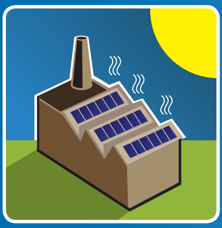


Solar Heating and Cooling
application factsheet

Solar heat for industrial process

GLOBAL SOLAR WATER HEATING PROJECT

Project partners:

APPLICATION:
Solar thermal collectors for the production of hot water used in low temperature industrial processes

DESCRIPTION OF USE

When considering industrial needs for heat, usually the first image that comes to mind is that of metallurgy. While some industrial processes require very high temperatures, most of the energy needed for industrial processes requires low or medium-temperature heat.

Industrial processes can use low temperature for washing or dyeing textiles. The dairy sector uses heat for washing and pasteurization. Other industries, such as mining, can use it for leaching. Therefore, the use of low temperature heat in industrial processes can be widely diverse. The biggest potential is seen in the food and beverage industry but also in the metal and mining sector.

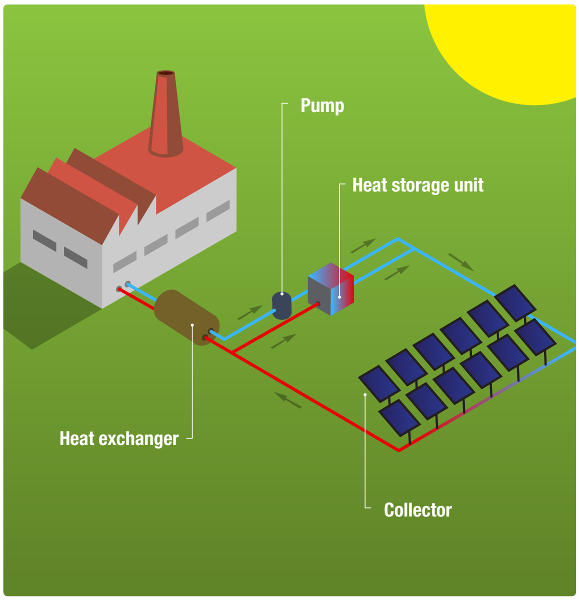
EXAMPLES OF APPLICATIONS

Solar thermal systems are **well suited for generating low temperature heat** up to 150°C. This can already be supplied by commercially available solar thermal collectors. Most solar applications for industrial processes are on a relatively small scale and still largely of an experimental nature. There is **potentially a wide range of solar thermal applications**. There are already well known applications of solar thermal heat in breweries, mining, agriculture (crop drying) or textile sector. In 2015 about **150 large-scale SHIP** systems are documented worldwide ranging from **0.35 MW_{th} to 27.5 MW_{th} (39 300 m²)**.

PRINCIPLES AND BASIC OPERATION

A system providing solar heat for industrial processes includes a large or very large solar collector field, through which a working fluid circulates. This fluid can be water, a combination of water and glycol or other. By means of a heat exchanger, the heat is transferred from the primary circuit to the process heat circuit in the form of hot water, air flow or steam, depending on the requirements of the industrial process.

The system may incorporate a heat storage unit. This unit can be used to increase the period of the day when heat is supplied to compensate for variations of the solar resource, but also to even out the fluctuating heat demand at batch processes.



In such systems, an adequate function and yield control is essential for the regulation of the solar system and to identify potential breakdowns of the systems or loss of performance.

A system is considered very large when it is over **350 kW_{th} (500 m²)**, although such systems can have a wide range of sizes.

SYSTEM REQUIREMENTS

Temperature

40°C to 125°C

Solar heat for industrial processes (SHIP) can go above 300 °C. This factsheet addresses low temperature applications. The range of low temperature SHIP varies according to different authors, being considered up to 90 °C in some cases and even 250 °C in other.

Advanced Metering | **Remote Monitoring** | **Advanced Controls**

SHIP requires advanced control and metering, integrated with the overall management of the heat supply to industrial processes.

Operation & Maintenance

Medium

The operating and maintenance requirements are in line with operating such large systems, either solar thermal or using other technologies. Correct operation is also required to maximize performance.

SECTORS COVERED

Residential

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

Tertiary

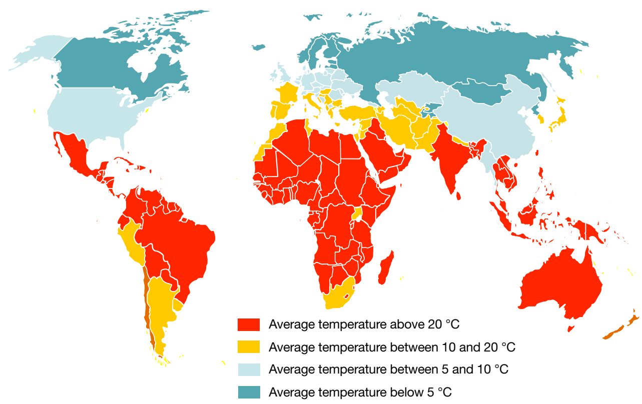
- ☐ Commercial (offices, hotels, shopping centers, ...)
- ☐ Institutional (schools, nursing homes, hospitals, ...)

Industrial

- ☑ Low temperature processes (washing, dyeing, pasteurization, ...)

WORLDWIDE APPLICABILITY

These systems are applicable worldwide. They are naturally very well suited for regions with higher solar irradiation, although there are already systems installed in colder climates, e.g. in Europe and in the United States. In colder climates, where usually energy costs are higher, these systems are more competitive. For instance, out of 155 systems using solar heat for industrial processes, **56 are located in central Europe**.



Map of Average Temperature Per Country

BENEFITS

The benefits of solar thermal systems, in particular for such large systems, cover environmental, political and economic aspects.

Environmental benefits stem from the capacity to reduce harmful emissions. The reduction of CO_2 emissions depends on the quantity of fossil fuels replaced directly or indirectly, i.e. when the system replaces the use of carbon-based electricity used for water heating. Depending on the location, a **1.4 MW_{th} (2000 m²)** system could generate the equivalent of **1.1 MWh_{th} /year, a saving of around 175 Mt of CO_2** [(1)].

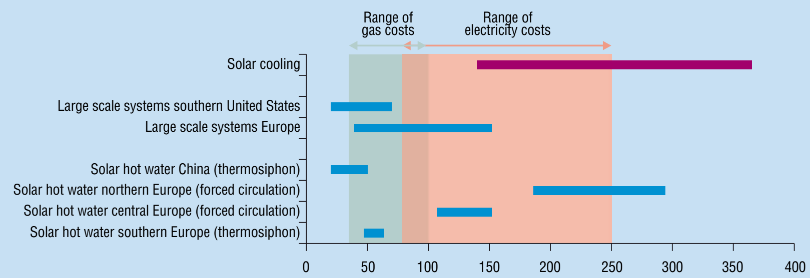
Political and economic benefits are associated with the potential savings in energy costs and the possibility of improving energy security by reducing energy imports, while creating local jobs related to the manufacturing, commercialization, installation and maintenance of solar thermal systems.

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.

According to the IEA, for large systems in Europe, the investment costs can go from **350 to 1040 USD/kW_{th}** (315 to 936 EUR/kW_{th}). In terms of energy costs, it can range from **20 to 70 USD/MWh_{th}** (18 to 63 EUR/MWh_{th}) in Southern United States and between **40 and 150 USD/MWh_{th}** (36 and 135 EUR/MWh_{th}) in Europe.



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

EXAMPLES

ASIA

Solar Pre-Heating for Textile Dyeing in Hangzhou, China

Since 2007, the **13 000 m² (9.75 MW_{th})** flat plate collector field in the city of Hangzhou, in the Chinese province of Zhejiang, **pre-heats water to 55 °C**. The installation is one of the largest solar process heat systems in China. The pre-heated water is stored in a tank and then heated to around 100 °C to produce steam for dyeing textiles.

The total investment in the plant was around **EUR 1.1 million** (1.22 mio USD), i.e. the turnkey costs including solar collectors, piping, support construction, storage, design and commissioning, less subsidies. National ministries supported this environmental initiative with a total of **EUR 84 500** (93 400 USD). The estimated pay-back time was 3 to 4 years, according to the Chinese Solar Thermal Industry Federation (CSTIF).

Reference:
http://ship-plants.info/solar-thermal-plants/57-daly-textile-china

Key data

13 000 m² (9.75 MW_{th})

One of the largest solar process heat systems in China

Water pre-heated to **55 °C** and then heated to **100 °C** to produce steam for dyeing textiles

SOUTH AMERICA

Copper Mine, Calamara, Chile

Inaugurated in June 2013, the **27.5 MW_{th} (approx. 40 000 m²)** installation should cover more than 80% of the heat used to **refine copper** at **one of the largest copper mines in the world**. The mining company, signed an agreement with a Chilean ESCO (Energy Service Company) to **deliver solar heat** to the mining factory **over a 10-year period**. The main process in the copper mine is electrolytic refining, during which copper is heated up in a bath to between **46 and 51 °C** and deposited through electrolysis, another very electricity-demanding process.

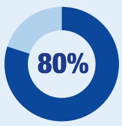
Reference:
http://solarthermalworld.org/content/275-mw-provide-heat-copper-mine-chile

Key data

27.5 MW_{th} installation

one of the largest copper mines in the world

Cover over



of the heat used to refine copper

EUROPE

Brewery, Leoben, central Austria

Part of the EU project Solar Brew. In order to optimize the brewing process and to enable the integration of solar heat, new heat exchangers were developed for the mash tun. Instead of steam, which is usually used to heat mash tunes it is now possible to use hot water from the solar collectors. Mashing only needs an actual **process temperature of around 60 to 78°C**. Solar can provide these temperatures as long as the systems are correctly integrated. The investment amounted to **320 000 EUR** (355 500 USD), i.e. the turnkey costs including solar collectors, piping, support construction, storage, design and commissioning, less 50% subsidies.

Reference:
http://www.green-foods.eu/best-practice/solarbrew-goss-austria/

Key data

1500m² collector area

200m³ energy storage tank

Process temperature of around **78°C**

REFERENCES

(1) 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 solar heat for industrial processes 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

Database for applications of solar heat integration in industrial processes, http://ship-plants.info/

IEA-SHC Task 49: Solar Heat Integration in Industrial Processes, http://task49.iea-shc.org/

Solar Heat for Industrial Processes – Technology brief, IEA-ETSAP and IRENA 2015, http://www.irena.org/DocumentDownloads/Publications/IRENA_ETSAP_Tech_Brief_E21_Solar_Heat_Industrial_2015.pdf

Average temperature per country: http://data.worldbank.org/developers/climate-data-api

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