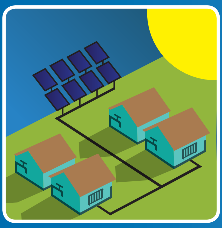


Solar Heating and Cooling
application factsheet

# Solar district heating

GLOBAL SOLAR WATER HEATING PROJECT

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

## APPLICATION:
### Solar thermal collectors for the production of hot water used in district heating networks

## DESCRIPTION OF USE

District heating is a network providing heat, usually in form of hot water. This heat is mainly used for **space heating and for domestic hot water** (drinkable water); however, It usually also meets some industrial needs. **District heating** systems can serve whole cities; when a system is limited to a group of buildings it is referred to as **block heating**.

The main advantage of these systems is that the large district heating plants are **more efficient, more economic and create less pollution** than decentralized fossil fuel based boilers. The heat generated in a centralized manner is then distributed to urban areas through a system of pipelines specially designed for transporting heat, which is then supplied house to house.

## EXAMPLES OF APPLICATIONS

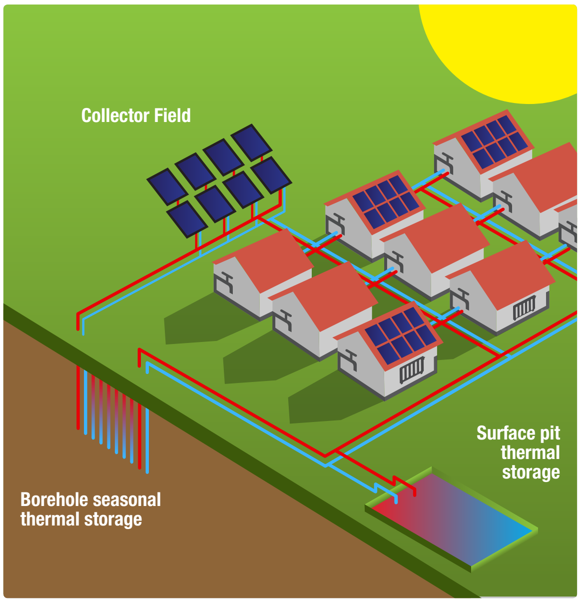
In a district heating system, the heat is generated on a larger scale. Therefore, solar thermal, as other technologies, can be **scaled up** to provide large quantities of hot water. Hence, solar district heating (SDH) plants are a **very large scale application of conventional solar thermal technology**.

These plants are integrated into local district heating networks for both residential and industrial use. During warmer periods they can wholly replace other sources, usually fossil fuels, used for heat supply. Thanks to developments in large scale thermal storage, it is now also possible to **store heat in summer for winter use**. Solar thermal can also meet a share of the heating demand during the winter.

## PRINCIPLES AND BASIC OPERATION

These systems consist of solar thermal plants, made up of hundreds of solar thermal collectors. Considering the requirements of such large systems, **larger collectors** working with **bigger loads** have been designed specifically for such application. For smaller systems (block heating), normal solar thermal collectors, either flat plate, evacuated tube or even concentrating, can be used.

These solar thermal plants supply heat to a district heating network. It can consist of a **centralized supply**, where a very **large collector field** delivers heat to a main heating central. It can also provide, directly or indirectly, a **large seasonal heat store** that will contribute to increasing the input of solar thermal plant to the whole system.




The other possible configuration is a **decentralized supply** or **distributed solar district heating**. In this case, solar collectors are placed at suitable locations (buildings, parking lots, small fields) and **connected directly to the district heating primary circuit** on site. This solution can also be interesting for smaller district heating networks or block heating networks.

A system is considered as very large when it is over **350 kW$_{th}$ (500 m²)** but solar district heating systems can reach sizes 100 times bigger, i.e. **35 000 kW$_{th}$**.

## SYSTEM REQUIREMENTS

### Temperature

**40°C to 100°C**

40°C to 100°C temperature is the typical usage of solar thermal systems. The temperature requirements highly depend on the currently used temperature in the grid and just follow the demand.

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

Solar district heating systems require advanced control and metering because an adequate control strategy in place is paramount for improving the performance of the system. This control is usually done remotely.

### Operation & Maintenance

**Low**

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, ...)

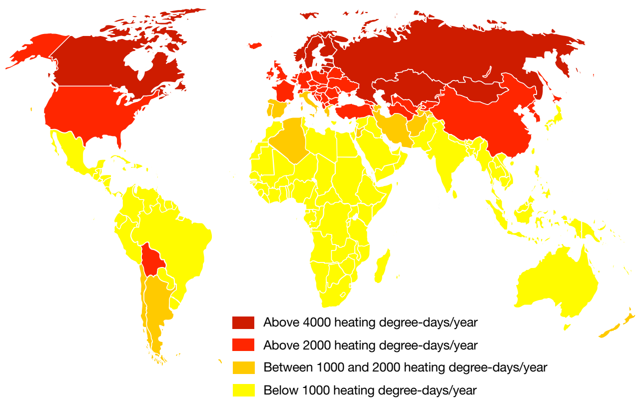
**Industrial**

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

## WORLDWIDE APPLICABILITY

These systems are applicable wherever there are **district heating networks**. Usually such networks exist in cold climates, where there is a **substantial demand for heat during autumn and winter**. Although it may be considered that using solar thermal energy in such climates would be neither feasible nor competitive, the reality proves the opposite to be true.

Economic and environmental benefits derived from the acknowledged reliability of this solar thermal application, combined with the technical expertise gained over decades, have contributed to the growing interest in its commercial operation and currently there are many plants in operation in Sweden, Denmark, Germany and Austria.




Map of Worldwide Heating Needs

## BENEFITS

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

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

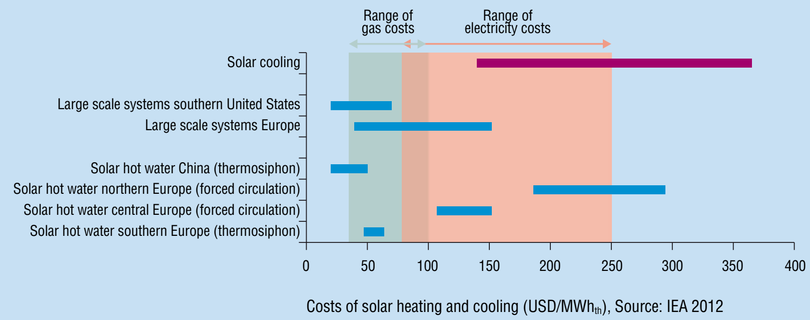
Political and economic benefits are associated with the **potential savings in energy costs** and the **possibility of improving energy security** by reducing energy imports, while creating local jobs related to the manufacturing, commercialization, installation and maintenance of solar thermal systems.

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 and135 EUR/$MWh_{th}$) **in Europe**.




## EXAMPLES

### NORTH AMERICA

*Solar Community, Okotoks, Alberta*

Announced in March 2005, the Drake Landing Solar Community project came on stream in June 2007. The Drake Landing Solar Community is a prime example of the **successful combination of energy efficient technologies with the unlimited renewable energy of the sun**. Okotoks, in Alberta, is ideally situated for solar energy collection as it has many days of sunshine per year, it can get almost as much solar energy as Italy and Greece. However, as solar radiation is lower there during the winter months, the Drake Landing Solar Community uses a **central district heating system that stores solar energy in abundance during summer months** and distributes the energy to each home for space heating needs during winter months. The distribution temperature varies throughout the year, based on the outside air temperature, and the flow is regulated to match the homeowners' demand. Because of a lower water temperature used in the district heating system, each home is equipped with a specially designed air-handler unit for adequate heat distribution.

Reference:
www.dlsc.ca/

**Key data**

**52** houses supplied

**30%** more efficient than conventionally built homes

over **90%** of residential space heating needs met by solar thermal energy

Reduction of around **5 tonnes** of greenhouse gas (GHG) emissions per home per year

### EUROPE

*Solar assisted district heating in Vojens, Denmark*

Since 2012, this plant has met all the expectations of a solar district heating installation. The pilot scheme with a **17 000 m² (11.9 $MW_{th}$)** large collector field convinced the municipal utility from Southern Denmark to **add another 52 500 m² (36.75 $MW_{th}$)** to the field, as well as seasonal storage, which should increase the annual solar share from the 14 % measured in 2014 to an **expected 45 %**.

Grid temperatures have been set low to match the solar feed-in – they are 75 to 77°C in summer and 37 to 40°C in winter, respectively. Solar heat prices, including seasonal storage, should be around **42 EUR (52 USD)/MWh**, compared with **57 EUR (63 USD)/MWh** for natural gas supply. Hence, the plant is purely a commercial venture, which has not been supported by direct subsidies.

Reference:
http://www.arcon.dk/NY_Referencer/Udvalgte_ref/Vojens%20II.aspx

**Key data**

Additional field of **70 000 m² (49 $MW_{th}$)** original field of 17 000 m² (12.25 $MW_{th}$)

**Solar heat prices 42 EUR** (52 USD)/**MWh**

**Gas Heat prices 57 EUR** (63 USD)/**MWh** (natural gas supply)

### MIDDLE EAST

*University in Riyadh, Saudi Arabia*

Operating since mid-2011, the 25.4 $MW_{th}$ solar district water heating plant provides heat for the **Princess Nora Bint Abdul Rahman University**, which has a campus for 40 000 students, lecturers and other staff. Its amenities include accommodation, research facilities and a hospital. The collector surface area is **36 305m² (25.4 $MW_{th}$)**, which is equivalent to **five football pitches**. The solar panels are mounted on the roof of the university building. These are large-surface collectors, 5m long and 2m wide (10m²). They are used for **high-capacity solar thermal systems** of over 60m² and are adapted to suit the Arabian deserts with their heavy sandstorms. Each solar collector is made from special solar glass and equipped with a modified mounting system to withstand unfavourable weather conditions, it has 95% absorption capacity and weighs 170kg. Throughout its life, the system will **save approximately 52 million litres of diesel** and reduce the carbon footprint by **125 million kg of $CO_2$**.

Reference:
http://millenniumenergy.co.uk/princess-noura-university-women-pnuw

**Key data**

**25.4 $MW_{th}$** plant

Over **40 000** people served

collector surface area is **36 305m²**

**125 million kg of $CO_2$** saved over lifetime

## 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 assisted district heating worldwide, the reference value for multi-family houses is sued, 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
Technology Roadmap: Solar Heating and Cooling, IEA 2012, www.iea.org/publications/
Solar District Heating Platform, http://solar-district-heating.eu/
Worldwide Heating Needs, heating degree-days, http://chartsbin.com/view/1029

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