Solar Heating and Cooling
application factsheet

Domestic water heaters for social amenities

GLOBAL SOLAR WATER HEATING PROJECT

Project partners: European Solar Thermal Industry Federation (ESTIF), UNDP, International Copper Association – Copper Alliance

APPLICATION: Solar thermal collectors for the production of hot water in non-residential buildings

DESCRIPTION OF USE

Domestic hot water refers to the heated water used for domestic purposes. Energy consumption for domestic hot water depends on different factors, namely consumption patterns, how much hot water is used and the increase in water temperature required (difference between the inlet and the outlet temperature). We can consider that, on average, the annual energy consumption for domestic hot water in developed countries is around 1000 kWh per person [1].

Domestic hot water demand is rather constant all year round. Solar thermal collectors are, therefore, particularly suited to meet this demand. In higher latitudes, where the radiation in winter is significantly lower than in summer, such systems can cover between **60 and 80% of the annual domestic hot water demand**. This means that a supplementary or back-up heater is required. In low latitudes, solar thermal can cover **100% of the domestic hot water demand** and no backup heater is required.

EXAMPLES OF APPLICATIONS

These applications use mainly forced circulation. They are used in different social amenities, wherever there is a substantial use of domestic hot water. These can include schools, hospitals, swimming pools and sport facilities, dormitories, retirement homes, etc.

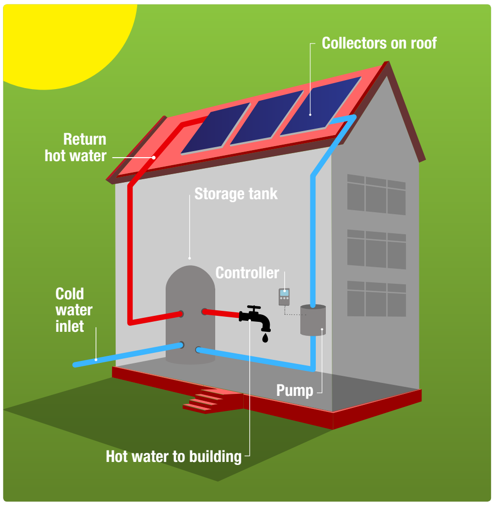
These applications are similar to some in **commercial buildings**, such as hotels, camp sites, shopping centres, restaurants, car washes, etc. Such installations vary widely in terms of size, depending on requirements. The main factors to be considered regarding the demand profile are: the hot water demand in terms of quantity, i.e. when it is needed, the amount and desired temperature (to assess the energy required to warm it up from the inlet to the outlet temperature).

This size of these systems can vary hugely, from relatively **small systems of 10 m^2 (7 kW_{th})** to systems of **500m^2 (350 kW_{th})**, or even larger.

PRINCIPLES AND BASIC OPERATION

The operating principle is rather simple. The sun heats a fluid in a solar collector, which is then used to store domestic hot water in a hot water store, ready to be used.

Larger systems are usually forced circulation systems (example in the figure), consisting of solar thermal collectors, pipes, hot water store, pumps, controller, heat exchanger, valves and backup heater.



The solar irradiation is captured by an absorber and converted into heat. To increase efficiency, the absorber is often selectively-coated, which means that the absorption of the irradiation is maximised, but the emission of heat is minimized. The absorber heats a fluid circulating in contact with it. The heat carried in this fluid is then transferred to domestic hot water by a heat exchanger. The domestic hot water is pumped into a hot water storage tank, ready for use. Additional water heating systems, such as gas boilers, usually also feed into the hot water store.

SYSTEM REQUIREMENTS

Temperature

40°C to **60°C**
This is the usual temperature range required for the most common uses, even if the user lowers the temperature by mixing with cold water.

Simple Metering | **Simple Control** | Remote Monitoring

These systems require simple metering and control. Alhough it is possible, and even desirable, for larger and/or commercial systems to have advanced metering and control, with remote monitoring.

Operation & Maintenance

Low
The operating and maintenance requirements are rather simple, requiring usually one routine visit per year.

SECTORS COVERED

Residential

- ☐ Single-family house
- ☐ Multi-family house

Tertiary

- ☑ Commercial (offices, hotels, shopping centers, …)
- ☑ Institutional (schools, nursing homes, hospitals, …)

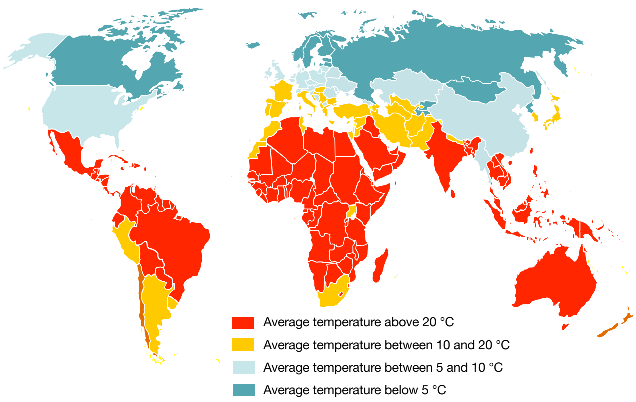
Industrial

- ☐ Low temperature processes (washing, dyeing, pasteurization, …)

WORLDWIDE APPLICABILITY

Solar thermal systems for the production of domestic hot water in social amenities have the potential to be deployed in **all geographical areas**. Naturally, system configurations would vary depending on the geographical location. Forced circulation systems are well suited for these applications but also thermosiphon systems can be considered in some cases. Both flat plate and evacuated tubes collectors can be used and, in some cases, unglazed solar collectors can be an option to supply hot water at lower temperatures (e.g. swimming pools).

From an economic and energy system point of view, the applicability of solar thermal collectors for domestic hot water in social amenities is particularly indicated for countries with **high energy dependency** on fossil fuels imports, in particular gas, as well as countries with an **unbalanced power grid system** relying on electricity for some of their heating needs.



Map of Average Temperature Per Country

BENEFITS

The benefits of solar thermal collectors cover several aspects: environmental, political and economic.

Environmental benefits are associated with the capacity to reduce harmful emissions. The reduction in CO_2 emissions depends on the quantity of fossil fuels replaced directly or indirectly, for instance, when the system replaces the use of carbon-based electricity used for water heating. Depending on the location, a system of **14 kW$_{th}$ (20 m²)** could generate the equivalent of **11 MWh$_{th}$ /year**, a saving of around **1.75 Mt CO_2** (2).

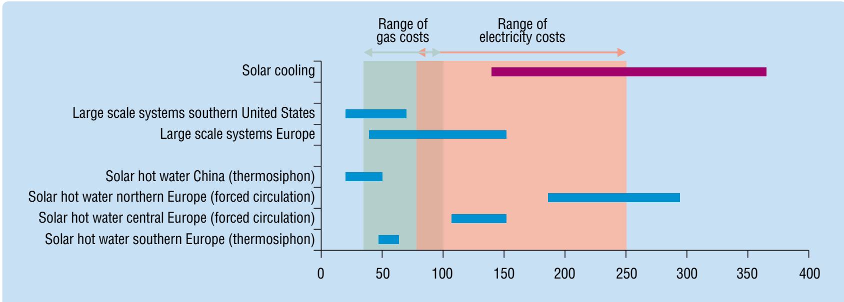
Political and economic benefits relate to the potential savings in energy costs and to the possibility of improving energy security by reducing energy imports, while creating local jobs related to the manufacturing, commercialization, installation and maintenance of solar thermal systems.

Regarding energy costs, and potential savings, there are three main aspects to consider that have a bigger impact on the comparable costs of the energy produced by a solar thermal system. These are the initial cost of the system, the lifetime of the system and the system performance.

These factors depend on the location (affecting climate, insulation, taxes, cost of living, etc.) and quality of the system (affecting performance, lifetime and cost). This can vary significantly from country to country.

Therefore, average investment costs for solar thermal systems can vary greatly from country to country and between different systems. Thermosiphon systems, the cheapest, are more appropriate for single family houses (or individual supply).

For social amenities, pumped indirect systems are the most commonly used. For these, investment costs can go from **850 to 1900 USD/kW$_{th}$ in central Europe** (765 to 1710 EUR/kW$_{th}$), while in **northern Europe** they can go up to between **1600 and 2400 USD/kW$_{th}$** (1440 to 2160 EUR/kW$_{th}$). In terms of **energy costs**, the former can range from **18.5 to 29.5 USD cents/kWh$_{th}$** (16.7 to 26.6 EUR cents/kWh$_{th}$) while the latter may range between **10.5 and 15 USD cents/kWh$_{th}$** (9.5 to 23.9 EUR cents/kWh$_{th}$).



Costs of solar heating and cooling (USD/MWh$_{th}$), Source: IEA 2012

EXAMPLES

AFRICA

Thermosiphon systems for domestic hot water in retirement village, Cape Town, South Africa.

The objective of this installation is to meet the consumption of domestic hot water by the residents of a retirement village, while upgrading the pre-existing conventional electrical hot-water heaters. The installation consists of indirect thermosiphon systems with flat plate collectors. The system includes 33.76 m² (23.6 kW$_{th}$) of collectors and a total of 9 storage tanks with a capacity of 300 litres each. This installation is expected to reduce the emission of CO_2 by 9.89 t per year.

Reference:
www.soltrain.co.za/

Key data

Annual solar yield: **28 485 kWh$_{th}$**

Avoided emission of **9.89 tonnes** of CO_2 per year

Collector area: **33.76 m²**

NORTH AMERICA

Commercial Solar Pool and Solar DHW System, Mazatlan, Mexico.

The system uses 2320 m² of solar pool collectors to heat five pools, covering more than 3700 m², during the winter. Feed water introduced into the system at 24°C is returned to the pool, after a single pass, at 32°C. The system was designed to support the resort's domestic hot water needs during summer. The water is preheated by the panels to between 27.7°C and 41°C, supplying more than 50 percent of the resort's hot water needs.

Reference:
http://www.heliocol.com/pdf/case-study-heliocol-commercial-resort.pdf

Key data

Reduction of final energy: **34 000 kWh/a**

Replaced energy: OIL **Heating oil**

Expected return of investment period: **7 YEARS**

TOTAL COST: **€55 000**

SOUTH AMERICA

Solar-preheated Water for Factory Canteen, São José dos Campos, São Paulo, Brazil.

The installation was done in a factory canteen, serving 10 000 meals per day in three shifts. The system consists of 180 collectors totalling an area of 427 m² (300 kW$_{th}$). These are installed on the flat roof of the kitchen building, together with four tanks of 4000 litres each. The hot water is required at 60°C and is used to clean the factory's kitchen and restaurant. When the solar hot water does not reach the target temperature, an auxiliary system, composed of gas boilers, is used to heat up the preheated solar water.

Reference:
http://www.solarthermalworld.org/content/brazil-solar-preheated-water-factory-canteen-aircraft-producer-embraer

Key data

A Polysun simulation has calculated a specific yield of **919 kWh/m²**

This corresonds to **69% LESS GAS PER YEAR**

Without subsidy, this system is estimated to pay off in around **4 YEARS**

REFERENCES

(1) Value is an approximation. Energy consumption depends on:
   a. How many litres of hot water at a given temperature are used per day (e.g. 40 litres at 50 °C)
   b. how much energy is needed to heat up this amount of water (eg. 1.6 kWh per day if the water is heated from 15 to 50 °C)
   c. Which type and quantity of fuel is used (or replaced)
   Some studies estimate the consumption of hot water on the basis of house area, as this is the pattern for estimating overall energy consumption. For domestic hot water the number of inhabitants is more relevant than the area. Consumption averages can vary being usually above 4 000 kWh while the average of inhabitants per house is between 3 and 4.

(2) According to IEA-SHC, the average specific solar yield for solar thermal systems for domestic hot water heating in multi-family houses by end of 2013 is 569 kWh per square meter of solar collector per year. Lacking an average for the use in social amenities worldwide, the reference value for multi-family houses is used, rounded to 550 kWh for simplification. Installed capacity is converted according to IEA-SHC default: 1 m² -> 0.7 kW$_{th}$. Estimations of CO_2 savings based in calculations from IEA, namely in the Solar Heating and Cooling Technology Roadmap (1 kWh -> 0.16 Kg CO_2).

Solar Heat Worldwide, IEA-SHC 2015, www.iea-shc.org/data/sites/1/publications/Solar-Heat-Worldwide-2015.pdf
Technology Roadmap: Solar Heating and Cooling, IEA 2012, www.iea.org/publications/freepublications/publication/technology-roadmap-solar-heating-and-cooling.html
Domestic Solar Water Heater for Developing Countries, Professor Ashok Gadgil et al., 2007 http://energy.lbl.gov/staff/gadgil/docs/2007/solar-water-heater-rpt.pdf
Solar thermal in the Mediterranean Region: Market Assessment Report, OME 2012 www.solarthermalworld.org/sites/gstec/files/news/file/2013-04-26/regional_market_assessment_report_ome-mediterranean.pdf

Exchange rates calculated at 1 USD = 0.9 EUR, a rounding of the approximate exchange rate in September 2015.