Vacuum Tube Solar Panels Information Manual

While we run courses on designing and installing your own solar system, doing this is not beyond the scope of most competent DIY enthusiasts and plumbers. This manual assumes that you are a plumber or have plumbing experience. You will find useful information here to help you design and install a system and to specify the equipment you want to use.

If you don't understand any aspect of this document, please email us – it is essential that solar panels be fitted properly. Like a solid fuel range, they produce heat all of the time, regardless of whether your pump is working and for that reason, certain safety considerations must be properly understood.

WHAT CAN YOU USE SOLAR PANELS FOR?

Domestic Hot Water - If your house is well insulated, you will not be using your central heating much between March and October. During this time, your hot water either comes from an electric immersion or from running the heating system just to heat hot water. Both of these are very inefficient.

A solar panel excels at providing hot water during this time of the year when your hot water would otherwise be very expensive. During the winter, it will pre-heat your water – often to 35 or 40 degrees – reducing the work your heating system will have to do, but the main financial gains come in the summer months.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
kWh/m2 day	0.56	1.07	1.97	3.32	4.40	4.30	4.30	3.40	2.69	1.43	0.77	0.43
30 tube panel	0.79	1.50	2.76	4.66	6.17	6.03	6.03	4.77	3.77	2.00	1.08	0.60

Space Heating? - We generally don't recommend solar panels for space heating – in a well insulated house they work best when you need them least. However, if you have a system with a large buffer tank (such as a wood gasifying boiler) then a solar panel can dump surplus heat into this buffer tank to provide additional heat at night.

Swimming Pools – Solar panels are an excellent source of heat for swimming pools as they are extremely efficient at raising water temperatures to 30 / 35 degrees. Usually a large array of panels can be used to heat domestic hot water first, and then diverted to put their surplus heat into a swimming pool or hot tub. If chlorine is used in the pool, a stainless steel heat ex-changer would be needed. A 20 tube panel will heat between 7m2 and 10m^2 of pool space, though usually a system will be required to provide domestic hot water first, and then heat a pool.

B&Bs – Unlike with space heating, for B&Bs solar panels work best when you need them most. A large array will provide lots of hot water during the summer and will continue to provide reasonable amounts of hot water during the autumn and spring when occupancy rates are falling. For B&Bs we recommend a series of pre-heat cylinders daisy-chained so that a small amount of useable hot water is available at the fringes of the season, while large amounts of hot water can be obtained in the height of the summer.

B&B system Kinsale Co. Cork

Designing Your System

Size of your domestic hot water cylinder

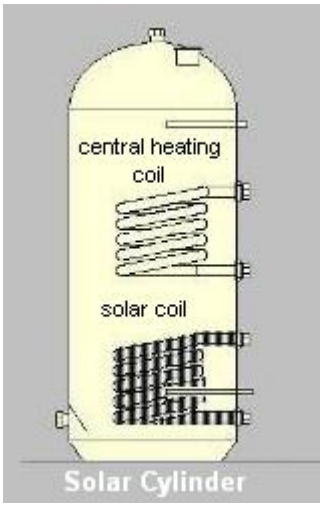
There is a tendency for solar companies to supply standard kits. While we can do this, a properly designed system tailored to your own needs will work much better.

The size of solar panel you require will be determined by the size of your cylinder and your daily water requirements. Many solar companies love to sell a huge system but a smaller cylinder and small panel will provide a quicker return on investment, and some small households get on fine with a modest system based on a 135L solar cylinder and a 20 tube panel. This panel would cost €750 incl. VAT (and attract a grant of €510).

The standard small cylinder in most houses is about 120L. However solar systems normally need a larger cylinder. When you fill the bath in the evening, the cylinder quickly gets re-heated by either a boiler or an electric immersion. A solar system will only heat your cylinder once - during the daytime. For this reason, a solar system will need a larger cylinder which can meet all your daily needs. If you regularly need two baths a night and use a lot of hot water, get a larger cylinder, and a larger panel to match. However, we don't recommend buying a huge system for the odd occasion when you need two or three baths. Switching on the immersion heater occasionally is not a mortal sin…

Do you need to change your cylinder?

If you have a small cylinder with an old-fashioned lagging jacket tied onto it, you almost certainly do. Insulation is essential in a solar system because hot water will need to be stored from one day to the next. If you have a large enough cylinder with good insulation, you can usually fit your solar panel in such a way that it shares a coil with your central heating system. There will be some loss of efficiency because the coil is not the right type for a solar panel.



Ideally a solar cylinder is tall and thin, and has two coils inside it; one high surface-area coil at the bottom of the cylinder connected to the solar panel and one regular coil in the centre of the cylinder connected to whatever central heating system you have.

In this way, the solar panel will heat the whole cylinder during the summer. In the winter it will pre-heat water at the bottom of the cylinder to perhaps 30 to 40 degrees, and this water will then be topped up using your central heating system.

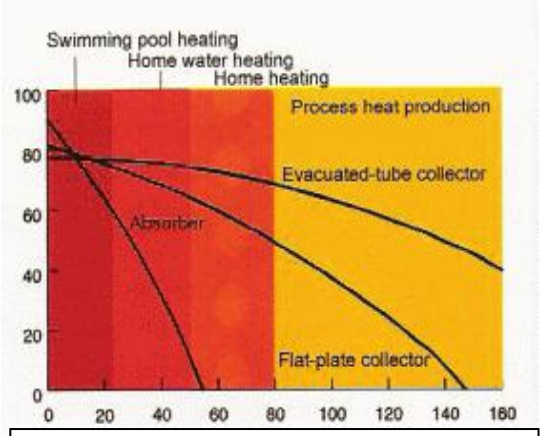
We offer two types of cylinder – copper cylinders are cheaper for small open-vented systems. For larger systems we find stainless cylinders are cheaper. If you have acidic water, or if your domestic hot water system is pressurized (i.e. you have no attic tank at all) you would need to opt for one of the stainless steel cylinders.

Matching a panel to your cylinder

A small panel and large cylinder will give you a huge amount of lukewarm water. A small cylinder and large panel will regularly over-heat, wasting valuable energy.

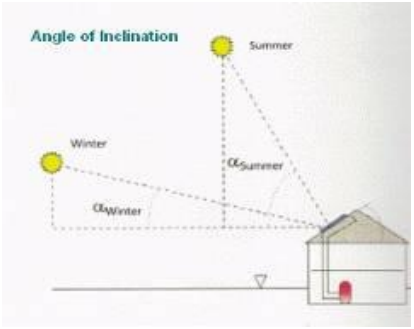
Vacuum tube solar water heaters are more efficient than flatplate collectors - especially during cold weather. Our 20 tube panel will provide sufficient hot water for cylinders between 135L and 160L if the roof is facing due south. If your roof deviates from south by more then 20 degrees, you may need slightly more panel area. A 30 tube panel would heat a cylinder between 200L and 240L, and above that you would use two 20 tube panels or a combination of 30 tube and 20 tube panels.

If you are also using a lot of hot water during the day, you should factor this in when calculating the panel size. For example, if you use 60L of hot water during the day, and you want to have 240L hot at night, your panel should be based on a 300L system. Similarly if you are fitting a solar panel in a business premises, most of the hot water is used during the day so you need less storage.



Efficiency of different systems at temperatures between 0 and 180 degrees

Locating your panel

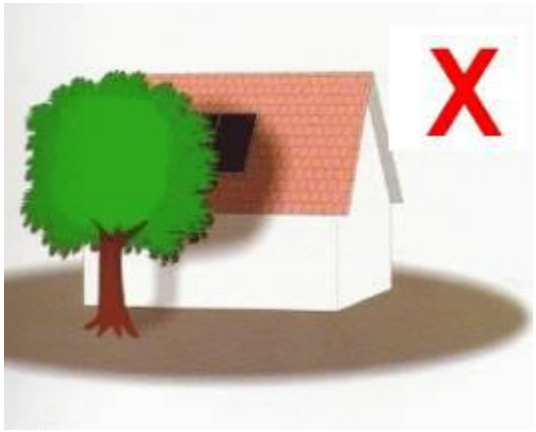


Most houses put their panel on a south-facing roof. If your roof faces between south-east and south-west, you will suffer losses of about 10%. Deviating further from this will cause more inefficiency and you may need more panels to compensate.

If your roof is sloped east-west, you will need almost twice the number of panels to do the same job. These can be connected using an east-west controller and two separate pumps.

If you have a complex roof shape which causes your south-facing roof to be shaded, you should put the panel near the top of the roof and as far away from the shading factors as possible. If you are short of space, you can put a panel on either side of a hip roof, but you will need to use an east-west controller and two pumps.

FACTORS AFFECTING EFFICIENCY					
Angle to Horizontal	**South**	**South Plus or minus 22.5 degrees**	**South Plus or minus 45 degrees**	**South Plus or minus 77.5 degrees**	**East or West**
15 degrees	91%	90%	89%	86%	82%
30 degrees	96%	95%	92%	88%	82%
45 degrees	100%	98%	95%	90%	81%
60 degrees	100%	99%	96%	89%	79%
75 degrees	98%	96%	93%	86%	75%
90 degrees	91%	89%	85%	78%	69%
Distance from collector to cylinder	**5m**	**10m**	**15m**	**20m**	**25m**
Efficiency	100%	98%	96%	93%	90%



Other Considerations

You will also need to ensure that your location is not going to be shaded for a large part of the day by trees. The location should also be accessible with scaffolding or a cherry picker.

Thermosyphon system

If you are lucky, it may be possible to position the panel either on the ground or on a conservatory roof in such a way that the hot water cylinder is almost directly above the cylinder. Because hot water rises, the hot water will automatically flow from the panel to the cylinder (called thermosyphon) without the need for any pump.

For thermosyphon to happen, the horizontal distance must not be more than twice the difference in height between the bottom on the cylinder and the top of the panel. Even at this, a larger pipe size (ideally 1") should be used, and there should be no sharp bends in the pipework. A plumber would be able to advise on the feasibility of this.

Controllers
Unless you have a thermosyphon system, you will need a small pump to bring the hot water from the panel to the cylinder. A controller or "differential thermostat" has two temperature probes, one of which is in the panel and one in the cylinder. When the panel is hotter than the cylinder, the pump is switched on.

We have a more sophisticated controller (the Resol BS3) which has a third probe in the top of the cylinder, and has a digital readout which can tell you the temperature of the various parts of your system. This provides useful information on how much hot water you have. The controller also enables you to divert surplus heat from the panel into a bathroom radiator if the system is overheating.

The BS3 controller also provides an anti-freeze function to prevent the panel from freezing by pumping water from the cylinder back up to the panel if the temperature goes below a pre-set level.

Dumping surplus heat
Regardless of what system you have, there should be some method of dumping surplus heat whenever the hot water cylinder has reached its maximum temperature. We usually recommend a three port motorized valve which diverts water from the solar panel into a radiator in the bathroom. This divert valve can be powered by an output from the controller, or by a pipe thermostat on the return pipe from the cylinder to the solar panel.

Many companies allow their panels to “stagnate” when the cylinder has reached its temperature. This allows the panel to boil and vaporize the water in it, reducing the effectiveness of the antifreeze and perhaps damaging pipe insulation in the vicinity of the panel. Our panels will reach temperatures up to 200C. While panels may occasionally stagnate during power cuts, allowing them to do so regularly is not considered best practice in the industry.

Pipework and Insulation
Solar systems can get incredibly hot if there is a power cut. In a pressurized system the circuit will boil at about 150 degrees centigrade, and for that reason all plumbing must be in copper with Armaflex™ HT insulation which we can provide. The copper should be joined using compression rather than solder fittings because solder joints can melt and push out at these temperatures.

In an “open vented” circuit (where water to the panel is supplied from an attic tank) the system will boil at 100 degrees and regular Armaflex Class O insulation / solder joints can be used.

In either situation, the pipework between the panel and the cylinder must not be plastic. You can either use copper pipework, or flexible pre-insulated stainless steel pipework which we can supply.

So what will you need?
If your panel is on the roof, above the level of your attic tank, some sample installations might be;

Item Description	2M panel	3M panel	5M panel
	135L cylinder	200L cylinder	300L cylinder
Solar Panels	750	1,120	1,870
Roof Mounting Brackets	18	27	45
BS3 Controller	210	210	210
Circulating Pump (available at your local hardware)	78	78	78
Anti-syphon valve	6	6	6
Pressure Kit	110	110	110
TOTAL COST (incl. VAT)	€1,172	€1,551	€2,319

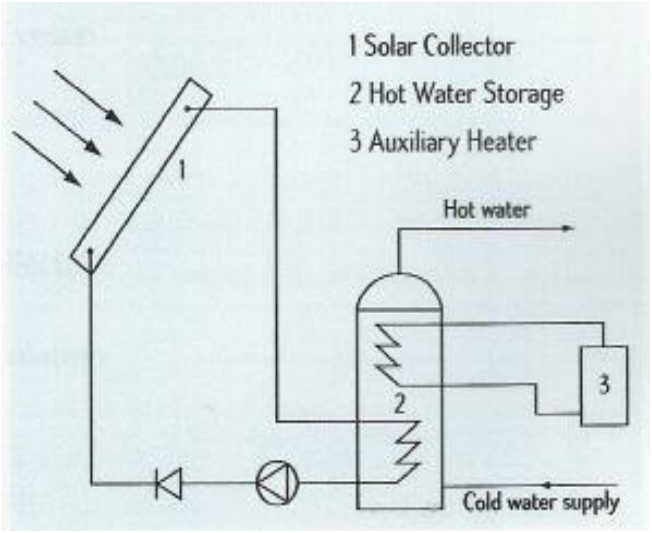
In addition, you will need a hot water cylinder with a solar coil. These may be available from your local builders’ merchants who can obtain them from Coppercraft in Dublin. We can supply these.

You will also need pipework and Armaflex™ pipe insulation, a motorized valve, radiator etc.

If you can fit an attic tank above the level of your panel, forget the pressure kit. If your panel is below your hot water cylinder and allows thermosyphon, forget the pump and controller.

Because you have certain fixed costs (controller, pump, pressure kit, labour etc.) doubling the size of your solar system does not double the price. However, it is better to build a modest solar system within your budget than to do nothing!

PLUMBING SYSTEMS



Solar panels should heat your water indirectly via a coil in your domestic hot water cylinder. Otherwise, as water is heated in the panel, lime-scale would gradually build up reducing its efficiency.

Usually your cylinder will have two coils. The top coil will be used to heat the cylinder when your central heating is on, and the lower one will be used to heat the cylinder with water from your solar panel.

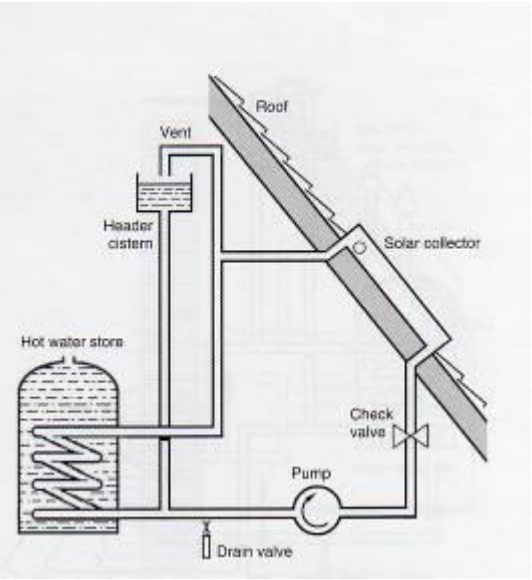
There are three likely scenarios; Open-vented, Pressurised and Thermosyphoning.

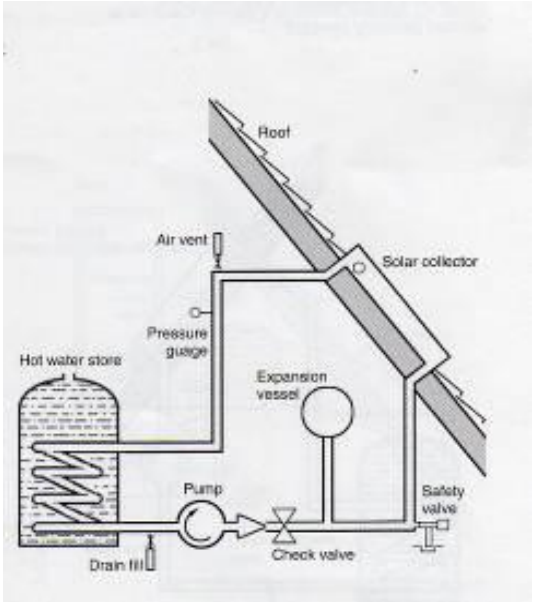
Open Vented: The indirect feed is supplied by a small header tank in the attic. This tank must be located a few feet higher than the panel to avoid pitching in the event of the system boiling.

A controller measures the temperature at the cylinder and the temperature at the panel. When the panel is 6 degrees hotter than the cylinder, the pump will switch on, bringing hot water from the panel to the coil in the cylinder. When the temperature difference falls to 4 degrees, the pump will switch off.

This is the simplest system to operate. If there is a power cut, the water in the panel can safely boil into the attic tank.

There is a check valve or one-way valve. This is to prevent hot water from the cylinder travelling up to the panel at night.





Pressurised System - Required when there is no space for a header tank in the attic (usually the panel is located quite high on the roof). The indirect circuit is a closed loop. Water needs to expand as it heats up, so an expansion vessel is used to maintain pressure at a steady level – usually at 1 bar.

If there is a power cut, the panel will boil and pressure will build up in the system until the safety valve blows off (usually at 3 bar pressure).

If there are no chemicals added to the water, it may be acceptable to use an automatic filler valve to keep the system topped up in the event of a power cut.

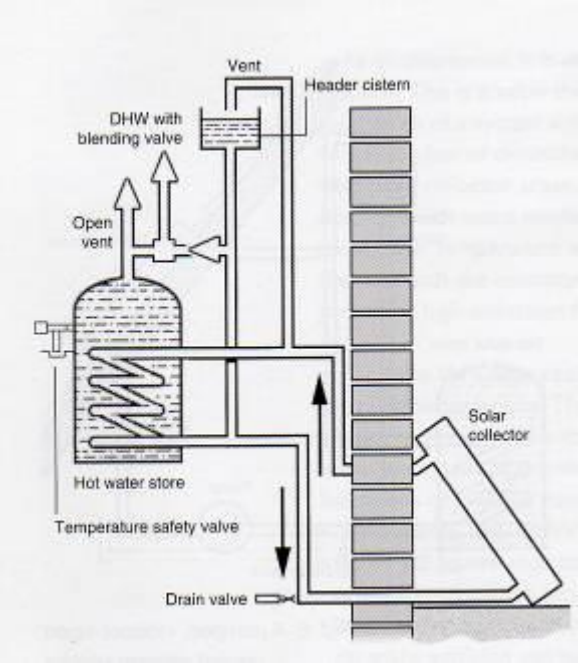
Air needs to be bled out of the system at commissioning and may be necessary if the system boils. Automatic air vents are normally not designed to withstand the high temperatures in a solar system. We can supply special high-temperature automatic air vents, but an alternative is to use an air vent with a ball valve below it which is normally closed unless air gets into the system.

Thermosyphoning – It may be possible to mount solar panels on the ground, or on a conservatory roof with the hot water cylinder above it (and not too far away). In such a case, the hot water in the panel will rise naturally without any need for a pump or controller.

For this to work, the difference in height between the panel and the coil of the cylinder must be *at least* half the distance from the cylinder to the panel. For the circuit to flow freely, it should ideally be plumbed in 1" copper, and there should be no elbows – a pipe bender should be used, and the pipework joined with straight connectors only.

You should also fit a thermostat onto the bottom of the cylinder and this can work a motorised valve which diverts hot water to a radiator when the system gets too hot.

In case of a power cut, a temperature safety valve is needed to ensure that the domestic hot water does not boil. A thermostatic mixing valve is fitted to the water outlet to prevent scalding hot water coming out of the system.

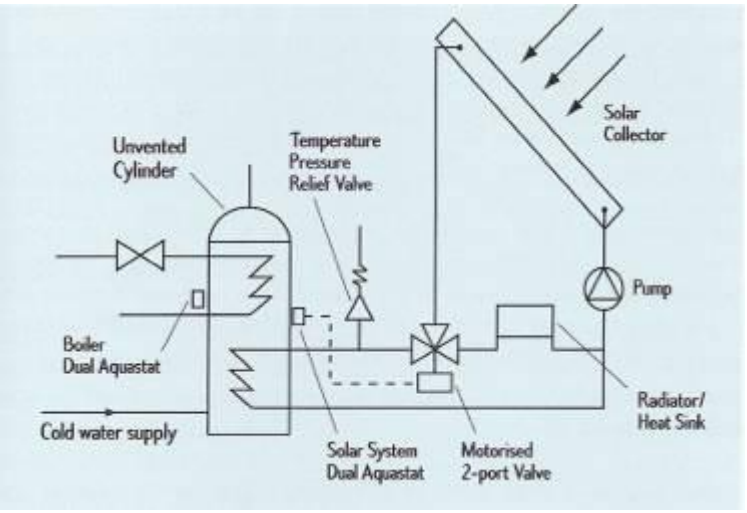


Generally it is not recommended that thermosyphon be used with a pressurized cylinder.

OTHER PLUMBING REQUIREMENTS

Overheating Dump Circuit
On all of the above systems, there should be a system to dump surplus heat - especially during summer holidays when a family may be away for two weeks, and no hot water is being used.

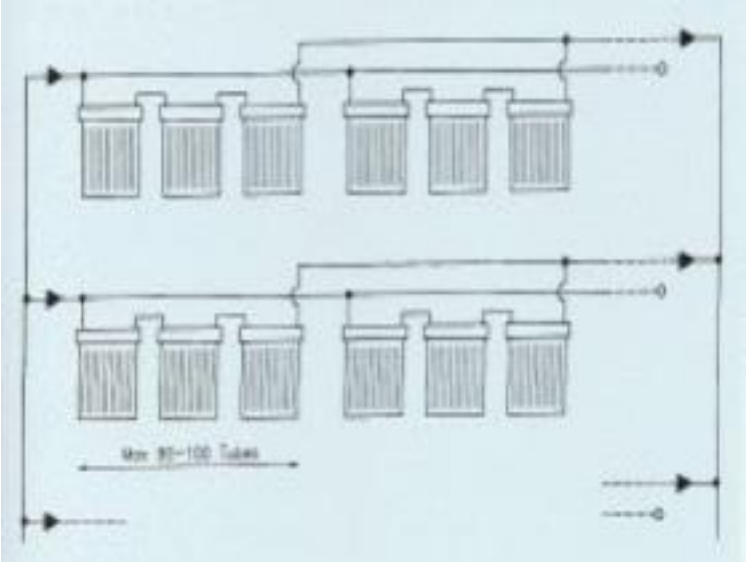
There are a number or options for doing this, but the most common is to use a three port motorised valve to divert water from the panel into a radiator. This valve can be operated by the controller or in the case of a thermosyphoning system by a thermostat on the cylinder The radiator can be fitted in a large hotpress (such as a walk-in one), but if it is likely to end up smothered by clothes, it would be best to fit it into the loft where the heat can be more effectively dissipated, or in the bathroom (where it may be useful in the summer to reduce condensation).



Plumbing options – The plumbing from the panel to the cylinder should all be in copper pipe. For most installations this can be ½" copper and the lowest setting on a central heating pump will easily cope with the heat flow needed. For larger installations or in the event that the panel is located a considerable distance from the cylinder, the following chart outlines the pipe sizes needed;

Distance from panel to cylinder	5m	10m	15m	20m	25m
10 to 30 tubes	1/2"	1/2"	1/2"	1/2"	3/4"
40 to 50 tubes	1/2"	1/2"	1/2"	3/4"	3/4"
60 to 80 tubes	1/2"	1/2"	3/4"	3/4"	3/4"
80 to 100 tubes	3/4"	3/4"	3/4"	3/4"	3/4"
100 to 120 tubes	3/4"	3/4"	3/4"	3/4"	1"
120 to 150 tubes	3/4"	3/4"	3/4"	1"	1"
150 to 180 tubes	3/4"	3/4"	1"	1"	1"
Over 180 tubes	1"	1"	1"	1"	1"

The figures in this chart are not critical – deviating may mean that the pump needs to be run at a higher speed.



It is generally a bad idea to put more than 90 tubes in series. It is better to put them in parallel banks of less than 80 tubes with a gate valve fitted to each loop to ensure that one circuit is not flowing more quickly than the others.

Earth Bonding – Pipework from the solar panel should be earth bonded. In accordance with regulations, it should already be bonded via the cylinder.

WHERE TO START ON THE INSTALLATION

It is generally best that the tubes are not inserted into the panel until the system is ready for commissioning as the panel will immediately heat up. In winter you may safely leave the panel for a few days, but at other times there must be water in the cylinder and in the panel circuit, and there should be a permanent electricity supply to the controller. Otherwise the tubes may overheat the manifold and damage pipe insulation.

In a retrofit, normally a team of two will have one person assembling the solar panel frame and preparing scaffolding for roof mounting. Two people are required (one inside and one outside) for mounting the solar panel on the roof. Pipework and pumps are insulated, fitted, and pressure tested.

The tubes are then installed and the system commissioned. The controller should be set (see separate instructions on how to programme the controller for heat dump / frost protection functions).

Finally all joints must be insulated completely with larger sleeving (it is essential that there are no slits or openings anywhere in the pipe or joint insulation).

Legionnaires Disease
Legionella bacteria are commonly found in water supplies. They breed at temperatures between 25 degrees and 42 degrees, and thrives on sludge and rust found at the bottom of most cylinders. During the winter, and on the fringes of the season, these conditions can occur in the bottom of a solar cylinder.

It is essential that precautions are taken to prevent Legionnaires Disease. Options include;

- Ensuring that either the immersion or central heating heat the top of the cylinder to at least 54 degrees on a timer before hot water is used.
- A de-stratification pump can heat the entire cylinder to 54 degrees once a week on a timer and set to operate at a time when the heating or an immersion heater is on
- Heat the cylinder once a week to 54 degrees using the solar coil connected temporarily to the central heating using motorised valves.

Roof Mounting Instructions

First you need to erect a good platform to work from. Scaffold tower provides a quick and easy method. The towers must be secured to the building and firm. If you don't have experience using towers, please get someone to work with you who has roofing experience!

Start by assembling the jubilee clamps in the bottom rail of the panel.

Attach the vertical rails (2 for the 20 tube panel and 3 for the 30 tube)

Remove the four 6mm bolts that are in the manifold. Fit the manifold between the two lugs at the top of the frame and secure with the four 6mm bolts that were originally in the manifold.

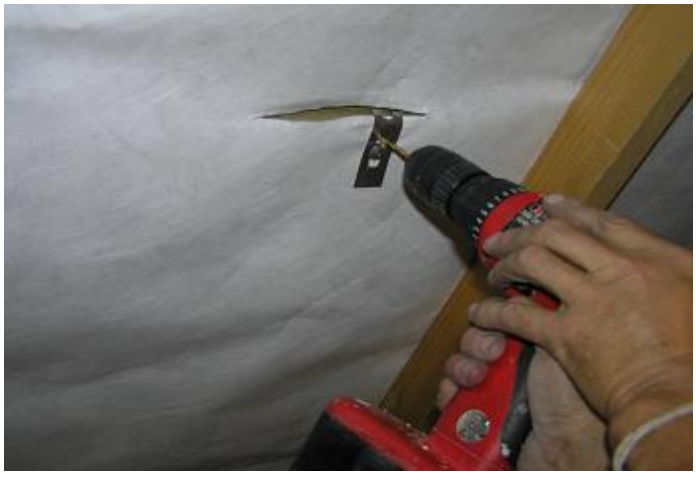
Once the frame is fully assembled, it is ready to carry up to the roof (this frame is for a 30 tube panel)

These stainless steel mounting brackets or strips are used to hang the panel on the roof

Ease the frame into position, and slide the straps up underneath the slates/tiles. If necessary, use a screwdriver to lift the slates slightly to facilitate this. Slide the panel upwards, until the mounting straps hit the battens. *(NB this panel is still 6" low, and will be pushed upwards before fixing)*

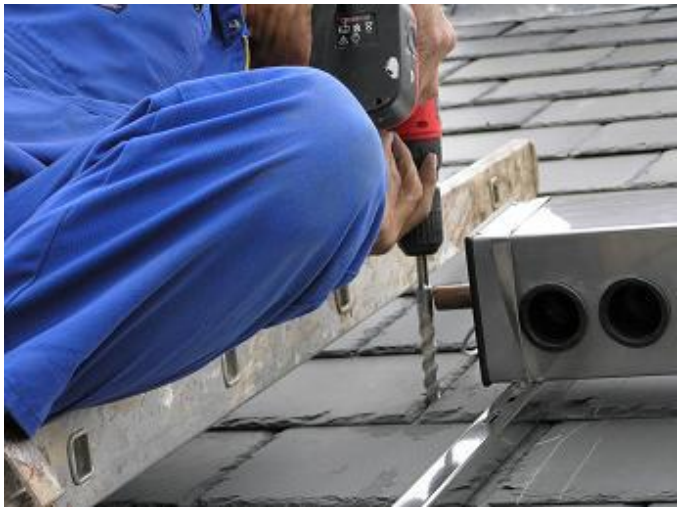
It is now necessary to go inside the loft space to locate the mounting strips. Once they have been located, cut the felt to allow the straps to protrude. Once each strap is clear of the battens, get an assistant to slide the panel up until the strap is as far under the slate as it will go.

Bend the strap over the nearest batten to produce a 'hook' to carry the weight, and fix securely to the batten with two screws. It may be preferred to attach a noggin at this point and attach to the noggin instead of the battens.



Now the panel is attached to the roof, the remaining roof mounting strips should be slid under the tiles and fitted to the vertical rails, using two 8mm bolts on each vertical leg. You can drill holes at appropriate locations in the vertical rails if

necessary.



Once the panel is fixed, you have to consider how you are going to run the pipework from the panel into the hotpress. There are other methods of doing this outlined below, and we prefer these to the standard method which is to drill a 16mm hole at both ends of the panel to accommodate the copper flow and return pipes.

Using a 22mm elbow with a reducing olive (to 15mm), attach a copper pipe at 90degrees and feed through the hole into the loftspace. Seal the hole with silicone, and insulate the pipes, using ties to prevent the insulation from becoming detached. The insulation should be protected with either UV resistant chlorinated rubber paint, or with some other tape covering that is UV resistant. Armaflex™ insulation is UV protected, but birds may make off with it during the nesting season.

or

This is the method of fitting traditionally used, but we prefer other options including;

- Install a venting slate above the panel. You can either run flexible pre-insulated stainless steel pipework from the panel through the venting slate and into the loft

from where it can be taken in regular copper (or continued in the flexible stainless pipe) to the hotpress. The stainless steel flexible pipe is quite expensive, but worthwhile for short runs like this.
- Using a venting slate above, run flexible ½" copper pipe through the roof, insulated with Armaflex™
- Some installers have made a copper slate, brazing a 1½" copper pipe through it. A ½" pipe and cable for the controller sensor are run through this, and held in with spray-foam.
- Other installers made up a flashing using lead.
- Run the pipe over the end of the roof and come through a gable wall.

Whichever method you prefer, please ensure that you also run a cable through the roof for the temperature probe from the controller. You will see a small hole at the end of the manifold where this probe is fitted. Run the cable from this through the roof. You can extend this cable with a pair stranded wire .75mm. We offer a special junction box for this connection which prevents the controller being damaged by a lightening strike.

If you are fitting more than one panel, it doesn't matter too much which panel the probe goes into, but it is better if it is somewhere in the centre or towards the first in the line of flow (assuming the panels are level, this can be determined when you come to fit the pump and connect the pipes to your cylinder).

Lightening Protection
If the panel is prone above the roof line, it should be protected from lightening (e.g. on flat roofs). You may already have lightening protection attached to your TV arial. If so, you should connect the panel to this using 16mm cable. If not, you should run a 16mm^2 cable from the frame to an earth rod (the cable should run outside the building only).

Please also note that copper pipework from the solar panel should be earth bonded.

When you have finished plumbing to the cylinder and fitting the controller, you can attach the tubes. (DO NOT put the tubes in before the controller and pump are running and everything is pressure tested because the tubes will overheat the manifold on a sunny day).

Smear the silicon heat-transfer grease provided in the kit onto the tip of each copper heatpipe. This ensures a good thermal contact between the heatpipe and the manifold. Attach the rubber cups to each end of the tube, moistening first, to allow it to be slipped on easily. Insert the bottom of each tube through the jubilee clip until it is just clear of the manifold, and then slide it up into the manifold. Once it is in, secure by tightening the jubilee clip until it barely grips the tube - take care not to over-tighten.

Attach the chrome-plated plastic reflector strips as you insert the tubes. You will need access to the back of the tubes, so fit the reflectors every four tubes or so.

In an extremely exposed location, these reflectors should be left off to allow the wind simply blow through the tubes.

Checklist of precautions

- Pipework from the panel to the cylinder must be copper and must be insulated properly with Armaflex™ or similar. If the panel is pressurized this must be Armaflex™ HT or similar capable of withstanding temperatures of 150 degrees.
- There must be a pressure relief valve and this must be run to ground to prevent scalding.
- There must be a heat divert mechanism in place to cope with summer holidays etc., when hot water is not being used. Heat dump radiators should be marked with instructions not to cover them.
- The controller must be set up in accordance with separate instructions for that purpose. By default the anti-freeze and heat dump functions of this controller are *not* set.
- All conditions set out in the SEI Commissioning report must be met. Please read and ensure that you understand this commissioning report before commencing the installation.
- Never put more than 80 tubes in series