Solar Heat for Cities, Towns and Energy Communities

Introduction to solar district heating by the IEA SHC Task 68 - Efficient Solar District Heating Systems
https://task68.iea-shc.org/
An enormous task...

... decarbonising around 6,000 district heating networks across Europe.

... solar heat is one of the proven, available, cost-effective measures to help complete this enormous task.

In this presentation we would like to show you how solar district heating works and who is using it successfully already.
Lemgo, Germany: Reducing gas price risk

“Our 5.2 MW solar collector field has been feeding into the city of Lemgo’s heating network since April 2022. It benefits from very low operational costs over its entire life cycle and also reduces the CO₂ and gas price risk.”
266 towns and cities in Europe use solar heat

Chart: IEA SHC Task 68
Source: IEA SHC Solar Heat Worldwide Report Ed. 2023 / own research

https://task68.iea-shc.org/
Multi-MW solar district heating plants on the rise across Europe

✓ **37 MW** collector field under construction in Groningen, Netherlands. 30 years solar heat delivery contract with utility company Warmtestad.

✓ The municipal utility in Leipzig, Germany, placed the order for a **41 MW** collector field in April 2023

✓ Financing is secured for a **41 MW** collector field in Pristina, Kosovo, planned by the local utility Termokos.

Photo: Ritter Solar XL
How does solar district heating work?
The advantages

SMART CITIES USE SOLAR HEAT

MEET YOUR CLIMATE TARGETS
Solar heat is emission-free and 100% renewable.

INCREASE ENERGY SECURITY
Solar heat is an unlimited resource of your municipality.

KEEP HEAT AFFORDABLE
Price of solar heat will remain stable for at least 20 years.

CREATE LOCAL JOBS
Solar heat replaces imported fuels and provides new jobs.

IEA SHC TASK 55
Mengsberg, Germany, heats with 100 % renewables

The German village of Mengsberg has built up an energy community that owns and operates a 100 % renewable district heating network with a wood chip boiler and a solar collector field.

Everyone who wants to join the energy cooperation makes a deposit of EUR 4,000 per building. In return, the transfer station is installed and the district heating pipes connected to the house.

Photo: Bioenergiegenossenschaft Mengsberg
Mengsberg's energy community owns the district heating system

141 participants

4,000 EUR deposit per building for the transfer station and the piping to the house.

112 EUR/MWh heat price (status November 2022). No basic price is charged.

Graphic: Task 68
Source: Bioenergiegenossenschaft Mengsberg
Mengsberg's energy community owns the district heating system

**Site**

<table>
<thead>
<tr>
<th></th>
<th>Mengsberg, Germany</th>
</tr>
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<tbody>
<tr>
<td>Inhabitants</td>
<td>925</td>
</tr>
<tr>
<td>Connected households</td>
<td>149</td>
</tr>
<tr>
<td>Length of piping</td>
<td>9 km</td>
</tr>
<tr>
<td>Wood chip boiler</td>
<td>1.1 MW</td>
</tr>
<tr>
<td>Solar thermal field</td>
<td>2.1 MW</td>
</tr>
<tr>
<td>Annual solar share</td>
<td>17 %</td>
</tr>
</tbody>
</table>

Map/Source for Table: Bioenergiegenossenschaft Mengsberg
Operator models for energy communities

1. Foundation of an energy cooperative as a legal entity to own and operate the heat network
   + heat prices only reflect the real costs, no trade profit margins included
   - a lot of voluntary work is required by the board members

2. Energy community signs a contract with a private heat supply contractor or the public or neighbouring utility company to create, own and operate the heat network
   + little responsibility for the members of the energy community
   + contractor/utility has specialist knowhow about renewable heat networks
   - slightly higher heat prices because of the profit margin of the heat contractor

Manual about energy communities (in German):
Grenaa in Denmark: Reduce the pressure on biomass

“Our board of directors shares one vision: to use solar to supply consumers with cost-effective heat. And we will save costs when the system produces solar energy in summer because we can shut down one of our two wood chip boilers during that time.”

Grenaa Varmeværk offers the fifth lowest district heating price in a comparison study from June 2022 carried out by the Danish Supply Authority.
Grenaa in Denmark: Solar heat and biomass are a good match

Net capital costs .......... 4.7 million EUR
Specific costs .............. 227 EUR/m² excl. VAT
O&M costs .................... 12,500 EUR/year
Solar yield 2021 ............. 10.2 GWh/year
Solar fraction ................. 7 %

FLAT PLATE
20,673 m², 14.5 MW
Savosolar, Finland

146 GWh / year total heat demand
Wood chip and natural gas boilers

4,500 m³ short term heat storage
118 km
summer 68 °C and winter 72 °C
summer 37 °C and winter 38 °C

5,300 inhabitants
Solar heat and biomass are a good match

**Save money:** thanks to the solar system, less wood chips need to be bought.

**Preserve the biomass boiler:** the solar system takes over the summer operation, the boiler is less stressed → service life is extended.

**Protect the climate and the environment:** reduced emissions through CO2 and air-pollutant-free solar energy.
Latvian utility company is cutting down on fossil fuel use

"We’ve been working on this project since we visited Denmark in 2016 to attend a conference on district heating. The aim is to reduce our carbon footprint and become less reliant on fossil fuels."

Photo: Salaspils Siltums
Salaspils, Latvia: 90 % renewable district heat since 2019

Contribution to total heat demand: 65 GWh / year
- Solar thermal: 16 %
- Biomass boilers + flue gas condenser: 72 %
- Gas boilers: 12 %
- Ø solar yield 2020/2021: 486 kWh/m²a

FLAT PLATE
- 21,672 m², 15 MW
- MANUFACTURER: Arcon-Sunmark, Denmark
- SUPPLIER: Filter, Latvia

8,000 m³ short term heat storage

Wood chip boilers
Gas boiler for peak load

90 °C
60 °C

21.3 km

17,000 inhabitants
Salaspils, Latvia: Constant solar heat prices over 25 years

“We are proud to have taken care of fuel diversification in the past, thus avoiding the effects of rapid fluctuations in the price of natural gas. The price of heat energy for Salaspils Siltums customers is stable and will not be increased.”

Source: Screenshot from https://salaspilssiltums.lv/
Big Solar Pristina replaced coal-based electric heating

Site | Pristina, Kosovo
--- | ---
New district heat consumers | 38,000
Annual solar share | 12 %
Capacity of solar field | 41 MW
Seasonal storage | 408,000 m³
Investment costs including extension of DH grid | EUR 80 million
Estimate start of construction | End of 2024

1.6 km pipeline between storage and CHP
4.2 km pipeline between solar field and the city
Big Solar Pristina: absorption heat pumps are key

The absorption heat pumps heat up the water from the seasonal storage tank, if it does not meet the demand of the supply line for the heating network.
Investment costs and heat prices

The trend curve suggests that for every doubling of the size of the plant, total installed costs decline by 14%.
110 MW in Silkeborg, Denmark, sets lowest benchmark costs

<table>
<thead>
<tr>
<th>Site</th>
<th>Silkeborg, Denmark</th>
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<tbody>
<tr>
<td>Connected heat consumers</td>
<td>21,000</td>
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<tr>
<td>Annual solar share</td>
<td>20 %</td>
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<tr>
<td>Capacity of solar field</td>
<td>110 MW</td>
</tr>
<tr>
<td>Commissioning date</td>
<td>December 2016</td>
</tr>
<tr>
<td>Investment costs</td>
<td>DKK 250 million</td>
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<tr>
<td></td>
<td>[in 2016]</td>
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<td></td>
<td>EUR 35 million</td>
</tr>
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<td>[in 2020]</td>
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Photo: Arcon Sunmark
Levelised cost of solar heat over 25 years of operation for a 110 MW plant is between 18 and 33 EUR/MWh.
Fast installation with prefabricated large collector panels

The larger the individual collectors, the easier and fast it is to install a system by crane. A dozen manufacturers in Germany, Austria and Finland have specialised in the manufacture of these prefabricated units with gross areas of 5 m² to 16 m².

Find a list of suppliers online: https://solarthermalworld.org/news/large-prefab-sdh-collectors-design-and-yields/

Photo: Greenonetec
Serbian municipality is striving for more after successful pilot project

Design, planning and obtaining permissions usually takes much longer than the construction of the solar plant itself.
HOW MUCH AREA FOR SDH DO YOU NEED ...

... to meet 20% of the total annual heat demand from 1,000 households living in old buildings?

1.0 hectar

0.7 hectar

0.5 hectar

SOLAR HEAT

Compared to area needed for one

SOCCER FIELD

SUPERMARKET
Yield per area comparison of different renewable technologies

Solar thermal harvests three times more kilowatt hours than photovoltaics and 33 times more than biomass on the same area.
1 MW solar heat capacity requires an area of 1,350 m²

8,300 m² collector area on 20,000 m² land

You need around twice as much land as the size of the collector field.

9,181 m² collector area on 17,000 m² land

14,797 m² collector area on 25,000 m² land

Source: Brochure about solar district heating from BSW Solar, Germany
Photos: Stadtwerke Senftenberg, Stadtwerke Lemgo, Stadtwerke Ludwigsburg-Kornwestheim

https://task68.iea-shc.org/
Each temperature level has a suitable collector type

Concentrating collectors (Point Focus Fresnel) deliver heat at around 160 °C in Hørsholm, Denmark

Combination of flat plate collectors (up to 70 °C) and parabolic trough collectors (here operated at 95 °C but could go higher) in Taars, Denmark
112 smart cities in Europe

EU Commission's target: 112 selected mission cities should be climate-neutral by 2030.

The solar field simulator of Task 68 “Efficient Solar District Heating Systems” identifies the area that is necessary to cover 20% of the total district heat demand in 12 of these cities using the sun.

Field simulator https://www.absolicon.com/fs/

Source: https://eurocities.eu/
There is space for solar heat even in larger cities

<table>
<thead>
<tr>
<th>Site</th>
<th>Turin/Torino, Italy</th>
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</thead>
<tbody>
<tr>
<td>Inhabitants</td>
<td>847,000</td>
</tr>
<tr>
<td>Heat demand in heating grid</td>
<td>1,815 GWh/a</td>
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<tr>
<td>Solar irradiation</td>
<td>1,476 kWh/m2a</td>
</tr>
<tr>
<td>Land size of solar field</td>
<td>129.7 hectares</td>
</tr>
<tr>
<td>Capacity of solar field</td>
<td>401.1 MW</td>
</tr>
<tr>
<td>Solar share</td>
<td>20 %</td>
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</table>

Source: https://www.absolicon.com/fs/
There is space for solar heat even in larger cities

<table>
<thead>
<tr>
<th>Site</th>
<th>Saragossa/Zaragoza, Spain</th>
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<tbody>
<tr>
<td>Inhabitants</td>
<td>736,000</td>
</tr>
<tr>
<td>Heat demand in heating grid</td>
<td>1,412 GWh</td>
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<tr>
<td>Solar irradiation</td>
<td>1,877 kWh/m2a</td>
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<tr>
<td>Land size of solar field</td>
<td>75.5 hectares</td>
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<tr>
<td>Capacity of solar field</td>
<td>233.5 MW</td>
</tr>
<tr>
<td>Solar share</td>
<td>20 %</td>
</tr>
</tbody>
</table>

A golf course has between 60 and 90 hectare.
Solar collector areas with ecological upgrade

Collector fields do not seal the ground and give plants and animals a good chance of continuing to use the area.

Photos: Guido Bröer, Erik Christensen
Senftenberg in Germany: No solar storage needed

The 8,300 m² vacuum tube collector field in Senftenberg can cover the complete energy demand in the heat network on a normal summer day.

It contributes 4.2 % of the annual demand of the heat network, so no solar thermal storage is necessary.

A bypass was also provided in the heating centre, so that the 2,000 m³ water content of the heat network can absorb the solar heat of the collector field output on particularly sunny days.


Photo: Stadtwerke Senftenberg
Senftenberg in Germany: Good yields over five years

Each temperature level has a suitable collector type

This 816 m² solar field consists of special high-vacuum flat-plate collectors supplying heat to the heat network in Geneva, Switzerland, at a temperature of 85 °C, even in winter. In 2021, 539 MWh were delivered, equivalent to 687 kWh/m².

Photo: TVP Solar
Each temperature level has a suitable collector type

This 9,118 m² vacuum tube collector field supplies heat at 90 °C to the district heating system of the German town of Lemgo.

Photo: Viessmann

By adjusting the speed of the pumps in the solar circuit, the target temperature of 90 °C is consistently achieved.
Distance between collector field and heat network

To minimise losses and reduce costs for the transport pipelines the collector field should be placed as close to the heat network as possible.

But the maximum distance between heat network and solar thermal plant is heavily dependent on the size of the collector field. If the costs of land are expensive close to towns and cities and the collector field is large, e.g. 70 MW, it can be placed three times further away than a 7 MW collector field, potentially resulting in the same costs.

Photo: AEE INTEC
How big does the solar storage need to be?

- At solar shares below 5 % **no daily storage** tank is necessary.
- For solar shares between 10 and 20 % **a daily storage tank** is required with 50 and 100 litres of storage per square metre of collector area.
- If solar heat should cover **100 % of the heat demand** in the summer months, a storage volume of above 200 litres per square metre collector area is recommended.
- If solar shares of above 30 % over the year are to be achieved, then **a seasonal storage tank** can be required.
Storing solar energy in summer for heating in winter

Chart: IEA SHC Task 55
Seasonal storage concepts

Solar district heating plants already have relevant experience with pit thermal energy stores, a proven and competitive seasonal energy storage option.
Construction of a pit heat storage

1. Dig a hole in the ground and put the soil around the edges.
2. Add a watertight liner at the bottom of the pit.
3. Fill the pit with water.
4. Put an insulating and floating cover on top.

A pit heat storage tank with more than 50,000 m$^3$ loses 10% of the stored energy over the year. The losses depend significantly on the size and construction of the cover.

Dronninglund in Denmark with 62,000 m$^3$ had measured losses 8% over the year. Source: Aalborg CSP

https://task68.iea-shc.org/
Summary: Solar heat is a team player

✓ Together with biomass boilers → to form a 100% renewable supply

✓ Together with seasonal storages → to form a flexible and efficient energy management system including power to heat

✓ Together with heat pumps → to form a decarbonization strategy even for district heating grids with higher temperatures above 80 °C
Where can you get further technical advice?

Research and engineering services:

IEA SHC Task 68
task68.iea-shc.org/

planenergi.eu/ in Denmark

www.solites.de/en/ in Germany

www.aee-intec.at/ in Austria

www.best-research.eu in Austria
Where can you get further technical advice?

Technology and turnkey suppliers:

Aalborg CSP, Denmark: https://www.aalborgcsp.com/
Absolicon, Sweden: https://www.absolicon.com/
Greenonetec, Austria: https://www.greenonetec.com/
Heliac, Denmark: https://www.heliac.dk/
Ritter XL Solar, Germany: https://www.ritter-xl-solar.de/
Savosolar, Finland: https://savosolar.com/
Solarlite CSP Technology, Germany: https://www.solarlite.de/
TVP Solar, Switzerland: https://www.tvpsolar.com/
Viessmann, Germany: https://www.viessmann.de/

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Thanks for your attention!

IEA SHC Task 68: https://task68.iea-shc.org/