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SOLAR HOT WATER

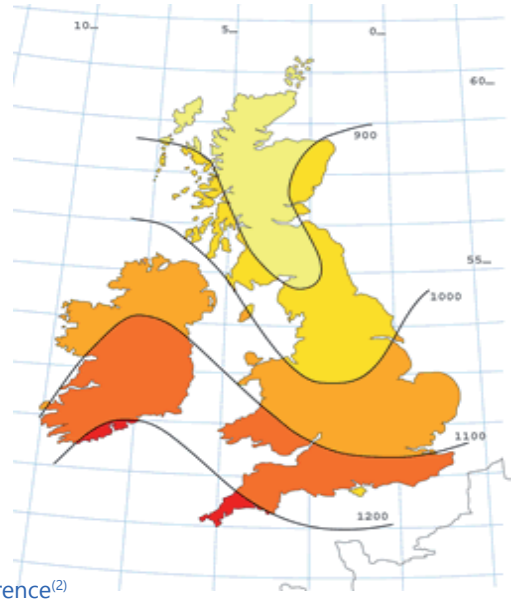
TARGET AUDIENCE & DESCRIPTION:
This document is intended for those unfamiliar with solar hot water technology. It is a general overview of the technology applicable to Scotland and provides signposting to sources of further information.

1 THE SUN AND SOLAR ENERGY

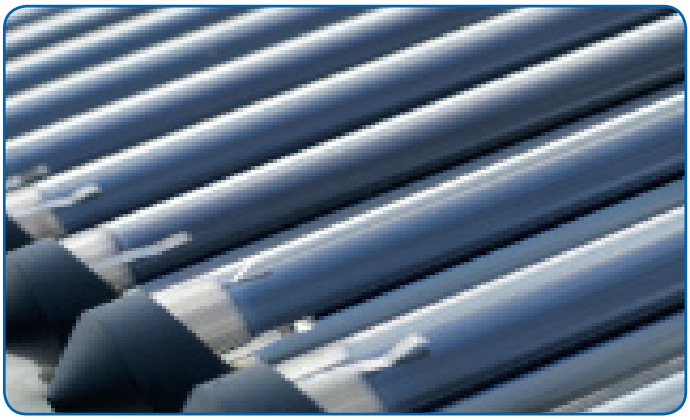
Solar energy in Scotland is far greater than most people imagine. In the summer, when car bodies are often too hot to touch we become aware of the Sun's heat. However, even in the spring and autumn and on clear winter days we receive very useful amounts of solar energy. By tilting a surface to an angle the amount of solar radiation falling on it will be greater than that falling on a flat surface. Fortunately, the average tilt of a house roof is about the optimum for receiving solar energy.

The map below shows the total average solar radiation falling on one square metre surface inclined at 30 degrees to the horizontal, measured in kilowatt hours. Scotland averages around 900kWh/m^2. The average property requires approximately 3,000 kWh per year for domestic water heating and it can be seen that the amount of solar energy falling on the roof of an average house will be significantly greater than that required to provide all its hot water[2].

However, we must note that there is a large difference between the radiation available in the summer and that available in winter; also systems will typically convert 40 to 50%[4] of the solar energy falling on the solar collectors into useful heated water. These factors must be taken into account in determining the optimum size for a system.



reference[2]



2 SOLAR HOT WATER SYSTEMS: WHAT ARE THEY & HOW DO THEY WORK?

Solar hot water (SHW) systems use solar panels, called collectors, fitted on the roof of a building to collect heat from the sun and use it to warm water stored in a hot water cylinder.

The systems normally work alongside a conventional water cyclinder and boiler to ensure year round hot water with the boiler (or an electric immersion heater) further heating the water until it reaches 60°C to avoid the growth of bacteria such as legionallae.

Systems have been available in the UK since the 1970's and the technology is now well developed with a large choice of equipment to suit many applications. A well-designed domestic system should provide almost all hot water requirements during the summer months and about 50% over a year[1].

Commercial facilities with high hot water demands and access to a good southern exposure can also be great candidates for solar hot water. Restaurants, bakeries, beauty salons, health clubs, and hotels are all potentially good sites. Anyone who operates a commercial swimming pool knows how expensive they are to operate. Pool heating typically provides the best payback for any solar option.

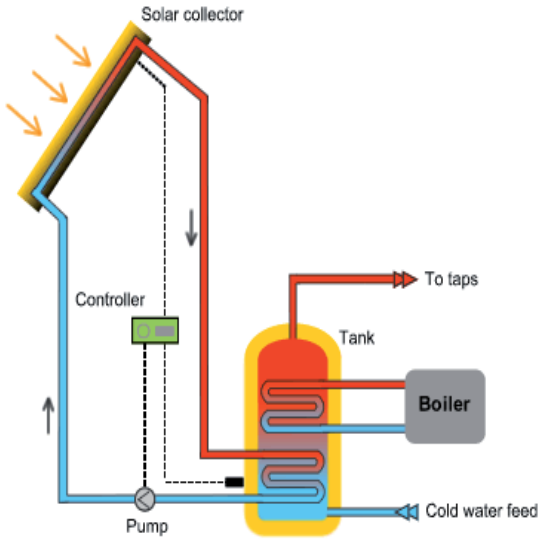
Besides heating domestic hot water and swimming pools, solar thermal collectors can heat just about anything from refrigerant to oil. In an industrial solar thermal process heat system the solar acts as a boiler or electric heater producing large amounts of heat at a reduced cost. The supplemental heat also lessens the load on regular heating equipment, which can lower maintenance costs and significantly extend

the life of equipment.

3 TYPICAL COMPONENTS

A solar water heating system typically comprises three main components:

- *Solar collectors:/Absorber plate:* These coated metal plates absorb and retain heat from the sun's radiation which causes its temperature to rise above the ambient. The plate then releases energy through radiation and convection to its immediate surroundings. Heat is transferred to a heat-transfer fluid within the collector which in turn feeds the hot water system.
- *Hot water cylinder(s) or buffer vessels:* Store hot water that is heated during the day and supply it for use later.
- *Plumbing system:* Made up of simple piping and sometimes a pump, which moves the heated fluid around the system and through the hot water cylinder.



A typical active solar heating system layout[3]

A typical ***active*** system is shown opposite. The different types of system are discused below.

4 TYPES OF CIRCULATION

Solar heating primary circuits transfer heat from the solar collectors to the pre-heat cylinder. They may be ***'Direct'*** or, in the UK, usually ***'Indirect'***.

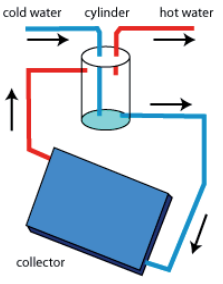
Direct circuits directly heat the water that flows from the household taps and although simpler and more efficient than indirect systems they are rarely used in the UK. They are subject to freezing unless water is drained-back when the pump switches off. This affects positioning of the collectors in relation to the feed tank. Also as water continually flows through the collectors, they can be prone to 'furring' in the collector waterways resulting in loss of efficiency. Most circulation systems in the UK are ***Indirect*** and use a separate 'heat-transfer fluid' circuit to transfer heat from the collectors to the pre-heat cylinder. Their main advantage is that they can employ a wide range of materials and fluids as part of the circulation.

For an ***Indirect*** system there are different types of circulation that can be used: ***Passive*** or ***Active***:

4.1 PASSIVE:

Passive indirect systems rely on gravity and the tendency for water to naturally circulate as it is heated, allowing water or heat-transfer fluid movement without pumps.

No electric components are present and as such, passive systems are generally more reliable, cheaper, easier to maintain, and longer-lasting than active systems.



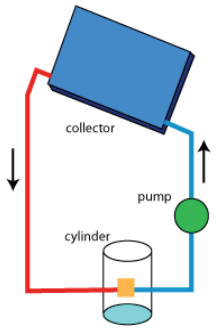
Passive Circulation[4]

They do however require careful planning to optimise performance, are prone to sluggish performance and poor control of over-heating.

There is also a need to locate the hot water storage tank above the collector level.

4.2 ACTIVE:

Pumped indirect systems, incorporating a heat-transfer fluid including anti-freeze and corrosion inhibitor, are the most popular type in the UK. The pump, controlled by a differential temperature controller, circulates the heat-transfer fluid from the collector panels through the heat exchanger in the hot water cylinder and back to the solar collectors for re-heating.



Active Circulation[4]

The temperature sensors of the differential temperature controller are situated at the solar collector and on the hot water cylinder. They ensure that fluid is only circulated when the fluid in the collectors is hotter than in the cylinder. The system has integral protection against freezing and overheat control and has a greater choice of collector and pipe layout. However it is more complex and expensive than a passive system and also uses electricity for the pump, although this can be alleviated by a microgeneration supplies.

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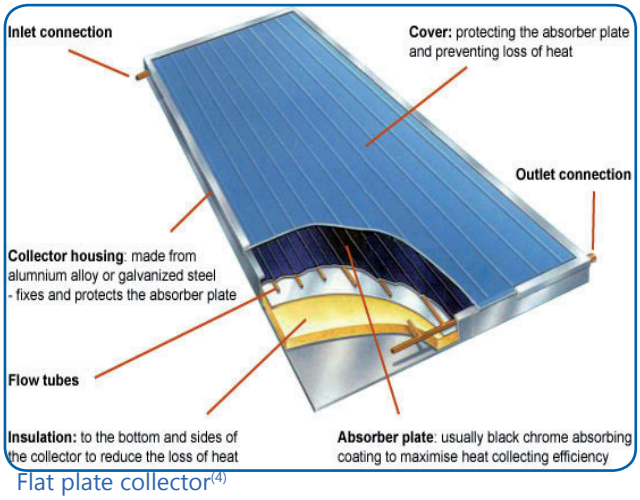
5. TYPES OF COLLECTORS: Collectors fall into two general categories:

5.1 FLAT PLATE COLLECTORS:

A flat-plate collector consists of an absorber, a transparent cover, a frame, and insulation. Usually an iron-poor solar safety glass is used as a transparent cover, as it transmits a great amount of the short-wave light spectrum. Only very little of the heat emitted by the absorber escapes the cover (greenhouse effect).

In addition, the transparent cover prevents wind and breezes from carrying the collected heat away (convection). Together with the frame, the cover protects the absorber from adverse weather conditions. Typical frame materials include aluminium and galvanized steel; sometimes fibreglass-reinforced plastic is used.

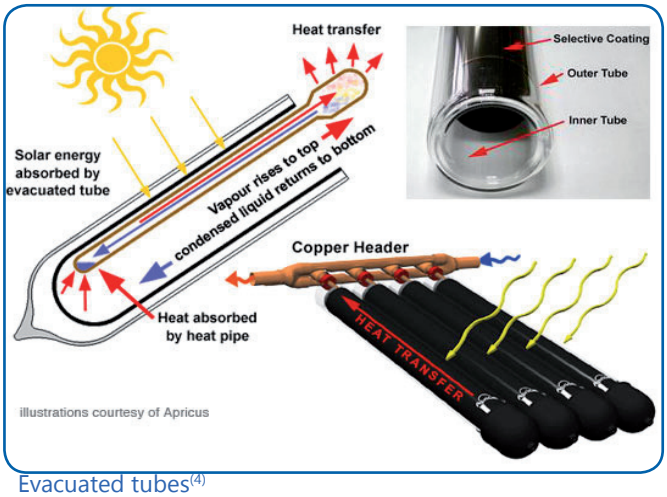


Flat plate collector[4]

The insulation on the back of the absorber and on the side-walls lessens the heat loss through conduction. Insulation is usually of polyurethane foam or mineral wool.

5.2 EVACUATED TUBES:

This system is a series of highly insulated glass tubes grouped together. The absorber strip is located inside the evacuated and pressure proof glass tubes. The heat transfer fluid flows through the absorber directly in a U-tube system. Several single tubes, serially interconnected, or tubes connected to each other via manifold, make up the solar collector. The Glass tubes incorporate a special fluid which begins to vaporize even at low temperatures. The vapour rises in each heat pipe and warms up the carrier fluid in the main pipe by means of a heat exchanger. The condensed liquid then flows back into the base of the heat pipe. The pipes must be angled at a specific degree above horizontal so that the process of vaporizing and condensing functions.



Evacuated tubes[4]

Evacuted tubes offer the advantage that they work efficiently with high absorber temperatures and with low radiation.

5.3 FLAT PLATE VS EVACUATED TUBE

Evacuated tube collectors, though much more expensive than flat plate collectors, achieve both higher temperatures and higher efficiencies. They perform well in both direct and diffuse solar radiation. This characteristic, combined with the fact that the vacuum minimizes heat losses to the outdoors, makes these collectors particularly useful in areas with cold, cloudy winters. Also because of the circular shape of the evacuated tube, sunlight is perpendicular to the absorber for most of the day. For comparison, in a flat-plate collector that is in a fixed position, the sun is only perpendicular to the collector at noon.

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6 DESIGN & INSTALLATION.

Ideally, for best performance any SHW system should face between southeast and southwest, and have an angle of tilt of 30-45 degrees to the horizontal for the UK; arrays should not be angled towards the north. Shading should also be kept to a minimum. For a typical domestic property you will need to consider:

Selecting the system and collector type

Refer to the previous information to select system type. A compatible boiler will also be required. Most conventional boilers and hot water cylinder systems are compatible with solar water heating. If your boiler is a combination boiler (combi) and you don't currently have a hot water tank then a solar hot water system may not be compatible.

Locating the collectors & available roof area:

2-6m^2 of southeast to southwest facing roof that receives minimal shading during the main part of the day will be required. Alternatively, if you have space, you could install two panels, one facing east and one facing west - but this will make installation more complex and costly.

The collector should be positioned to give optimum all year round energy collection is roughly south facing and at a tilt of 35 degrees to the horizontal. The orientation and tilt angle will usually be determined by the roof angle. Collectors can face anywhere between south, south east and south west and have tilt angles commonly found on roof of UK houses ie 15 – 50 degrees without losing more than 5% of optimum annual energy collection. Shading from trees, buildings etc. can produce significant losses in system efficiency and should be avoided.

The type & size of storage cylinder

You will need space to locate a larger or additional water cylinder if required. The choice is between a single cylinder with twin coils (vented or unvented) or the placement of a distinct pre-heat tank before the conventional cylinder. Mains pressure (un-vented) cylinders and thermal store (pre-heat) cylinders are more expensive than vented cylinders but they enable the hot water to be maintained at the same pressure as the mains supply. Allow for 40 - 60 litres / person / day. Allow a minimum of 80 and preferably 100 litres storage per m^2 of collector. A typical size for a family of four will be between 200 and 300 litres.

The pipe line & circulation pump

Piping is required to route and control the flow of heat transfer fluid between various components of the solar subsystem. Pumps should circulate heat transfer fluid at the design flow rate with minimum expenditure of electrical energy.

Other considerations

Where there is a shortfall, usually in winter, provision of an alternate supply of DHW will be required. There will be a number of options which will vary from electrical immersion heaters in the cylinder through to gas or biofuel powered boilers. If opting for electrical heating, consideration should be paid to the carbon cost of grid provision.

It should be ensured that there is at least 100mm of insulation around the hot water cylinder and that all pipework is insulated. All fabric penetrations should be sealed to avoid air leakage and penetrations of the roof fabric should be carefullly detailed to avoid water ingress.

7. PLANNING PERMISSION

In the UK most solar water heating systems don't need planning permission, but exceptions apply for Listed Buildings, and buildings in Conservation Areas and World Heritage Sites. You will need to consult your local authority.

8. PERFORMANCE & MAINTENANCE

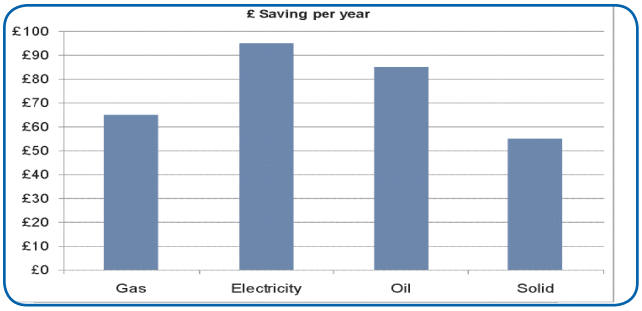
Maintenance of SHW systems is low, consisting of an annual check by the householder and a more detailed inspection and replacement of anti freeze by an engineer every 3-5 years.

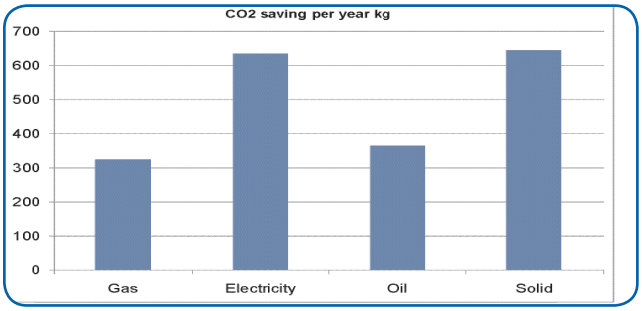
9. COSTS, SAVINGS AND $C0_2$

Costs vary due to a range of factors such as size of collector, type of roof, existing hot water system and geographic location. A significant proportion of the cost of a solar thermal hot water system is the collectors themselves, with the simpler flat plate design being less expensive. The price of a typical domestic solar thermal system (2-3 panels) installed and commissioned therefore, should be approximately:

Flat plate system	£2,000 - £4,000[5]
Evacuated tubes	£3,000 - £5,000[5]

Savings are moderate - a solar water heating system can provide about a third of your domestic hot water needs, reducing your water heating bill by between £50 and £100 per year. It will also save up to 645kg of CO_2 emissions, depending on what fuel you will be replacing.[6]





All savings are approximate and are based on the hot water heating requirements of a 3 bed semi detached home.[6]

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10. PAYBACK

The payback period varies significantly, as solar hot water systems are customized to individual buildings.

Factors that influence the payback period include:

- new building vs. retrofit (existing);
- Capital cost of the solar system;
- Size and energy efficiency of the hot water system the solar system is replacing.

In addition, premium system options may be selected which increase the total cost of the system relative to a conventional hot water system.

To calculate payback, you will need:

A System capital cost.

B Base system installed cost (e.g. electric water heating or natural gas)

C Annual energy savings as a result from switching to a solar system.

Simple payback formula: Payback in years = (A – B) / C.

Typical paybacks in the UK are usually around 10 years or less.

11. FUNDING

Grants are available to help with the costs of installing renewable and low carbon technologies. To be eligible for a grant you will need to use a certified installer and product Further information on grants & how to find a certified installer/product can be found under 'Signposting'.

12. SUMMARY

Many tens of thousands of solar domestic water heating systems are estimated to be used currently in the UK. Although in terms of wider use of solar water heating in Scotland there is a lack of positive influence by potential promoters such as architects and other building professionals. This is largely due to a lack of awareness and an insufficient availability of information regarding the technology among these professionals. Wider circulation of information could increase both professional and public awareness to make the technology mainstream.

Around 50% of annual household hot water needs can be produced by solar thermal, and provide at least 20 years' useful service. Other benefits include:

- Quick and easy installation, with little disruption to the household
- Free hot water generation
- Compact area requirement: 2-6 m^2 suitable for up to an average four-bedroom house (two flat plates or around 20 evacuated tubes)
- Long component lifetime
- Low maintenance
- Variety of installation methods including roof integrated.

Solar water heating has environmental benefits, which should be made clear in publicity and information material. Many people do not see it as modern or relevant to them. SWH is a way for the general public to 'do their bit for the environment'; it is not just for enthusiasts.

REFERENCES

No.	DESCRIPTION	LINKS
1	Solar Water Heating Factsheet	http://www.savenergy.org/pdf/EST_RE_Factsheets_05/Solar_Thermal.pdf
2	Solar Energy - The UK's large solar energy resource	http://www.solar-trade.org.uk/solarenergy/ukresource.htm
3	Solar Energy - How do Active Solar Heating systems work?	http://www.solar-trade.org.uk/solarenergy/how-work.htm
4	Circulation Systems (Indirect distribution)	http://www.greenspec.co.uk/html/energy/solar-collectors.html
5	Solar water heating factsheet	http://www.savenergy.org/pdf/EST_RE_Factsheets_05/Solar_Thermal.pdf
6	Solar water heating costs & savings	http://www.energysavingtrust.org.uk/Generate-your-own-energy/Solar-water-heating
7	University of Strathclyde: Active Solar Technology	http://www.esru.strath.ac.uk/EandE/Web_sites/01-02/RE_info/active_solar.htm#Conclusions

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SIGNPOSTING

GENERAL

TITLE	DESCRIPTION	LINKS
Renewable energy Factsheet: Solar Water heating	Energy Saving Trust factsheet 1	http://www.savenergy.org/pdf/EST_RE_Factsheets_05/Solar_Thermal.pdf
Solar Water Factsheet	Energy Saving Trust factsheet 2	http://server-uk.imrworldwide.com/cgi-bin/b?cg=businessdocs&ci=energyst&tu=http://www.energysavingtrust.org.uk/content/download/280455/801557/version/1/file/FINAL+solar+water.pdf
Solar Water Heating	Energy Saving Trust. Information on Solar Water heating	http://www.energysavingtrust.org.uk/Generate-your-own-energy/Solar-water-heating
Solar Hot Water Collectors	Greenspec information on solar hot water collectors	http://www.greenspec.co.uk/html/energy/solarcollectors.html
Solar Hot Water Systems: Guidance for professionals, conventional indirect models	Produced by the Energy Saving trust, this guide is designed to help installers, specifiers and commissioning engineers ensure that conventional indirect solar domestic hot water systems (SDHW) comply with current UK standards, regulations and industry best practice.	http://www.greenspec.co.uk/documents/energy/EST-solarWaterHeating.pdf
The Solar Trade Association Ltd. (STA).	Promoting Solar Thermal in the UK. The Solar Trade Association Ltd. (STA) is a company limited by guarantee, having been formed in 1978 to serve as a focal point for organisations with business interests in the Solar Energy industry. Those interests cover thermal applications, such as the production of domestic or industrial hot water or the heating of swimming pools.	http://www.solar-trade.org.uk/
Solar Thermal Hot Water Systems	Eco Centre Guidance on Solar Hot Water	http://www.ecocentre.org.uk/solar-hot-water.html
BRIEFING ON SOLAR WATER HEATING	For The Royal Society of Edinburgh	http://www.ma.hw.ac.uk/RSE/enquiries/energy/evidence/Genersys.pdf
Urban Solar Water Heating	University of Strathclyde: Urban Solar Water Heating	http://www.esru.strath.ac.uk/EandE/Web_sites/01-02/RE_info/active_urban.htm
Active Solar	University of Strathclyde: Active Solar Technology	http://www.esru.strath.ac.uk/EandE/Web_sites/01-02/RE_info/active_solar.htm

MANUFACTURERS & INSTALLERS

Please note the SCC does in no way endorse or recommend any manufacturer or installer. If you feel your company should be listed here please contact us.

TITLE	DESCRIPTION	LINKS
Green Book Live	Find certified products	www.greenbooklive.com/page.jsp?id=131
Low carbon Building Programme	Find an Installer	www.lowcarbonbuildings.org.uk/info/installers/find/installerfind
Solar Energy Businesses in Scotland	Solar Energy Businesses in Scotland	http://energy.sourceguides.com/businesses/byP/solar/byGeo/byC/Scotland/Scotland.shtml