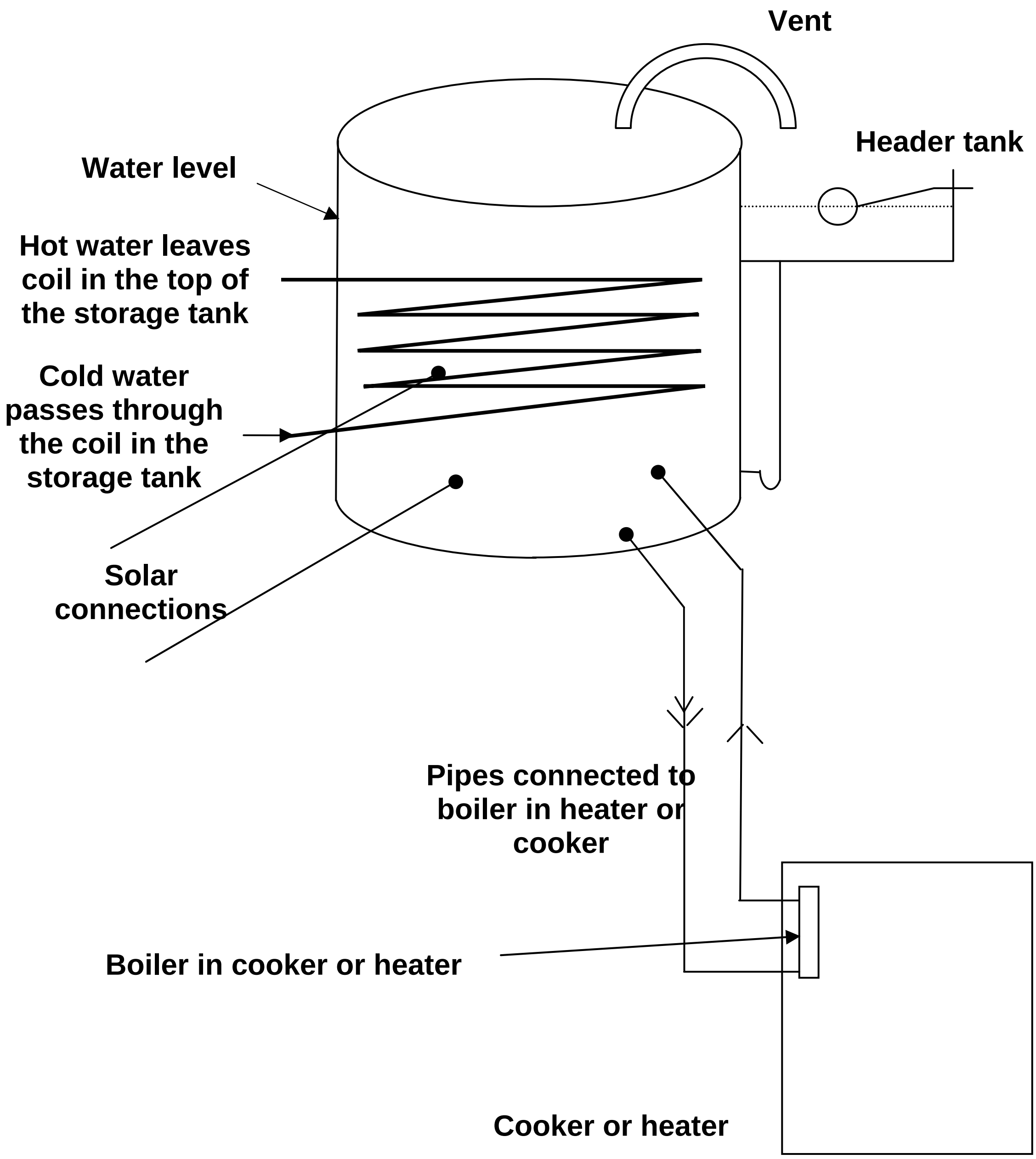


Figure 4.2.7 – Heat exchanger using copper tube coil

The heat exchanger in this system is a coil of copper tube (sometimes called a calorifier coil). It is located in the top of the hot water storage tank. It is heated by the hot water surrounding it. Cold water under high pressure passes through the coil and is heated by the hot water surrounding the coil, so that it comes out hot. If the water passes through too quickly, it may not have enough time to absorb enough heat to be at a satisfactory temperature (12 litres/minute is a common flow rate for a domestic system). The vent allows steam to escape if the boiler heats the water to 100ºC. This system has the disadvantage of heating the water as it is used. The rate of heating is limited by the rate of heat transfer, from the water in the tank, to the water in the coil of pipe.

Photo: Andrew Blair

Figure 4.2.8 – Mains pressure coils in the Rinnai Beasley factory in Adelaide

The coils are installed inside the copper tanks in the background of the photograph, before the copper tops and bottoms are fitted to the tanks. Mains pressure coils are just one type of 'heat exchanger'. Heat is exchanged (transferred) through the wall of the copper tube.

Notice the solar and boiler connecting nipples attached to the side of the copper tanks.

Heat exchangers

Other combinations involve the use of a heat exchanger set within or outside a mains pressure tank. The heat from the open-vented water from the boiler is conducted via the heat exchanger into the mains pressure water supply. This is a more satisfactory supply than the mains pressure coil within the tank as it allows hot water to be drawn off at a faster rate and then reheated over an extended period. These combinations are not common.

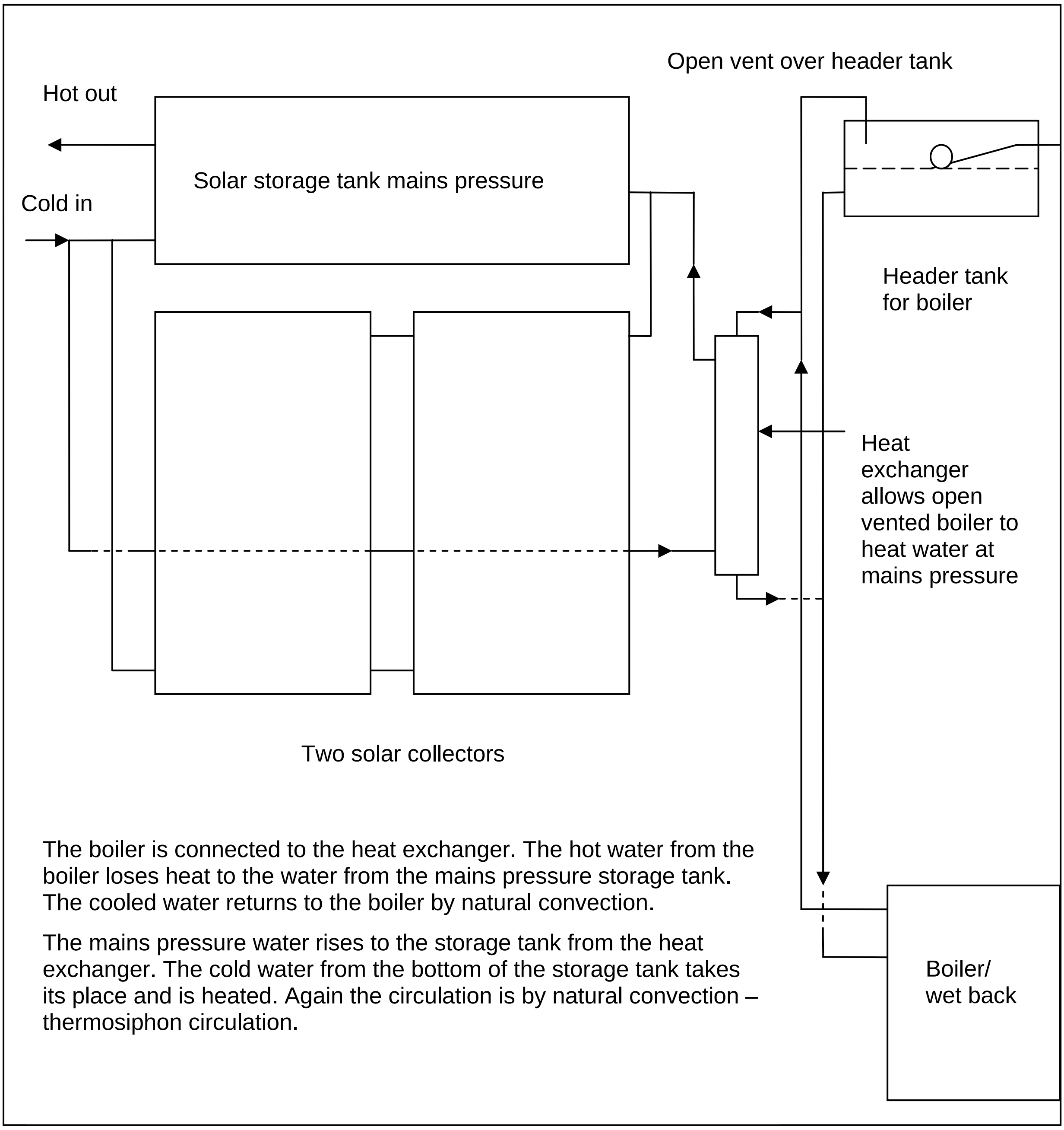


Figure 4.2.9 – Boiler connection to close coupled solar water heater

This shows how a boiler is connected to a close coupled, solar water heater using a heat exchanger to separate the water at two different pressures. It also permits water in the boiler to have additives (such as corrosion inhibitors) in the water. This is important if the boiler is steel or cast iron. A simple but perfectly adequate heat exchanger can be made from a two-metre length of 40mm copper tube with a 25mm length running through the centre. The outside is well insulated.

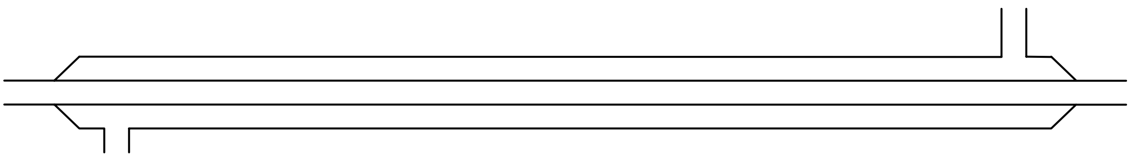


Figure 4.2.10 – Heat exchanger constructed from 40mm and 25mm tube

The heat exchanger to conduct more heat can be made using a 100mm diameter copper tube surrounded by insulation. Inside the large diameter tube is a series of smaller tubes carrying one lot of water and surrounded by a different lot of water. Heat is conducted between the two lots of water through the wall of the smaller tube. Unlike the simpler two pipe system, this unit cannot be made from standard pipe fittings. The length of the tube is determined by how much heat is to be transferred.

Water surrounding the thin 12mm tubes is heated by hot water passing down the inside of the thin tubes.

If the heat exchanger is working only by convection currents (thermosiphon flow), hot water will enter the central connection, pass through the tubes losing heat as it goes, coming out the bottom central connection. The water being heated enters the bottom side connection and leaves after being heated through the top side connection.

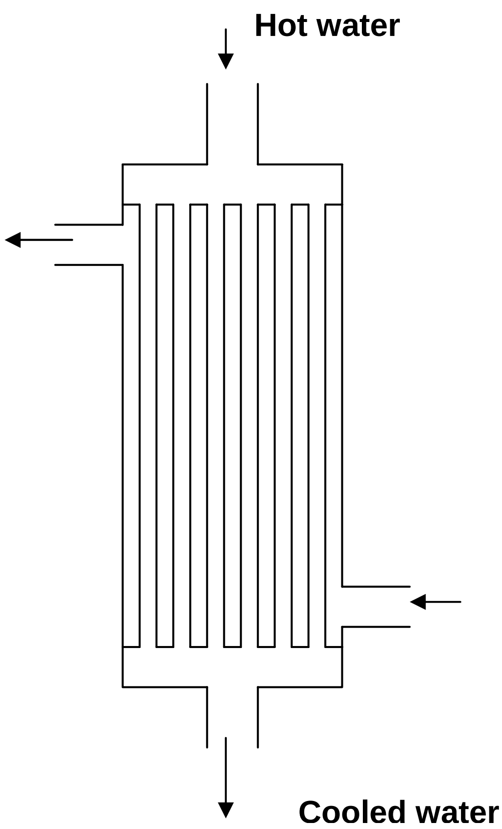


Figure 4.2.11 – Heat exchanger to conduct more heat

In Figure 4.2.12 (below), the heat exchanger is in the ceiling space and the (20mm) hot pipe from it comes up through a roof penetration and into the hot line (25mm) that connects the solar collector to the storage tank.

This particular unit has anti-freeze fluid in the collectors and surrounding the storage tank, so in fact there are two heat exchangers, the second being the jacket around the hot water storage tank.

Figure 4.2.12 – Roof penetration for heat exchanger

Key points

Boost heating can be done using solid fuels such as wood, bagasse, coal or briquette. Heating using these fuels is known as an 'uncontrolled' heat source. This sort of boost heating is normally used only with vented, low pressure systems, since the heat source can continue to provide heat even after the water has reached its set temperature.

Uncontrolled heat sources can include:

- Solid fuel heaters and cookers, often using a boiler coil
- Boilers, which might be a small rectangular tank made of copper
- Flue jacket boilers.

Water heating from solid fuels is not free, since it will decrease the amount of heat available for space heating.

Although many solid fuel boosted solar water heaters are vented, mains pressure hot water can be provided by running mains pressure water through a coil in the hot water tank, or using a heat exchanger within or outside a mains pressure tank.

Section 4.2 questions

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

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

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

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?

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

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

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?

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

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?

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

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

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