Solar Thermal Heating System – DIY Installation Review

Introduction

In December 2005, ever rising gas prices, plus the availability of plentiful sunlight for several months of the year, prompted consideration of a solar panel installation to supplement domestic water heating from the gas boiler.
Several options were considered during extensive internet research with much downloading and printing of data sheets, documentation and .pdf files. Flat panels initially seemed to have cost advantages, but the evacuated glass tube systems are by far the most effective, even generating useful energy in winter on cloudy days. However evacuated tubes systems were expensive circa £3,000+ making financial recovery (break-even) time dubiously long.

The Navitron solar panel used is based on the *Apricus* panel - the main difference being cost. Note that Navitron ceased trading in 2021 but other panels are available.

The system cost me a total of £1,500 for DIY installation - and that included updating my heating system to meet *Part L* of the new Building Regulations specification. I chose to carry out this update at the same time as it made practical and financial sense. The standard solar system with associated pipework and ancillaries was under £1,200.

As an Electrical and Electronics Engineer by profession, I have had many years experience in electrical installation as well as plumbing and property renovation. Therefore modifying the original cylinder installation (that I had previously installed some 13 years ago) and installing the solar panel would be relatively straightforward.

This review describes the installation of a complete Solar Thermal System together with the modifications necessary to optimise the system. There are numerous hints and tips to ease installation along with detailed explanations of areas not covered in the supplied installation guides.

Sourcing Components

Before purchasing any components, I checked with my local Council Planning Department as to whether Planning Permission was necessary. *Update note:* As of April 2008, Planning Policy was relaxed and providing you have a conventional property in a non-restricted area, it is now possible to install solar panels under Permitted Development without needing to contact the Local Planning Office. However in certain cases, especially those living in a Conservation Area, or owning a Listed Building, it is essential to confirm the situation with your local council, *in writing*, before commencing work, as Councils have different policies and attitudes towards energy conservation systems. If in doubt ask first!

The system includes a 20-tube solar panel kit, 1200mm x 450mm solar cylinder and *Resol DeltaSol BS/3* controller kit. I also purchased the fourth temperature sensor, non-return valve and *Armaflex HT* High Temperature pipe insulation for the flow pipe.

Whilst I used the cheaper *Climaflex* insulation for the return pipe, the flow pipe can exceed 120ºC and *Climaflex* will begin to melt above 105ºC. Therefore the *Armaflex HT* insulation is essential for the flow pipe. Some budget insulation materials may melt at temperatures below that of Climaflex and should be checked before use. For total piece of mind it is generally recommended to use Armaflex for both flow and return as this ensures that the insulation will not melt under stagnation conditions.

The other major components required are the expansion vessel, safety valve and filling loop. These are frequently sold as a complete all-in-one kit. However, due to a problem with external wall (drainage) access from my internal airing cupboard, it was necessary for these items to be separated within my installation and bought as individual components – see later.

Various sources were compared on price for copper pipe, fittings and other control equipment. In fact I used *eBay* to obtain the *Honeywell* motorised valves and cylinder thermostats, brand new, at half price including postage. I was also lucky to win two *Horne* H-2003 Thermostatic Mixing Valves (TMVs), normally retailing at £150, for around £45 each. These are high flow rate, low temperature differential TMVs to BSEN1287 DN20 for bath fill applications and are top quality if you can pick them up at sensible prices like this. *(*Note: Horne superseded these with the *HeatstatT2* model).

The bulk/trade fittings packs from *Screwfix Direct* are good value and whilst I buy a lot of these, you need to do enough plumbing to get full value from them. However is worth noting that a bulk pack of fittings (or screws etc) from Screwfix often costs less than a small retail blister pack of similar items from the likes of *B&Q*. Even if you don't use them all at once, it is often still cheaper to buy from Screwfix. Unfortunately there is a vast range of plumbing fittings that are actually available and on a job like this there are several areas requiring various threaded adaptors, and in my case 28mm valve and pipe fittings, that Screwfix simply do not sell.

Therefore I sourced some of the remaining parts from Plumbworld and the rest via BES Ltd. – all online via the Internet.

Installation Planning

In essence, I planned to allow one day each to:

a) Drain down and replace the cylinder, fit new isolating valves, and to fit TMVs to the two hot feeds from the cylinder – see note below.
b) Modify the boiler pipework to include three separate new two-port motorised valves in place of the existing single three-port valve, fit an Automatic Differential Pressure Bypass Valve (ADPBV), as required by Part-L of the Building Regulations.
c) Re-plumb the bathroom radiator direct to the boiler pump circuit to act as a heat dump if needed in summer months.
d) Carry out the electrical wiring for the new system components.
e) Fit the solar manifold on the roof.
f) Finish solar pipework, test, fit solar tubes, and commission the solar system.

Whilst somewhat over-cautious time wise, the job was planned for late March 2006, when the weather could still be cold. Apart from (b) and (c), the heating system could remain operational due to isolating valves already fitted to pipes feeding the cylinder coil. Also, the immersion heater in the new cylinder would provide hot water whilst the boiler pipes were disconnected.

After stage (b), the system would still run in a 'manual' mode by locking the manual levers on the zone valves and allowing the original three-port valve (still electrically connected) to control the pump and boiler. Whilst not ideal, it was only a one-day temporary fix.

Such cautious planning would not be necessary in the summer months when the family do not require the heating system to be operational! Also from past experience, it is better to allow for unforeseeable problems.

Note: Important safety advice. The solar system is easily capable of heating the cylinder to 65ºC and water at this temperature will cause instantaneous scalding. This is particularly serious with children or the elderly. A TMV is used to automatically mix cold water with the hot cylinder flow to reduce the *delivered* hot water temperature to a safe level. Because water flow rates from TMVs are often lower than that from a direct pipe, multiple TMVs may sometimes be necessary, installed near each point of use.

My domestic system has two 22mm feeds from the cylinder – one to the bathroom, the other feeding the kitchen, utility room and cloakroom. Hence in my case, two high flow rate TMVs were utilised.

Solar Cylinder Selection

Assuming the existing cylinder is correctly sized for the needs of the property and occupants, the solar cylinder will always need to be of larger capacity than the original standard cylinder. This is because the proportion of hot water capacity heated by the boiler in a solar cylinder is 20% to 30% *less* than that of an equivalent sized standard cylinder. Therefore to maintain full hot water capacity in winter, at least the next size up is required.

However going too large for the solar panel size will result in a lower average cylinder temperature. Aim to size the cylinder to maintain useable temperature hot water straight from the tap during summer months. This will eliminate (or minimise) the need for boiler top-ups during summer.

Solar Cylinder Installation

On the original installation thirteen years ago, I fitted gate valves from the main header tank feeds. I was concerned that they were getting somewhat 'graunchy' and that the cylinder feed valve may not shut off fully. This would make it tricky draining just the cylinder. I also found the stop-cock feeding the header tank was seized. In hindsight, two points of advice here:

i) Wherever possible, always use modern handle operated 'ball' type *full-bore* valves on main water feeds – they do not tend to seize up in the same way, and
ii) Operate all isolating valves at least every six months – to prevent them from getting stuck. Otherwise the only time you *need* to shut off the water is the time you discover that the valve no longer works!

I chose to replace the sticking gate valves as well, thus dictating the need to drain not only the cylinder but the header tank as well. Therefore the first job was to replace the stopcock.
Fortunately the main stopcock has been used more frequently and worked OK for this job. I also took the opportunity to tee-in the byelaw-R24 filling-loop isolating valve incorporating a double check-valve, which will be used to fill the solar system. This connects to a *Pressure Regulating Valve* the purpose of which is to limit the fill pressure automatically. Whilst not essential, it makes life easier when bleeding air from pipework in the loft, knowing that the system will not over-pressurise. The flexible filling loop then attaches to the outlet of the Pressure Regulating Valve. Draining the header tank is easy – just turn on the bath taps! I shut down the mains water tank feed first thing on the morning of drain-down to limit the wasted water. Draining down the cylinder always seems to take longer than anticipated - due to the continuously reducing head of water and invariably long length of small-bore garden hose…

Ensure that the immersion heater (if fitted) is isolated. This should be controlled by a double-pole isolator and locally fused at 13A unless supplied via a dedicated 16A circuit breaker in the consumer unit. Turn off the main electrical supply whilst disconnecting and temporarily fit a fully insulated terminal block or junction box on the free cable end, before turning the power back on.

Original installation water feed pipework

Whilst the main cylinder was draining, the primary coil pipework was also drained, disconnected, and the pipes capped. I had originally installed gate valves to the coil making this job simple, allowing the central heating system to continue in operation. These valves had remained free in operation due to the use of *Fernox MB1* corrosion inhibitor in the central heating system.

Original heating pipework and controls

New valve gear and TMVs – part of solar filling-loop and Pressure Regulating Valve at top

Once the upper part of the cylinder is drained, the top connection and pipework can be removed. The new cylinder is taller so this had to be replaced anyway.

After removal of the old cylinder, for easier access the new ball valves were fitted to the tank feeds and TMV pipework installed, before placing the solar cylinder in position. With the cylinder feed valve turned off, the header tank was refilled whilst the remaining cylinder pipework was completed. This also allowed the cold services from the tank (e.g. toilets) to be brought back into operation.

With new cylinders, it is sensible to refill slowly under control of the cold feed valve. I fit the immersion heater at the last moment – using the immersion hole to view the water level. Why? Because new cylinders can (and do) sometimes leak – they hold a lot of water, and remember how long it took to drain down the original! Fill the cylinder in steps to just above each union connection - simply to ensure there are no seeps. If all is OK, screw in the immersion heater and open the valve fully.

With ball valves fitted to the outlets from the cylinder, flushing the pipework to the TMVs is simple. This must be carried out prior to final fit of the TMVs, otherwise any warranty will be void.

After fitting the TMVs, vent the pipework to each hot tap. Reconnect the electrical cable to the immersion heater (with the same caveats as in disconnection above), as the immersion is required for hot water until the coil connections to the heating system are replaced.

Note: I had a delayed drip from the lower cylinder feed. Tightening further made no difference necessitating a cylinder only drain-down the following day. I resorted to placing PTFE tape around the olive and threads prior to tightening. Whilst this should not be necessary, sometimes the brass fittings on cylinders simply will not seal without extra help! If there is a leak, do not simply continue tightening the union with ‘as much force as you can muster’. The union is brazed to what is a very thin cylinder wall. Excess force may twist the union and irreparably damage the cylinder. It is far better to seal the leak properly.

Boiler pipework

When originally installing the heating system in 1992/3, I created two individual heating circuits – one for bedrooms and the other for the main living areas. The original reasoning behind this was to make any future maintenance easier since one circuit could be isolated without killing the entire system.

However the new requirements of Part-L of the Building Regulations require at least two independent heating zones in all properties with over $150m^2$ floor area. Whilst not falling within the floor area requirement at $142\ m^2$, it now followed that fitting two motorised zone valves onto these circuits, with individual time controls, would allow the bedrooms circuit to be shut-down during the day – thereby further conserving fuel. My system retains a single programmable room thermostat common to both radiator circuits but there is no reason why two room stats cannot be used if they can be suitably located. Remember that any radiator in the room where the thermostat is located must not be fitted with a TRV. It should be fitted with lockshield valves at both ends and adjusted during system balancing to ensure that the room is the last to reach the required temperature.

Completed boiler and solar pipework and flow controls

A further requirement of Part-L, is the fitting of an Automatic Differential Pressure Bypass Valve (ADPBV) between the pump flow feed and boiler return. This allows a minimum water flow through the boiler improving efficiency. It also reduces the ‘whistle’ that can be sometimes be heard from Thermostatic Radiator Valves (TRVs). This occurs when the system is at full temperature and the TRVs are shutting down, increasing the flow pressure from the pump. With an ADPBV, the valve senses the rise in system pressure, and ‘excess’ flow is allowed to return back to the boiler; thus maintaining a consistent flow rate and higher return flow temperature.

ADPBV detail on boiler coil – main system ADPBV in background (blue cap)

A disadvantage of extended radiator pipe runs in large properties is that when the cylinder thermostat ‘calls for heat’, a significant proportion of the boiler flow is diverted to the cylinder heating coil. This lowers the radiator temperatures, especially at the further ends of pipe runs.

After musing this problem, I installed an experimental solution utilising a second ADPBV. A 15mm direct pipe connection is used between the hot water zone valve and cylinder coil, with a 22mm pipe connection in parallel - via an ADPBV. In theory, with suitable setting of the ADPBV, around 75% flow can be maintained in the radiator circuit(s) when the cylinder is also heating. If the radiator circuit is off (or TRVs closing) the cylinder ADPBV will open, allowing full 22mm pipe flow through the cylinder coil. This is effectively a variable intelligent flow restrictor.

Author’s notes:
22nd April 2006 – this seems to work well allowing adequate flows to all radiators whilst giving a minimal increase to the cylinder reheat time.

19th June 2006 - In hindsight, I would have fitted the two cylinder thermostats 100mm higher; such is the efficiency of the system. It is also worth considering the option of a second boiler coil at higher level. This would have been better for early morning boiler top-ups on spring and autumn days when solar input takes longer due to variable British climate and weather conditions. The second coil would be fed via another 2-port zone valve controlled by a higher-level cylinder thermostat.

Solar Collector Assembly

The supplied manual fully explains how to assemble the complete panel and there is no point in reinventing the wheel. However, whilst it is a good idea to 'trial fit' a tube or two on the ground do not be tempted to lift the completed panel onto the roof! Firstly it is a lot heavier when completed than it looks, and secondly the tubes must not be fitted until the manifold and pipework is filled with water and the pump and controller have been tested.

Solar Collector Installation

My installation is on a bungalow with a relatively shallow roof angle (approx. 23ºC). Therefore access is easy and walking around on the tiles is relatively safe. However for steeper roof angles and installations on houses the correct safe working equipment is vital. Hire an aluminium access tower and roof ladder for a couple of days - the cost is usually preferable to falling off the roof! Also you ideally need a helper to pass tools and panel components up to you. Having to continually climb up and down every time you realise you have forgotten a minor item is time consuming and tiring.

I fixed the mounting straps directly to the rafters using two 8mm 'coach' screws on each strap before replacing the tiles. The solar panel frame is then bolted to the straps.

Because I have relatively thick concrete roof tiles that hang on the battens, the frame needed 'pulling-down' onto the tiles. Hence the mounting straps were bent to shape, attached to the rafters, and tiles replaced before the final fit of the manifold frame. The overlapping tiles needed to be lifted at least 25mm in order to slide back in the tile below – hence the need for the frame to be moveable until the tiles were refitted. Note how the top end of the strap passes *under* the tile above, thus being fixed securely at both ends.

The only comment I would make is that no shake-proof (locking) washers were supplied with the mounting frame. From both an engineering and assembly perspective this is a shame, since it is difficult to get a spanner under the frame channel section to hold the nuts secure when bolting the frame to the mounting straps. This may not be a problem on a flatter slate or tiled roof as it would be easier to slide the tiles under the pre-mounted frame. With hindsight, I would have obtained suitable locking washers prior to assembly.

The tricky bit is cutting the pipe holes in the tiles - without breaking them. If you blast it with a hammer drill, the most likely result will be a broken tile! Use a TCT hole-saw intended for cutting stone/concrete. Purpose designed pipe flashings are now available to use around the pipes rather than the silicone sealant I used.

Note: The grey water stain on the roof shots is *not* a leak – it was from run-off water that I used to lubricate the cutter whilst drilling the holes – those tiles are hard!

The only question is what to do regarding insulating the elbows and pipes exiting the manifold. These will freeze if left unprotected but pipe insulation is difficult to fix adequately on such a short and elbowed length.

Right-hand end cap box internal view

Left-hand end cap box complete

Also pipe lagging will degrade over time due to exposure to the weather. A neater, more permanent and reliable solution involves modifying a couple of ABS electrical enclosures of suitable size. The nearest I could find to the manifold box section dimensions were stock number 222-238 from *RS Components* - but they will only supply to trade account holders. A hole cut in two sides allows the base section of the box to be fitted onto the end of the manifold. The 15mm pipe passes through the base hole (slotted to the box edge on final fitting to ease assembly) and into the elbow. The box is held against the manifold using a clamp-around 20mm cable clamp of the type used for securing high current armoured cables. After leak testing the elbow joints, the pipes are lagged as normal. Then the remaining interior space of the box is filled with *Rockwool* loft lagging, in much the same way as the manifold itself. Similarly fill the lid section with Rockwool before screwing it in place – be careful not to trap the manifold sensor cable.

The sensor cable is passed through a separate 5mm diameter hole, drilled slightly forward of the main pipe hole. It is then sealed with silicone sealant. This is preferable to using the pipe hole since the cable would be in direct contact with the hot pipe, which may cause long-term degradation of the insulation – although the manifold sensor is fitted with a silicone insulated cable (the black one).

Silicone sealant is also used to secure and seal the box to the manifold along the top, front and rear edges. The bottom edge and exit slot hole were left to allow any water to escape should there be a leak from pipework or the box seal.

It is a shame the manifold does not include a bespoke screw-on insulating cover kit. Mass-produced insulated end covers should work out less than the £20 the boxes cost me and would be well worth the minimal extra cost in terms of the extra insulation and protection offered.

Although not carried out until later, it took about 1.5 hours to install all twenty tubes with reflectors. I initially fitted two tubes at the sensor end of the manifold and used these to ensure that the controller was working. Even two tubes were enough to raise the lower cylinder temperature by 4ºC in two hours with relatively overcast sky. The last thing you need is to have to remove the tubes again because there is a control or water circulation problem.

The installed solar panel complete

Solar Pipework

The basic plumbing schematic is illustrated in the installation manual. The only major deviation was the position of the one-way valve. Because this item contains plastic components that could be affected by extreme temperatures, I located it in the cooler *return* pipe - ensure it is fitted the correct way around!

Tundish

It is essential to fit an automatic Pressure Relief Valve (PRV) to the system. I used a 1.5 bar expansion vessel (Cal-Pro) and therefore a non-adjustable 3 bar PRV was used. This later proved to be the source of a problem during initial filling, as the system was continuously losing pressure. No leaks could be found until I realised that the overflow pipe was dripping continuously into the tundish/down-pipe. Manual operation of the valve failed to flush the problem away. Resorting to removing the valve revealed a curly length of brass swarf underneath the valve seat! This was carefully removed and the valve refitted. The system then held pressure with no further problems. It is likely that swarf was within the fitting from new, left from the manufacturing process. I was thankful for using a compression fitting on one side of the BSP threaded PRV to allow easy removal.

Flow pipe air vent detail and pressure relief valve

The other requirement is the ability to bleed air from the system pipework. The air vent is recommended to be "at the highest point in the system". This makes sense, as air will always rise to the highest point it can find. However placing the vent externally on the manifold gives rise to the problem of having to "nip up on the roof to check for trapped air" – not very practical!

However in practice, any air trapped within the manifold should be carried out around the pipework. Therefore I elected to fit an air trap inside the loft. The flow pipe bends down to the left of the photo, before bending up through the roof into the manifold. Therefore the horizontal pipe run shown here is still *physically* higher than the manifold outside on the roof.

The air trap consists of a 22mm compression Tee with reducing sets on the 15mm flow pipe connections. A 22mm pip rises from the 'Tee' to an air bleed at the top of the picture. The air bleed itself is a radiator type soldered directly to the pipe. Unfortunately I did not have the appropriate fitting to directly solder the vent to the 22mm pipe, hence the triple stage conversion!

The remaining pipework and the relief valve body was lagged after the photo was taken. (The lower green Climaflex-lagged pipe is the hot water expansion pipe from the cylinder.)

This vent worked extremely well for system filling and all remaining air was trapped and released from the pipework within the first ten minutes of running the pump.

Warning: Do not use conventional automatic air vents intended for central heating systems. These contain plastic components and are only rated at 90ºC to 110 ºC and will melt under fault conditions. Remember that the system is pressurised, so the boiling pint of the water is raised well above 100ºC. *Caleffi Solar* manufacture an automatic air vent capable of 150ºC – but at £18 why bother? Once the main air is vented, the air trap shown here will collect all remaining residual air bubbles.

There is also a vertical vent on the flow pipe into the cylinder coil. This is primarily used to vent air from the coil during system filling – although it does provide a secondary air trap during system operation.

The solar manifold connections were made using 22mm compression elbows with reducing sets to connect to the 15mm flow and return pipes. Use a small amount of pipe sealant (such as *Fernox “Water Hawk”*) on all compression fittings and reducing sets. As the system is pressurised, this will help to seal any minute imperfections in mating surfaces that may otherwise cause slight leaks. It is worth checking the tightness of all compression joints a day or two after completion. They tend to ‘settle’ and it is surprising how slack a joint may feel the following day – despite how tight is seemed when first done up!

It is preferable to use a pipe-bender wherever possible because each elbow fitting used adds a greater restriction to the flow rate. With practice, multiple bends are possible, thus minimising the use of fittings and reducing the chance of leaks later.

Use lead-free solder with appropriate flux on all soldered pipework connections as it has a higher melting point than leaded solder. (If higher pressures are used, under extreme fault conditions it is conceivable that the circulating water could reach the 180ºC melting point of leaded solder).

Author’s note: Subsequent experience has shown that for domestic installations, micro-bore 10mm diameter flow and return pipe is better suited for the solar pipework. It reduces the system water content and, being flexible, is easier and quicker to install.

System Filling

It is essential to flush the pipework to remove all traces of flux and debris from the system. Fill the system via the filling-loop, venting air as necessary. Use the manual knob on the PRV to flush the top end of the pipework via the overflow pipe. Closing a pump valve will force the water up and through the manifold to flush the upper pipework. Flush the cylinder coil and flow pipe using the drain-off in the return pipe.

At this stage it is worthwhile testing the pump and checking all pipe joints for leaks. Then drain the solar pipework into a bucket. Why? Because you need to know how much water content is in the system, in order to calculate the correct quantity of antifreeze to add… (My system contained just over five litres of water.)

The bodged, and efficient, ways to add anti-freeze

I used *Fernox ’Alphi-11’* a combined anti-freeze with corrosion and limescale preventer. I had initially intended to infuse the Alphi-11 by removing the vertical vent pipe from the Tee on the cylinder coil flow pipe and adding it directly into the coil – then simply fill the remaining system with water via the filling loop. Unfortunately the anti-freeze, being somewhat thicker than water, refused to flow into the pipe. It was sufficiently thick to cause an air lock in the temporary tube and funnel I was using. After some head scratching, I created (i.e. bodged) a makeshift adaptor for the filling-loop using a plastic drinks bottle and a ½” bsp male compression adaptor sealed in the bottle neck.

I subsequently purchased a *Hozelock Polyspray 3* – a two-litre garden spray with flexible hose for £14. Adapted to fit the filling-loop using a 3/8”bsp to 15mm adaptor fitting, this is a quick and mess-free way to pump anti-freeze into the system!

The actual quantity of antifreeze used depends on the desired protection temperature - the percentages and protection levels are quoted on the product container. This will depend on location and hence winter night-time temperatures, and also on the setting of the freeze protection parameters *OCF* and *CFR* on the *BS/3* controller.

Solar Controller and Sensors

The *Resol DeltaSol BS/3* controller was selected because it incorporates a second relay output that can be programmed to dump excess heat from the cylinder into the domestic heating system when high solar energy input combines with periods of low hot water use. For instance, if you go on a summer holiday and use no hot water for a fortnight, in all probability, the cylinder will reach the maximum temperature programmed limit. The controller then shuts down, and is likely to cause the manifold to boil and the system to vent excess pressure. If the solar tubes are regularly allowed to continue heating with no water in the manifold, long-term damage or performance reduction to the tubes could result. Whilst the glass tubes and heat pipes are relatively cheap to replace, the upgraded controller and installation changes to accommodate a heat dump are cheaper!

To achieve the heat dump capability, additional modifications are required to the existing boiler system wiring and pipework. The effort is worthwhile as it gives peace of mind and virtually guaranteed trouble-free solar operation.

The DeltaSol controller uses Platinum Resistance Thermometer probes of nominal 1000 ohms resistance at 0ºC; hence the term PRT1000. The black silicon lead version (FKP6) is intended for the manifold, S1, whilst the grey lead FRP6 sensors are for the cylinder and return pipe sensors S2 to S4. These can be readily extended using any two-core wire and terminal block connector if necessary - although I used genuine PRT extension cable and connector to extend S1.

PRT1000 sensors change resistance by 3.85ohms per ºC. Hence the 1000 ohm resistance will be relatively unaffected by the extension wire resistance and hence no significant temperature error will result.

S4 mounting method

It is worth checking the continuity of the sensors with a resistance meter before fitting. At 20ºC the resistance should be 1077 ohms. Fit the probes into their respective pockets using a small amount of heat conductive paste (as supplied for the solar tube heat pipes). A blob of silicone sealant will retain then in place.

If sensor S4 is used, this can be clipped to the surface of the return pipe using 13mm spring tool clips (*Farnell-In-One* stock code 103-022). It is not critical for S4 to be in the water flow and the additional compression adaptors to enable this are not worth the effort. Pipe lagging will retain a uniform sensor temperature.

The only potential reliability issue with the BS/3 controller is likely to come from the output switching relays (Finder type 34.51.7.012.0310) after several years of use. (OK, as an Electronics Engineer, I often take a peek inside electronic gizmos to inspect the design, manufacturing and soldering quality). Switching inductive loads, like a pump, always results in long-term wear on switch contacts due to arcing. *Farnell-In-One* stock codes 414-3103 or 414-3152 are equivalent replacements for the relays. These cost under £5 each and can easily be changed by anyone with electronics repair experience and, if necessary, is a far more economic repair than a new controller.

However, for added reliability and peace of mind (read ‘over-engineering’), I elected to buffer both solar controller relays with higher current versions. One relay was required in any case for the heat-dump control via the BS/3 ‘R2’ output, so I used a second ‘slave relay’ for the solar pump via output ‘R1’. The additional relays used were *OMRON* MY2-230V plug-in types, *Farnell-In-One* 186-284, mounted in a 529-734 DIN relay socket, retained with a pair of 103-923 clips. *RS* stock codes for similar items are 488-1904, mounted in DIN-rail sockets 830-376. As plug-ins, these relays are easily user replaceable in the event of failure and are mounted in the main wiring terminal box. See *Appendix A* for system wiring diagram used.

Warning: Do **NOT** use a slave relay for any solar controller designed for speed control of the solar pump. This includes the *Resol BS/4* and the *Sorel TDC3*.

Electrical Installation

Part-P of the new Building Regulations prohibits uncertified electrical work in certain areas including addition of new circuits and work in bathrooms and kitchens. The latest amendment to Part-P coming into force in April 2006 states under ‘*Table 1, Additional note n’* that “*New central heating control wiring installations are notifiable even where work in kitchens and bathrooms is avoided*”. This is ambiguous in that installation of the solar system is an *addition* and/or *modification* to the existing circuit and is not a ‘new installation’ as such. Modifications to *existing* installations are permissible providing they do not include provision of a new circuit. Therefore the effect of Part-P on a solar installation is debateable - since the electrical supply can be taken from the existing feed for the central heating system or from the immersion circuit as required, and, when linked to the existing heating system, is technically a ‘modification’. Check with your *Local Council Building Control* to clarify your own situation before proceeding.

Main wiring terminal and relay box for combined heating and solar wiring

Where the heat-dump option is employed, as in this example, *it is essential* that the *solar controller* be powered from the *same isolator* as the *central heating system and boiler*. Since the controls are electrically interconnected, they *must* have a single common point of isolation for safety.

The illustrated connection box replaced the original Randall WC/3A wiring centre and was assembled using industrial terminal components - although any appropriately rated relays and terminal blocks are suitable. As already stated, the solar pump relay is not essential and was added for personal preference with a view to long-term reliability. The important regulatory point is that all mains connections (and relays where used) *must be inaccessible without the use of a tool* i.e. they must be located behind the cover of a box whose lid is only removable using a tool (e.g. a screwdriver). Cable glands are used to safely secure the flexible cables, the fixed cables entering via cutouts and protected by PVC mini-trunking. Two 3.15A fuses are also used – one each for the solar and boiler system power. In addition to fault protection, these also allow shutdown of boiler or solar circuits individually for repair or

Twin programmers and electrical control installation maintenance. Note that these are in addition to the 5A fuse feeding the complete installation via a switch-fused spur. A wiring diagram illustrating the connections for the components used is shown in *Appendix A*.

Heat Dump Mode Operation Description

The Heat Dump is controlled from the BS/3 'R2' output. When the cylinder reaches the limit temperature set by parameter '*AH0'*, relay R2 will operate. This operates the 'Heat Dump' double-pole-changeover type relay in the control box. With reference to *Appendix A*, it can be seen that one pole is wired so as to open the 'Domestic Hot Water' motorised valve. In turn, the valve initiates the central heating pump operation as normal. This circulates water around the boiler circuit, 'pulling' heat out of the cylinder via upper the boiler coil. I also re-plumbed the bathroom radiator direct to the boiler pump circuit to act as the dump load. Some systems may already be configured this way.

Of course, under normal circumstances, the boiler would also fire at this point – which is clearly undesirable since the object is to cool the cylinder, not heat it further. Therefore the normally-closed contact on the second pole of the 'Heat Dump' relay is utilised to disable the "call-for-heat" *switched-live* feed to the boiler. This prevents the boiler firing for as long as the Heat Dump mode is in operation - the shut-off temperature being set by the BS/3 '*AHF'* parameter.

Cylinder solar coil connections also showing 10mm pipes to bathroom radiator in foreground

It is highly unlikely that the central heating would be required at the same time as the heat dump is operational but clearly the cylinder would also dump into the heating circuit if the room thermostat were calling for heat at the same time.

I also modified the pipework to the bathroom radiator so as to connect it directly to the boiler circuit independent of the heating zone valves. This means that this radiator will act as a dump load but also will get hot whenever the boiler is heating the hot water only (and the central heating is off). In my case this is desirable since the bathroom is on the north side and can feel cold, even in summer.

Important: The original development wiring method described inhibited the boiler's 'pump over-run' function since the boiler pump must be controlled direct from the Zone Valves. In my installation this is not a problem since the boiler has never been run hot enough for the over-run to operate on the fully-pumped system.

Author's note March 2009:

The latest versions of the *System Wiring Schemes* downloadable files are designed to maintain the boiler pump over-run function and are suitable for all boilers employing a common neutral connection between boiler and pump.

There is now a new file specific to the *Alpha* CDR range of condensing 'heat only' boilers which utilise an electronic control pcb for the boiler and pump.

Initial BS/3 Solar Controller Initial settings

With reference to the *DeltaSol* manual, the *current* parameters (as of June 08) set in the described installation are programmed as follows:

Function	Description	Setting
Arr	System mode	Arr 2 (After-Heating mode)
OHQM	Heat quantity balancing	OFF
DTO	Switch-on temperature	7.5K
DTF	Switch-off temperature	4.5K
SMX	Maximum Store temperature	75ºC
EM	Collector safety limit temperature	130ºC
OCX	System cooling function	ON
CMX	Maximum collector temperature	115ºC
OCN	Minimum collector protection function	ON
CMN	Minimum collector temperature	18ºC
OCF	Collector anti-freeze function	ON
CFR	Freeze protection operating temperature	1.5ºC
OREC	Re-cooling function	OFF
OTC	Collector special tuning control function	OFF
AHO	Heat dump mode ON temperature	69.5ºC
AHF	Heat dump mode OFF temperature	69.0ºC
HAND	Operating mode	AUTO
HND1	Relay 1 mode	AUTO
HND2	Relay 2 mode	AUTO
LANG	Language	En

The ΔT values *DT0* and *DTF* set the temperature differential in degrees between collector and cylinder temperatures. The Kelvin K unit was initially confusing but effectively the value can be taken to be in degrees C. (since the Kelvin temperature scale is incrementally identical to Centigrade except that it is offset by -273ºC).

The higher the *DT0* value, the higher the temperature difference between manifold and cylinder before the pump turns on.

Increasing the difference between *DT0* and *DTF* will increase the pump run time. Similarly lowering the *DTF* turn-off value will extend the time taken to cool the manifold to the turn-off temperature difference. Be aware that too low a value for *DTF* may cause the pump to run continuously in warm weather. There is a trade-off between higher differential temperature (giving a higher rate of heat transfer) and the electrical (pump) energy consumption. Arguably it is more efficient to allow the manifold to heat up, dump that heat into the cylinder and then shut-off to repeat the manifold heating cycle. But a higher manifold differential takes longer to heat the manifold between pump runs, therefore less thermal energy may be transferred.

Higher values for DTO (8K-12K) improve efficiency where there are long pipe runs between the solar panel and cylinder. This helps to overcome the increased thermal losses on the pipework.

This system was run for the first year with DTO=5.5K and DTF=3.5K with the solar pump logging a total run-time of 1180 hours and the Heat Dump 6 hours. The DTO and DTF values have now been increased as in the table above for a comparison over the next twelve months.

Note: The *BS/3* controller uses the *upper* cylinder temperature sensor to detect the *AHF* Heat Dump shut-off temperature. This is somewhat wasteful of solar generated heat since the lower cylinder needs to be reduced to around 59ºC (on my cylinder, with *AH0* = 67.5ºC and AHF = 67.0ºC) in order to 'pull' sufficient heat from the top of the cylinder for S3 to detect a drop change of 0.5ºC. As a result, the dump radiator will be hot for a considerable time. To minimise the dump run time it is essential that the difference between AHO and AHF is only 0.5ºC. Important: Ensure that any thermostatic valve fitted to a single bypass Heat Dump radiator is set to **maximum** during summer!

Summary

Installation was as easy as expected, despite the fact that this was my first solar system installation. Providing the concepts of solar heating and the safety requirements of pressurised heating systems are understood, the installation of a solar system is no more difficult than any other central heating or plumbing job.

As of May 6th 2006 the system has been fully operational for a month or so. On cloudy, overcast days, the system reliably raises the lower cylinder temperature to around 35ºC – despite drawing-off hot water during the day. Thus in cloudy conditions, the cylinder still requires a 'top-up' from the boiler first thing in the morning.
Whilst 35ºC is not hot enough to use direct from the tap, it must be remembered that it is creating a major reduction in the quantity of heat input required from the boiler to finish raising the water to a useable temperature. Hence even with no sunshine, savings are still being generated.

Intermittent or hazy sunshine reliably achieves a lower cylinder temperature of around 42ºC.

The first continuously sunny day since installation occurred on 5th May 2006. The cylinder peaked at 62ºC at the top and 58ºC at the bottom. It provided ample hot water for two baths, one shower, one washing machine run - and several lots of washing up! The boiler did not cut-in all day.

As June progressed into July, the boiler was redundant for all but a few dull/rainy days.

After a one-week holiday at the end of June, the controller logged three hours run-time on the Heat Dump circuit (with *AHO* originally set to 67.5ºC).

This clearly demonstrates the efficiency of the system, and justifies the decision to install the Heat Dump capability for non-use (holiday) periods.

I am seriously impressed with the effectiveness of the system, even in cloudy conditions. It provides a top grade evacuated tube solution at less than the cost of a flat plate collector system. Even if you are not able to DIY, the fully installed cost ensures you are not fleeced for "going-green". Unlike higher priced competitors, there is a foreseeable payback period with the review system; and you are helping the environment and your reducing gas bill in the process.

Of all the renewable energy systems, solar water heating is currently the most cost effective and the prospect of renewable energy at home is within the economic grasp of everyone.

Author's note: With pricing reductions, solar PV panels and an immersion diverter may now be more effective for year round hot water generation.

References

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Plumbworld: http://www.plumbworld.co.uk/ Plumbworld.co.uk Ltd, 2, Millenium Court, Enterprise Way, Evesham, Worcestershire WR11 6GS

BES Ltd. http://www.bes.co.uk/ Unit 3, Junction 6 Industrial Park, Electric Avenue, Birmingham, B6 7JA 0800-801090 / 0121-322-6400

Newark Copper Cylinder Co. Ltd: https://www.newarkcylinders.co.uk/

Resol GmbH: http://www.resol.de/en/index.html

Horne Engineering Ltd: http://www.horne.co.uk/ 01505-321455

Armaflex: Armacell UK Ltd. http://www.armacell.com/uk

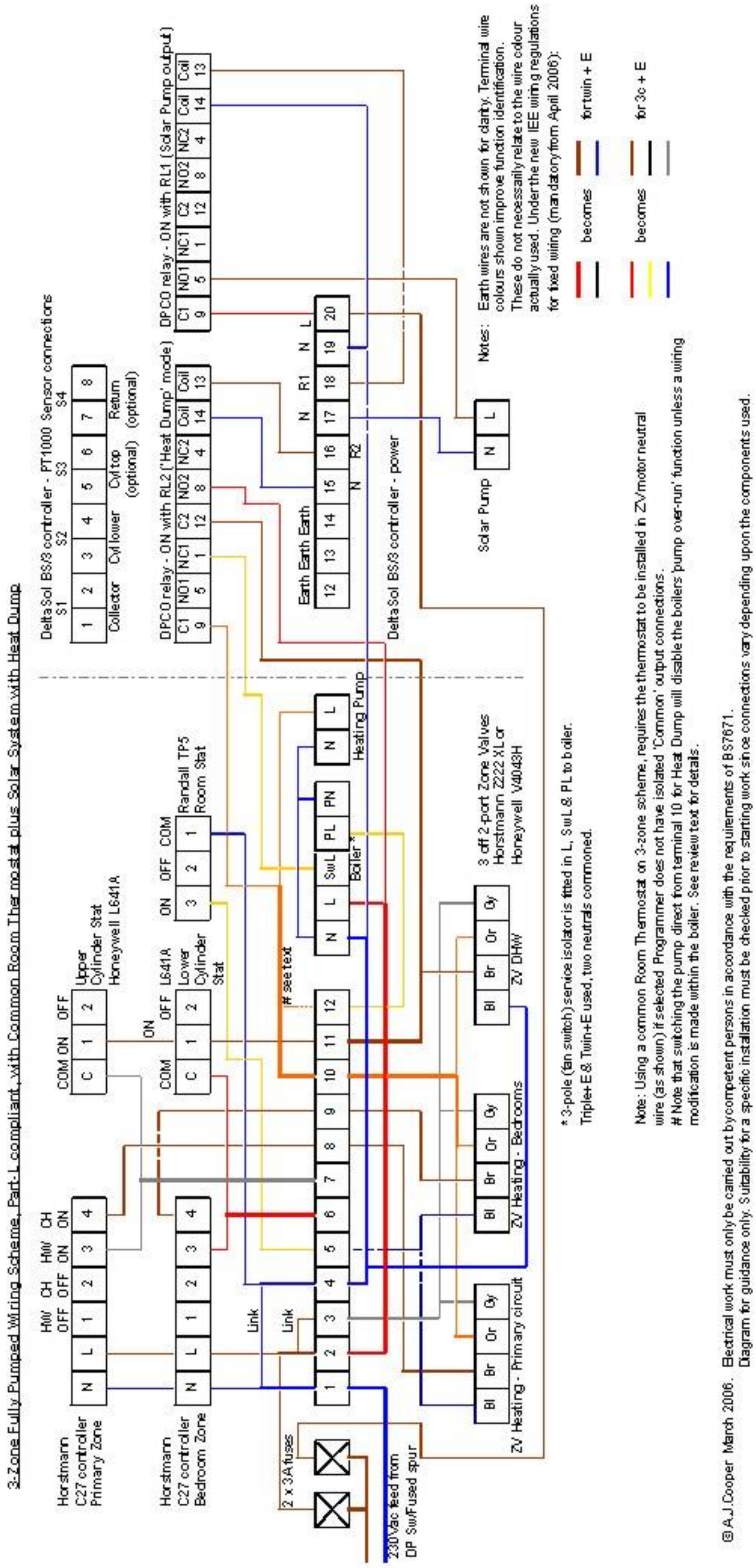
Climaflex: http://www.climaflex.com

Fernox: http://www.fernox.com

Building Regulations (Part L and Part P) can be downloaded from:
http://www.planningportal.gov.uk/approveddocuments

Appendix A

The wiring diagram specific to components used in this project, based on the *Honeywell S-Plan Plus* system, is reproduced below from the Excel™ spreadsheet master. Updated files are available for customising if required including alternative options for *S-Plan* and *Y-Plan* schemes. Do NOT use a slave pump relay on solar controllers capable of speed controlling the pump.



Update – April 2007

The system has now been in operation for a full year and the fourth-quarter gas bill since installation has been received. This allows a direct 'before and after' comparison to be made.

Gas consumption reduced by 5,400kWh in the year April 06 – March 2007. This equates to approximately 23% saving over the previous 2005-06 period. The savings over previous years is slightly higher but it must be remembered that UK winters are tending to become warmer so reduced use of central heating in the winter quarters must be taken into consideration when lauding the savings.

Actual cost savings worked out to around £120 year-on-year. But it must also be considered that as part of the package, I spent a further £300 updating the existing CH/DHW controls to meet full Part-L specification. Hence not all the savings can be attributed to the solar installation.

This saving also occurred during one of the hottest summers on record and when the gas prices were at their highest. Even compensating for these factors, it is still a very worthwhile return.

Putting this into context (for anyone sceptical about spending £1,200-£1,500 to upgrade their system), a £120 return on a £1,500 investment over 12 months equates to an interest rate of **8% tax free**. To achieve this sort of return you would either need to invest the same amount in an ISA at 8% or in a taxable account paying 10% gross – try doing that in your High Street Building Society!