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Information paper – 23
Solar hot water types and efficiency

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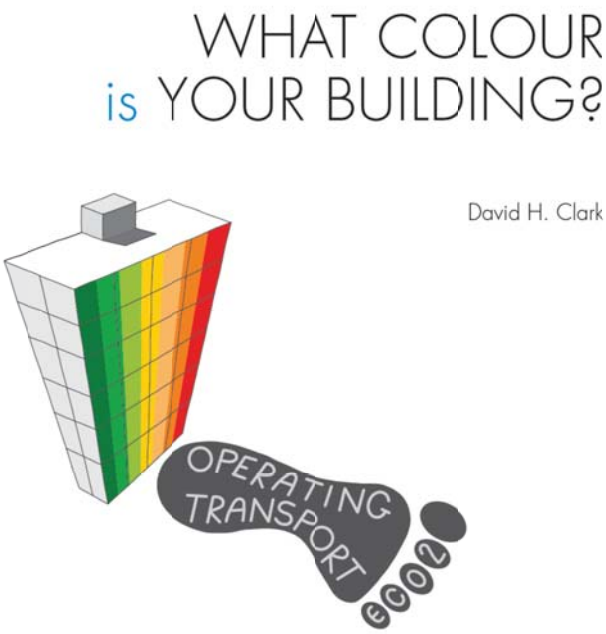

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This information paper is one of a series of papers written during the preparation of the book **What Colour is Your Building?** (www.whatcolourisyourbuilding.com). The papers do not form part of the book and have not been peer reviewed. They provide further technical detail, analysis and information to support statements made in the book. All of the papers can be downloaded from www.wholecarbonfootprint.com.

Solar hot water types and efficiency

This information paper provides a brief overview of the efficiency of different types of solar hot water systems – flat plate collectors and evacuated tubes.

1. TYPES OF SOLAR COLLECTOR

There are two main types of solar collector used to generate domestic hot water in buildings: flat plate collectors and evacuated tubes. Figure 1 shows the two types of panels.

Fig 1 **Flat plate collectors (left) and evacuated tubes (right) – images courtesy of Bosch Thermotechnology Ltd**

Choosing the type of panel to use on a project can involve consideration of thermal efficiencies, water temperatures required, available space, mounting requirements and capital cost (of the panels and associated system components).[1] As discussed later in this paper there appears to be little difference between the two types for most applications on buildings in the UK.

2. PANEL AREA

There are three different surface areas that can be used to define the size of a thermal solar collector: gross, aperture & absorber. It is important to understand which area is being used when calculating efficiencies and system sizes.

- **Gross area** is the physical size of the panel (total height x width) and can include frame, manifold casing, and the spaces between evacuated tubes. It is useful to determine if a solar collector will fit on a roof, but has little bearing on efficiency.
- **Aperture area** is the area through which solar energy enters the collector and has been widely adopted as the standard surface area to use when quoting efficiency values:
    - Flat plate – the area of the glazing (glass) exposed to sunlight.
    - Evacuated tube – the inner diameter of the clear glass tube.
- **Absorber area**:
    - Flat plate – the exposed area of the solar absorber.
    - Evacuated tube – the diameter of the round absorber, or flat area of the absorber for evacuated tubes with absorber fins inside.

The system capacity, in kW_{heat}, can be estimated for all system types by multiplying the collector aperture area by 0.7.[2] This enables installed capacity to be compared with other renewable energy sources such as biomass boilers, photovoltaics and wind turbines.

3. SYSTEM EFFICEIENCY

Calculating the efficiency of solar thermal systems is complex as it varies with external temperature and the temperature of water required. Figure 2 shows some independent test results from the European Solar Collector testing facility SPF based on different panel types and applications at a constant outdoor air temperature of 0 °C.[3] The area used is the collector aperture area.

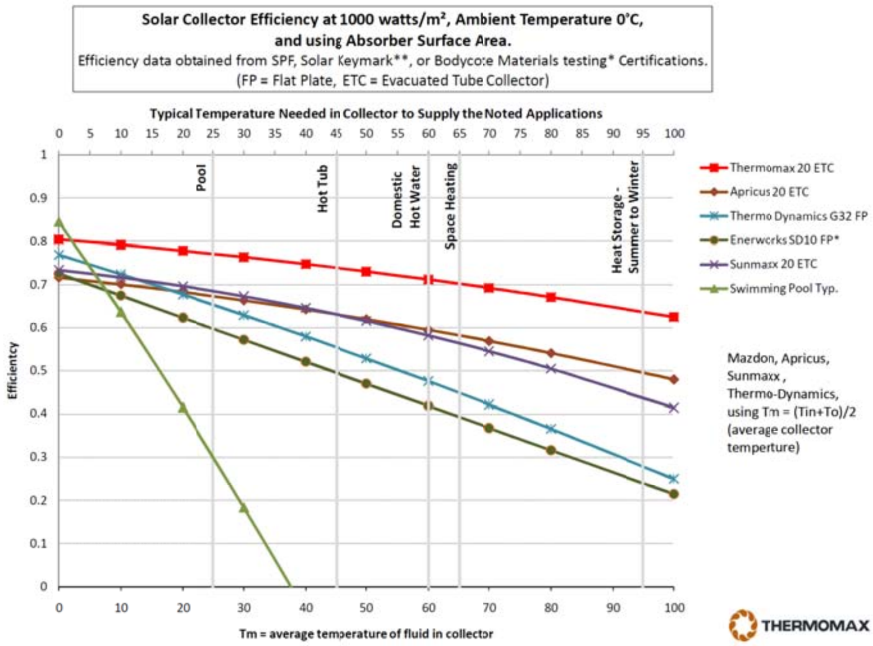

Fig 2 **Measured solar collector efficiency of sample Thermomax solar systems based on aperture area (source: Thermomax Industries)**

Figure 2 shows efficiencies at a fixed external temperature, however temperature varies throughout the year. The typical annual efficiency of glazed flat plate and evacuated tubular collectors generating domestic hot water is 44% based on the aperture area.[4]

The calculation of annual thermal energy output from these typical collectors is:

Annual output (kWh) = 0.44 x annual horizontal solar irradiation (kWh/m^2) x aperture area (m^2)

In comparison the efficiency for an unglazed swimming pool collector is 29%. If glazed panels are used in a system providing combined domestic hot water and space heating the efficiency is around 33%.

In Chapter 7 of the book a total system efficiency of 37% was assumed based on gross collector area and annual solar irradiation of 1,078 kWh/m^2 on a 60° tilt in London, giving an annual output of 418 kWh/m^2. Assuming a ratio of aperture to gross area of 0.93 and annual horizontal solar irradiation of 1,002 kWh/m^2 then using the formula above the system output is 410 kWh/m^2 (0.44 x 1,002 x 0.93) which is similar to the value in Chapter 7.

A field trial of household systems providing 60°C domestic hot water in the UK found there was little difference between flat plates and evacuated tube systems.[5] The trial also found that the way householders use their solar water heating system is critical in achieving the best results from solar water heating systems and that insufficient insulation installed on some hot water storage cylinders and pipes significantly reduced the proportion of hot water their solar water heating systems provided.

4. SYSTEM SIZING

Well-installed and properly used systems should provide around 60% of a domestic household's hot water. A field trial in the UK in 2008 by the Energy Savings Trust found the median across all systems was 39%, and that where systems were not properly configured or used the contribution from solar was as low as 9%.[6]

Why is 60% the typical limit?

Consider a DHW energy requirement of 1,000 kWh/day. Figure 3 shows the solar heat energy collected each month for two systems in London: a system sized to provide 60% of DHW energy and a system sized for 90%.

The area of panels to provide 90% of hot water energy (1,150 m^2) is 2.2 times greater than the area required to provide 60% of the energy (525 m^2). Solar thermal energy systems are more expensive than conventional boilers (if they weren't they'd be on every house) and preparing a business case to justify their inclusion on a project can sometimes be difficult. Doubling the cost of the system, and then wasting one third of the solar energy produced, does not make financial sense.

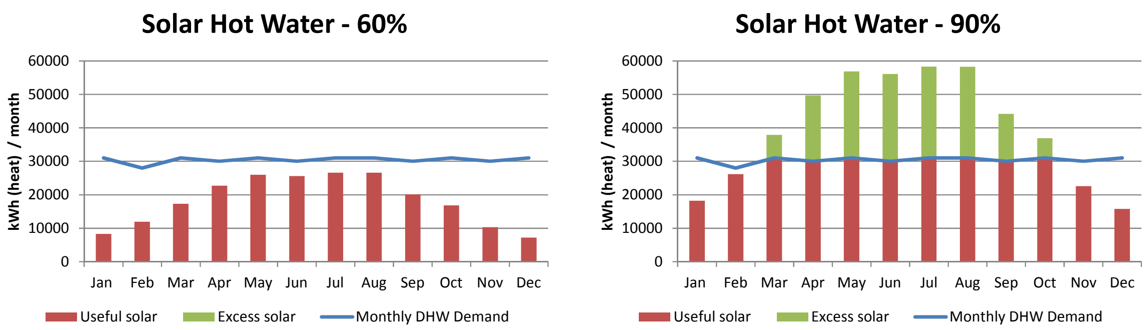

Fig 3 Monthly solar thermal energy generated compared to DHW demand

Notes

All websites were accessed on 20 July 2013 unless noted otherwise.

1. www.homepower.com/articles/solar-water-heating/equipment-products/flat-plate-evacuated-tube-solar-thermal-collectors

2. *The IEA Solar Heating and Cooling Programme and the Solar Industry agree on a common methodology to calculate the installed capacity of solar thermal collectors,* IEA explanation note, 2004 www.iea-shc.org/Data/Sites/1/documents/statistics/Explanzation_Note-New_Solar_Thermal_Statistics_Conversion.pdf

3. Chart taken from www.solarthermal.com/applications/efficiency

4. Efficiencies taken from the presentation *Simple method for Converting Installed Solar Collector Area to Annual Collector Output*, Jan Erik Nielsen, ESTIF technical consultant. The presentation was downloaded from the Common Calculation Method: Solar Collector Energy Output page of the International Energy Agency's Solar Heating and Cooling Programme website. www.iea-shc.org/common-calculation-method

5. *Here comes the sun: a field trial of solar water heating systems*, Energy Saving Trust, 2011. www.energysavingtrust.org.uk/Publications2/Generate-your-own-energy/Here-comes-the-sun-a-field-trial-of-solar-water-heating-systems.

   The website *Build It Solar: The renewable energy site for do-it-yourselfers* contains some data and formulas on solar collector efficiency.

6. Refer to note 5.