

# BRIEFING ON SOLAR WATER HEATING

## For The Royal Society of Edinburgh

by Robert Kyriakides, Genersys plc  
37 Queen Anne Street London W1G 9JB

1. Basic Concepts
2. Types of Collector
3. Types of System
4. Heat Systems
5. Feasibility
6. Sustainability
7. Capacity
8. Energy Balance
9. Infrastructure Requirements
10. Timescales for Development
11. Financiabilty
12. Estimates of costs
13. Economic impact
14. Environmental impact
15. World Perspective



## 1. Basic concepts

Solar water heating simply converts light into heat and uses the heat to heat water. It is a very mature technology, which has been used for over eighty years; although in that time there have been many improvements.

The efficiency of systems should not be judged by the conversion of light into heat; all modern solar water heating systems convert almost identical amounts of light into heat and as the source of light is free, efficiency by conversion rates is not helpful.

Modern European test standards for solar panels or collectors (EN 12975 1 & 2) reflect the need to have a durable long lasting product that requires little maintenance.

Most people still do not appreciate that solar panels work well in the diffuse radiation emitted on a cloudy day. Although direct sunlight makes the panels work more quickly, direct sunshine is not essential.

Two issues have to be catered for in system design; panels can overheat and provide water that is too hot, particularly in summer, and because panels are roof mounted, the issue of freezing has to be overcome. A great advantage of using solar thermal systems is that the heat energy can be stored. For this reason, most designs of solar systems provide for a much larger than usual hot water cylinder so that on average about twice the daily consumption of hot water is stored.

## 2. Types of Solar Panels (also called “collectors”)

There are two types of solar panels. The most widely used type is the flat-plate panel. This is usually a glazed insulated panel containing an absorber surface designed to convert light into heat. The absorber surface is connected to a meandering system of pipes so that heat is collected in the absorber surface and conducted into the pipes.

The second type of solar panels is a series of evacuated tubes. Each tube contains an absorber plate and a pipe. Heat is transmitted into the pipe and then into a manifold. The vacuum is usually more efficient at preventing heat losses than insulation.

Both types of panels work in exactly the same way; vacuum tubes are helpful where space is at a premium but tubes do fail and need to be replaced. Vacuum tubes were invented in Germany and were originally very popular, but their share of the German market has fallen consistently over the past ten years. In 2003 vacuum tubes constituted 18% of the market with flat plate 82%; in 2004 vacuum tubes fell to about 10% of the market.

## 3. Types of Solar System

There are three types of modern solar systems.

First, there is a gravity fed thermo-siphon system. These are common in Greece, Cyprus and Israel. A Panel is mounted above a hot water store and the whole apparatus roof mounted. Water pressure fills the cylinder with cold water and the solar panel is connected to it to heat the water. These systems are very popular in hot countries because they are cheap. Freeze protection is not usually an issue in the places where these systems are installed. They do not work terribly well, even in hot countries, and have almost no application in the United Kingdom.

The second type of system is a direct system; it comprises a panel through which the potable water flows and as the water is pumped through it the panel to heat it. The potable water is stored in a cylinder. There is usually a regulator to prevent water flow when very hot temperatures are reached. Freeze protection is catered for by the regulator switching off the pump and the pipe-work used being plastic, which is designed to be freeze tolerant. These systems, which run the potable water through the panels, have, in most solar engineers' opinions two deficiencies. First, running potable water through the panels requires in most cases some system of water softening to prevent panel corrosion and/or liming. Secondly, there can be an enhanced risk of legionella in certain conditions.

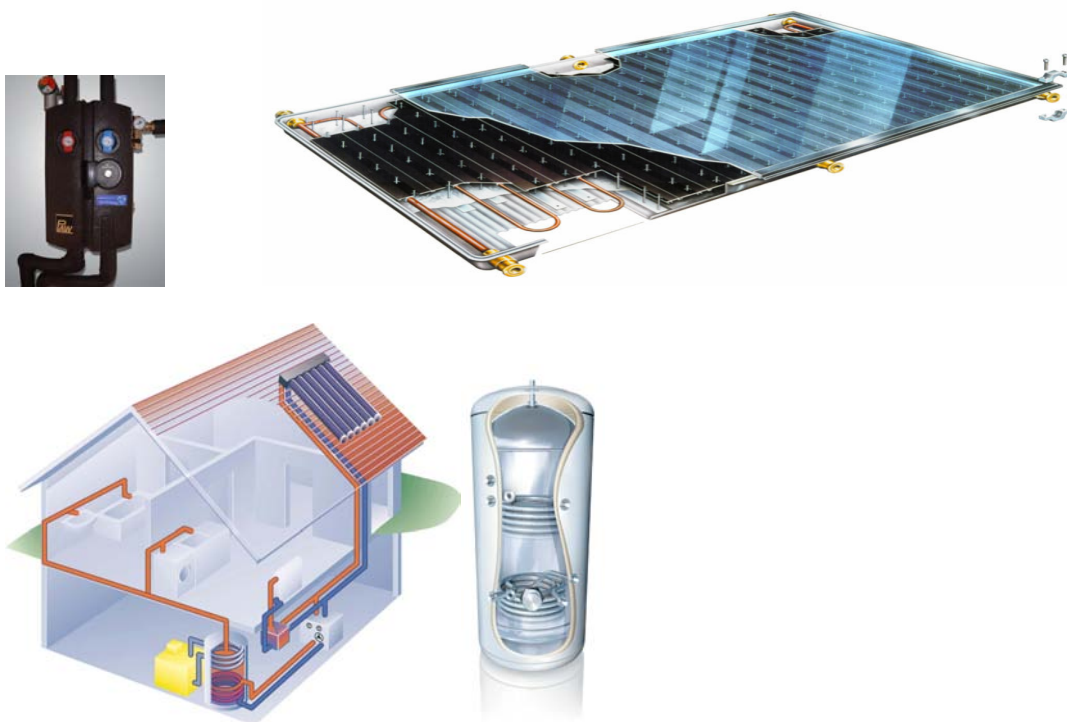
The third type of solar systems are those that work using heat exchange – the potable water does not enter the panel at all and some form of heat exchange operation transfers the heat to the potable water. The heat exchange fluid is pumped, which requires small amounts of mains electricity – probably no more than about £7 worth a year. Heat exchange based solar systems are in turn subdivided into two categories; those that drain back and those that are fully pressurised.

Drain back systems were designed in the 1970s as a solution to prevent panel damage by freezing. When a certain temperature is reached (usually 3 degrees Celsius) the system stops collecting heat and the fluid in the panels drains into a small container, so that pipe work is not damaged. When outside temperatures rise again, the panel is refilled and heat is exchanged into the cylinder.

Drain back systems were invented in order to overcome the need to put anti-freeze into the heat exchange circuit. In the 1970s the most available form of anti-freeze was car anti-freeze, which is carcinogenic and dangerous. Similarly, if the system overheats, the fluid also drains back preventing damage by over reheating. Drain back systems became very popular in Holland where in the 1970s the water authorities prevented draining car anti-freeze into the water system. These systems are robust but suffer from two disadvantages; they do not work in cold weather and stop working in hot weather.

The most popular systems in Northern Europe are pressurised pumped systems that do not drain back. These are proven and are a mature technology.

The following is a schematic for such a system.

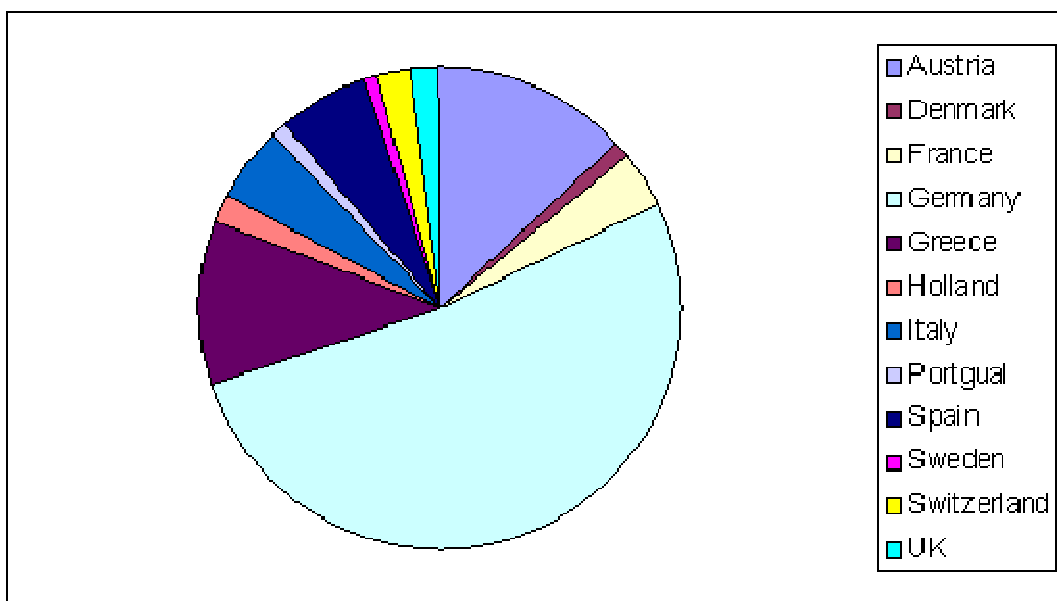


Fully pressurised systems do not drain back because they are filled with a glycol propylene mixture (food safe and edible) which acts as an antifreeze. Accordingly the strength of the mixture freezing can be protected to very low temperatures. The default for the UK protects down to -30 degrees Celsius. Systems are pressurised up to 4 bar. This raises the evaporation point of the glycol considerably. These systems can, subject to demand and light availability, provide hot water in very cold and very hot conditions.

Heat exchange systems are very sophisticated now. The heat exchange operation is regulated by a digital controller automatically, often with the pump modulating to provide the most efficient heat exchange available according to panel temperatures and hot water demand.

The following illustrates which European countries bought the most thermal solar systems in 2004. It should be noted that German and Austrian systems are almost wholly fully pressurised pumped systems, whereas Greek systems are mainly thermo siphon gravity fed systems. Italian and Spanish systems were originally thermo siphon systems but now fully pressurised heat exchange systems are preferred.

If you are buying into this technology, I submit that it makes sense to follow the best practice of the countries that have real experience of the technology.



#### 4. District Heating Systems

Solar panels have been successfully used in Denmark to provide large scale district heating schemes. An annex is attached which explains as a case study two District Heating Systems in Denmark.

#### 5. Feasibility

All solar systems are feasible for use in Scotland and indeed we have provided systems which have successfully installed and are in use in Scotland. However, they can never be regarded as a sole source of heat energy for hot water.

In Scotland there will be little difficulty in a good solar system providing over 50% of a household hot water demands free. Figures of between 60% and 70% are probably typical. Most homes find that they can switch off the fossil fuel in the summer. For the rest of the year the system will make a viable contribution to water heating, but the short winter days prevent systems from providing a 100% solution.

Of course, every household can use hot water in different ways and actual lifestyle can make a difference to the percentage of hot water obtained and the benefits for the household.

## 6. Sustainability

Good thermal solar systems should be designed to be as much of the house infrastructure as a chimney or a roof. Typical panels are made from aluminium, copper and glass, all of which are in plentiful supply and easily recycled at the end of the product life. Some panels, (usually those made in the USA) use black chrome for the absorber plate, which is in our view environmentally dangerous. Good panels will use sustainable materials for the absorber plate and its coating, typically aluminium or copper and oxides of them.

The remaining parts of the system should be are manufactured from sustainable recyclable materials. In the case of pressurised pumped systems they will generally be made from copper and brass and sometimes from steel. In the case of direct systems panels and their constituents are often made from plastic compounds which are oil dependent and difficult to recycle.

Our panels recover the energy used in their production and installation in about two years but have an estimated life span of 35 years.

## 7. Capacity

There is a modest manufacturing ability for solar panels in the UK; most of the facilities rely on hand building flat plate panels and are limited by a very tiny market. There is good evacuated tube manufacturing capacity in the UK but huge numbers of tubes are made in China where they are used widely for water heating. There is high evacuated tube capacity in Germany as well.

Flat plate panel manufacturing capacity is mainly located in Europe, with Germany and Slovakia having the highest production facilities. Our plant in Slovakia made around 40,000 panels in 2004, most of which were used in Germany. Production potential from this automated plant is significantly higher but without, for example a large UK demand there is no reason to significantly increase production.

Genersys/ThermoSolar have around 25% of the German and Austrian market. If the UK market were as large as the German market and our market share (which is around 25% in the UK) were maintained then there would be no difficulty to supplying the market. The real barrier to capacity is lack of demand, not lack of ability.

## 8. Energy Balance

This is critical in our view to any energy policy. No renewable source of microgeneration should be considered as a 100% solution although there is potential for individuals to create homes which are wholly self energy producing, this is expensive and impractical for the mass market.

Solar water heating has a significant part to play in providing a sustainable energy balance but one that is largely ignored. Households create about 30% of the UK's carbon dioxide emissions and probably a higher percentage in Scotland with more homes off the gas grid and colder weather. Water heating accounts for about 24% of the household carbon output. Good solar systems can save at least half this figure so that 12% of 30% savings of a country's carbon emissions can be made in every home were fitted with solar water heating. It is not a panacea but an important and neglected contribution to an overall balance of energy.

## 9. Infrastructure Requirements

Solar water heating does not have to be grid connected and does not require a dependency upon any centralised system. It is a micro-generated form of energy which is local and enables users to be a little more energy independent.

There are requirements that are economic and educational and in so far as these are infrastructural I shall deal with them here.

Most homes connected to the gas and/or electricity grids are benefiting from an infrastructure in place and mainly paid by the tax payer over the period when the infrastructure was developed. This gives the fossil fuel energy business an advantage in that the present costs do contain the hidden infrastructural subsidies.

Solar water heating, in order to compete, needs a levelling of the playing field. How this is done is a matter for policy, but in our view, drawing on the high take up of solar water heating in Austria, tax credits for consumers that install solar water heating is probably the best and fairest way to encourage take up and level the playing field.

The other infrastructural requirement is educational. The greatest part of the cost of a solar thermal system by far is the installed cost. By training specialist installers installation costs can be greatly reduced. We do train installers but unless they have a sufficient flow of installation work some of the skills are lost and the installers need re-training.

Finally ensuring that new homes have roof pitches which are south facing would ensure optimum efficiency when fitting solar thermal systems.

## 10. Timescales for Development

The technology is mature and ready to use. There are a number of trained installers in Scotland who would develop their businesses according to demand.

Once the skills for domestic water heating have been learned the market would likely develop skills for domestic space heating systems, which are becoming increasingly popular in Germany, as well as more commercial projects such as pool heating and water heating for industrial processes.

## 11. Financiabilty

The cheapest way to install solar thermal is to do so when a building is being constructed. The cheapest way to finance a system is for the consumer to add the

cost on to his or her mortgage. That way the overall cost of the system in terms of monthly repayments would be less than the additional mortgage expense incurred.

## 12. Estimates of costs

A typical Genersys system costs £1,180 for all the equipment except a hot water cylinder. Hot water cylinders may add another £230 to the cost. Typical Scottish installation costs on retro fitting are around £1500. On new build the costs should be not more than £800. The Scottish market is such that a flat price structure for product exists; no-one is taking sufficient volume to justify discounts and no one is holding any significant stocks.

### Genersys Payback Analysis for UK Home Users

#### Assumptions

Fuel inflation	8.0%
General inflation	2.5%
Performance of DHW Water Heating as Percentage of fuel bill	60.0%
	24.0%

Current Cost Elements	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14
Gas electricity and other Fossil Fuel Costs	1000	1080	1166	1260	1360	1469	1587	1714	1851	1999	2159	2332	2518	2720
Boiler Servicing	120	123	126	129	132	136	139	143	146	150	154	157	161	165
<b>Total annual cost</b>	<b>1120</b>	<b>1203</b>	<b>1292</b>	<b>1389</b>	<b>1493</b>	<b>1605</b>	<b>1726</b>	<b>1856</b>	<b>1997</b>	<b>2149</b>	<b>2313</b>	<b>2489</b>	<b>2680</b>	<b>2885</b>
<b>Cumulative cost</b>	<b>1120</b>	<b>2323</b>	<b>3615</b>	<b>5004</b>	<b>6497</b>	<b>8102</b>	<b>9828</b>	<b>11685</b>	<b>13682</b>	<b>15831</b>	<b>18144</b>	<b>20633</b>	<b>23312</b>	<b>26197</b>
<b>Genersys System Cost Savings</b>														
Fossil Fuel Saving	144	156	168	181	196	212	229	247	267	288	311	336	363	392
Boiler Servicing (Saved due to reduced usage)	24	25	27	29	31	33	36	39	42	46	49	53	57	62
Boiler Replacement Saving	37	37	37	37	37	37	37	37	37	37	37	37	37	37
<b>Total annual saving</b>	<b>168</b>	<b>180</b>	<b>195</b>	<b>210</b>	<b>227</b>	<b>245</b>	<b>265</b>	<b>286</b>	<b>309</b>	<b>333</b>	<b>360</b>	<b>389</b>	<b>420</b>	<b>454</b>
<b>Cumulative Saving</b>	<b>168</b>	<b>348</b>	<b>543</b>	<b>753</b>	<b>980</b>	<b>1225</b>	<b>1489</b>	<b>1775</b>	<b>2084</b>	<b>2417</b>	<b>2777</b>	<b>3166</b>	<b>3586</b>	<b>4040</b>

Note: in the lifetime of the solar system the user will have at least two boilers



### 13 .Economic impact

There are genuine savings for the consumer which can be as high as £350 a year.

However, a vibrant competitive and significant solar thermal market in Scotland would create jobs in (a) installation of systems (b) selling of systems (c) distribution of systems and finally in (d) servicing systems.

Of these the large job market would be for installing systems. Retro fitting a solar system usually takes less than two days for two trained people. Companies in Scotland who would be sure of securing installations of more than five systems a week would invest in a work force. Companies who can be sure of installing 100 systems a week would develop a successful trained work force which would significantly reduce the installation cost. These additional jobs would greatly benefit employment, particularly in rural and semi rural areas and help local economies.

Installers would then naturally develop the skills to look for larger solar projects, such as pool heating, district heating and space heating.

### 14. Environmental impact

Installed solar systems would save at least half a tonne of carbon dioxide each year. They would also save the particulate pollution that happens when heating oil is burnt for water heating, the sulphur and acidic rain pollution that occurs when all fossil fuel is used for water heating, making a contribution to a cleaner healthier atmosphere.

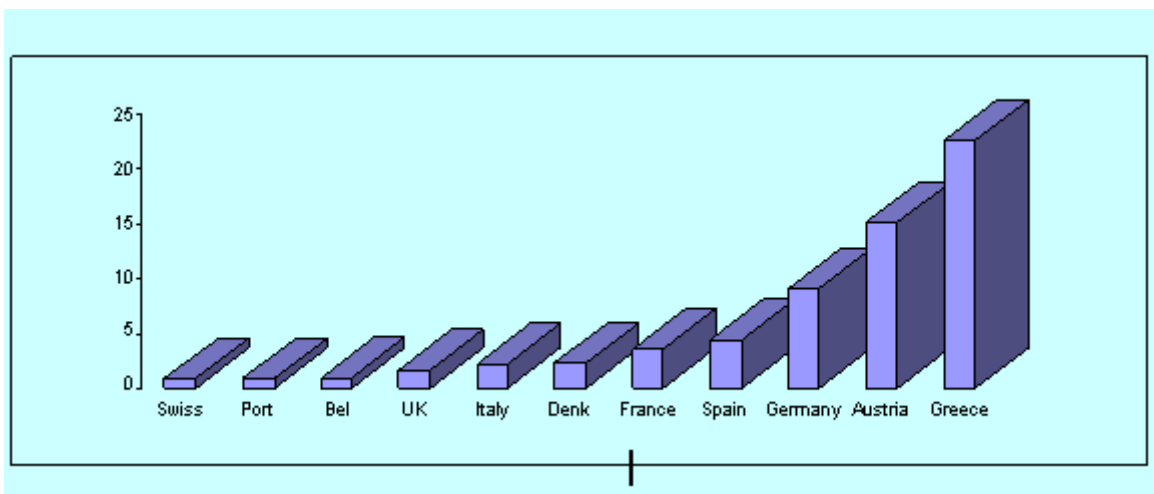
Panels are very unobtrusive compared with other renewable energy generating systems; we have had them fitted to homes in the Lake District National Park. They can now be integrated on all roofs, giving a ground level appearance of a large Velux window or series of them. Most installations will need between four and six square metres of roof space.



## 15. World Perspective

It should be appreciated that all solar thermal businesses are small, some very small, by national standards of energy producing businesses. Scotland accounts for about 8% of our sales in the British Isles. In terms of England the take up is higher when expressed as systems per 1000 population but it is lower than the take up in the Republic of Ireland, which accounts for about 20% of our sales.

The following illustrates the installation of solar thermal systems expressed in terms of 2004 new installation per 1000 inhabitants:



Square metres perinhabitant

There is a large scale deployment of thermal solar in China and some deployment in Japan and Australia but the figures are not known to me in these markets. Very few other countries have any significant thermal solar sales, although we have launched a joint venture in Mexico, and are developing markets in Korea, Chile Bolivia and the USA.

In all the circumstances, thermal solar should be seen as a viable source of independent energy for all countries. All nations should put in place the policies necessary to encourage and reward its take up, as the source of renewable technology that is used first and foremost.

I would be very pleased to attend the Inquiry and answer any questions arising out of this brief report.

30<sup>th</sup> November 2005

