# Task 55 Towards the Integration of Large SHC Systems into DHC Networks

## Techno-economic comparison of the collected examples

IEA SHC **TECH** SHEET 55.A.1.2

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| Subject: | Techno-economic comparison of the collected best-practice examples |
| Description: | Comparative analysis of technical and performance data of the best-practice examples collected in A-1.1<br>Comparative analysis of the economic parameters |
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| Download possible at: | http://task55.iea-shc.org/fact-sheets |

## Contents

Subtask A "Network analysis and integration" focuses on the overall aspects of district heating and cooling networks with integrated solar thermal (ST) technologies. Particularly important are the cases in which the solar share is such to significantly influence the operation of the network and the other heat/cold supply units. In the present factsheet, the best-practice examples collected in the factsheet A-D1.1 are analyzed and compared. Focus is paid on following data:

- Network data (temperatures and heat demand)
- Size of ST system (collector area) and thermal energy storage (TES)
- Installed ST capacity (MW)
- Annual ST generation and ST share
- GHI-based ST efficiency
- Annual operating and full-load hours of the ST system
- Investment costs of the ST system
- Operating costs of the ST system
- LCOH (Levelized Cost Of Heat) from ST

## Overview

Table 1 gives an overview of the 18 best-practice examples here analyzed. The large majority of them use flat plate collectors (parabolic troughs are only in Brønderslev and in a part of the ST system of Taars) and tank storage systems (borhole TES is implemented at Drake Landing Solar Community and pit TES in Langkazi and Dronninglund). One of the considered systems (Senftenberg) has no TES, since it is a decentral ST system with feed-in of the entire production. Twelve of the eighteen installations started operating in the period 2015-2019.

*Table 1. Overview of the analyzed best-practice examples*

| # | Plant | Country | ST collector type | TES type | Start-up |
|---|---|---|---|---|---|
| 1 | Nahwärme Eibiswald | Austria | Flat plate | Tank | 1997 |
| 2 | Graz – FHW Mitte | Austria | Flat plate | Tank | 2007 |
| 3 | Salzburg-Lehen | Austria | Flat plate | Tank | 2012 |
| 4 | Drake Landing Solar Community | Canada | Flat plate | Tank + Borehole | 2007 |
| 5 | Langkazi | China, Tibet | Flat plate | Pit | 2018 |
| 6 | Brønderslev | Denmark | Parabolic trough | Tank | 2016 |
| 7 | Dronninglund Fjernvarme | Denmark | Flat plate | Pit | 2014 |
| 8 | Halskov | Denmark | Flat plate | Tank | 2019 |
| 9 | Løgumkloster Fjernvarme | Denmark | Flat plate | Tank | 2014 |
| 10 | Silkeborg Fjernvarme | Denmark | Flat plate | Tank | 2016 |
| 11 | Smørum Kraftvarmeværk | Denmark | Flat plate | Tank | 2018 |
| 12 | Havdrup, Solrød Fjernvarme | Denmark | Flat plate | Tank | 2017 |
| 13 | Stenløse, Egedal Fjernvarme | Denmark | Flat plate | Tank | 2019 |
| 14 | Hybrid SDH in Taars | Denmark | 60% flat plate, 40% parabolic trough | Tank | 2015 |
| 15 | Châteaubriant | France | Flat plate | Tank | 2018 |
| 16 | Chemnitz-Brühl | Germany | Flat plate | Tank | 2016 |
| 17 | Senftenberg | Germany | Flat plate | None | 2016 |
| 18 | Mengsberg | Germany | Flat plate | Tank | 2018 |

Figure 1 illustrates the main characteristics of the ST plants aggregated for each country; the columns represent the overall gross collector area, TES volume, ST capacity, ST production of the considered plants.

Denmark is highly represented with 9 best-practice examples. Austria and Germany are represented by 3 plants, while Canada, France, and China by one plant. However, the plant of Langkazi in Tibet is very large and makes the country reach the second position in terms of values of all the 4 considered parameters.

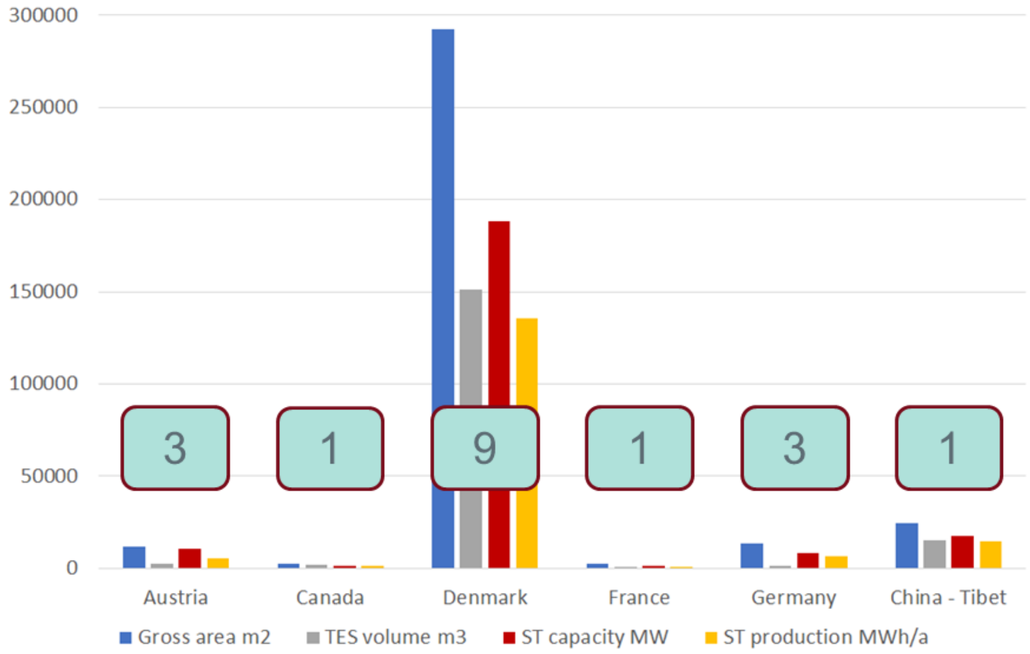


*Figure 1. Characteristics of the investigated ST plants aggregated for each country (Source: AIT)*

## Comparative diagrams

This section reports comparative diagrams of technical and economical parameters. Figure 2 illustrates annual average values of network supply and return temperatures and annual GHI at the location and annual ST production. The annual GHI ranges between 981 and 1374 kWh/m$^2$ excepts for the very high value in Langkazi (1370 kWh/m$^2$). The most integration schemes are return-to-supply and/or return-to-storage, while two systems with high network supply temperatures (Graz Mitte and Châteaubriant) use the scheme return-to-return.

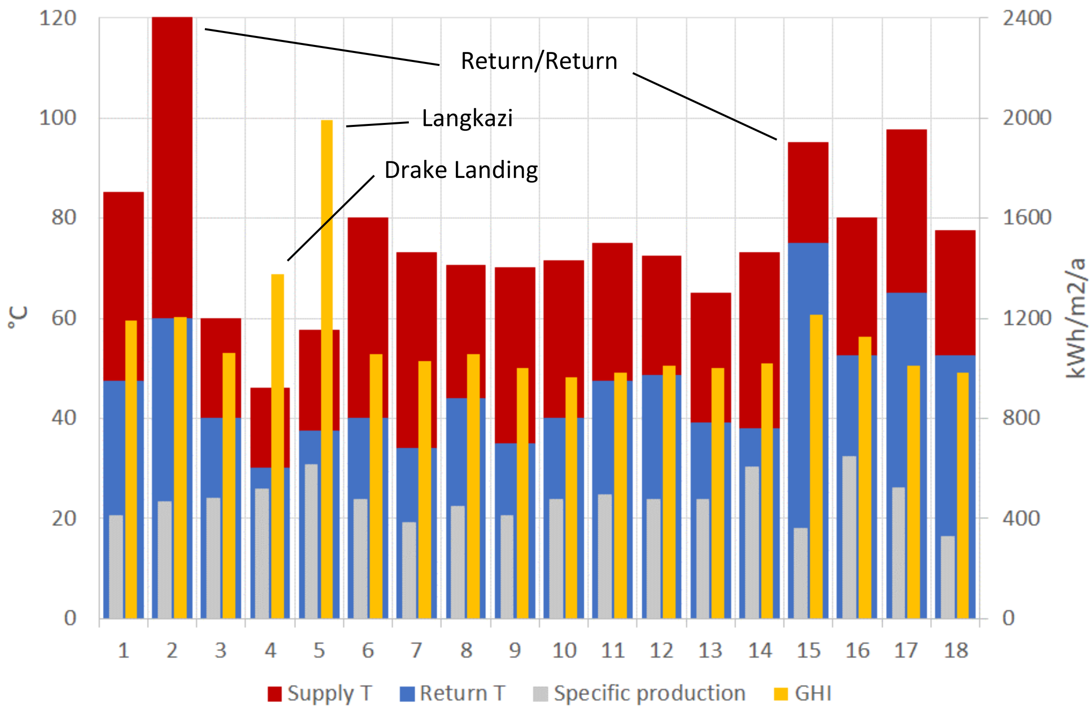


*Figure 2. Operating data of the best-practice examples (Source: AIT)*

Figure 3 shows the specific ST production vs. the network supply temperature. This plot does not include the two systems with return-to-return integration, and it is reported to illustrate that the relationship between these parameters is not very recognizable. Indeed, while on the one hand it is true that higher temperatures cause lower ST efficiencies, on the other hand other aspects of the system play also an important role in determining the ST production, such as the energy management system (of course, besides the solar radiation, which however in these examples does not show a significant variation apart from the two cases in Tibet and Canada). Therefore, the network temperature is not the only variable affecting the ST production.

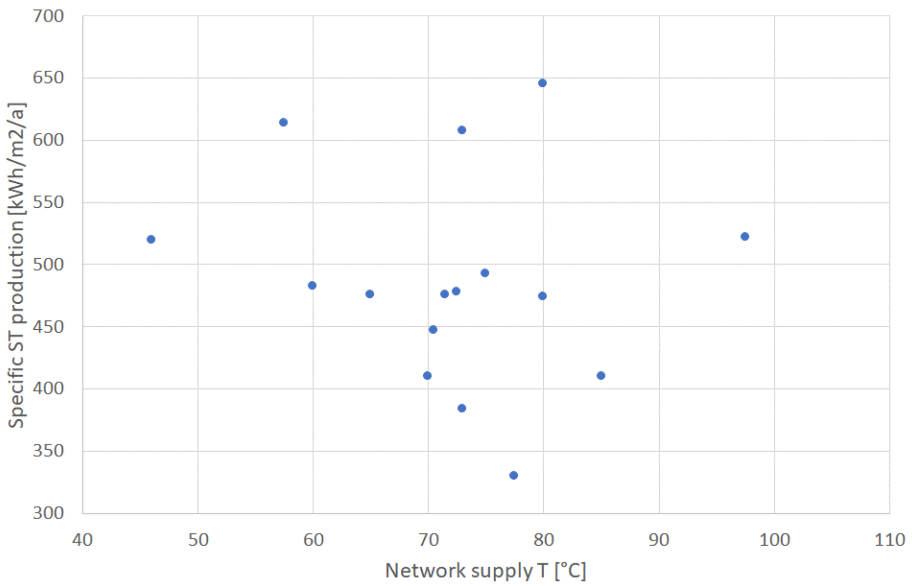


*Figure 3. Specific ST production vs. average supply temperature (Source: AIT)*

Figure 4 illustrates the collector area per network demand and the TES volume per collector area, as well as the ST share in the network and the GHI-based efficiency of the ST system, which ranges from 31% to 60%, with an average value of 43%. The plants 9, 15, and 17 are integrated with decentral feed-in, which allows to avoid the TES in the case 17 (Senftenberg) and to use a storage of lower volume than in central systems in the case 15 (Châteaubriant).

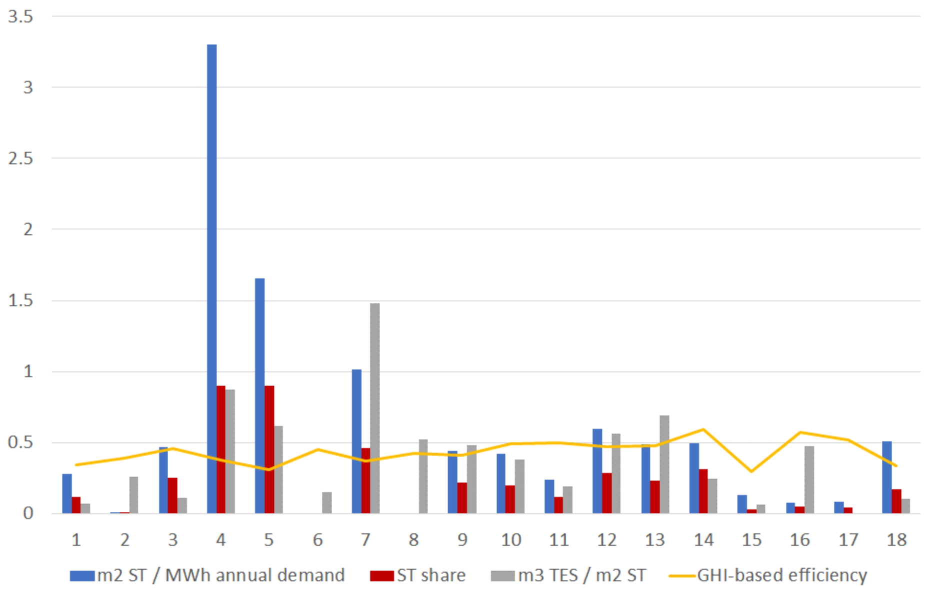


*Figure 4. Analyzed examples: ST and TES size, ST share, system efficiency (Source: AIT)*

The annual ST share vs. collector area per network demand is reported in Figure 5. It is possible to recognize a linearly growing trend in the left part of the plot, with slope 55%/($m^2$/MWh), up to 1.65 $m^2$/MWh and ST share 90%, corresponding to Langkazi (only Drake Landing falls clearly outside of this trendline). On the contrary, a trend of ST share vs. storage volume per collector are is not recognizable (Figure 6), whilst the role of the storage is to enable higher shares. This fact could be a sign either that some TES systems are oversized or that the available volume is not optimally used.

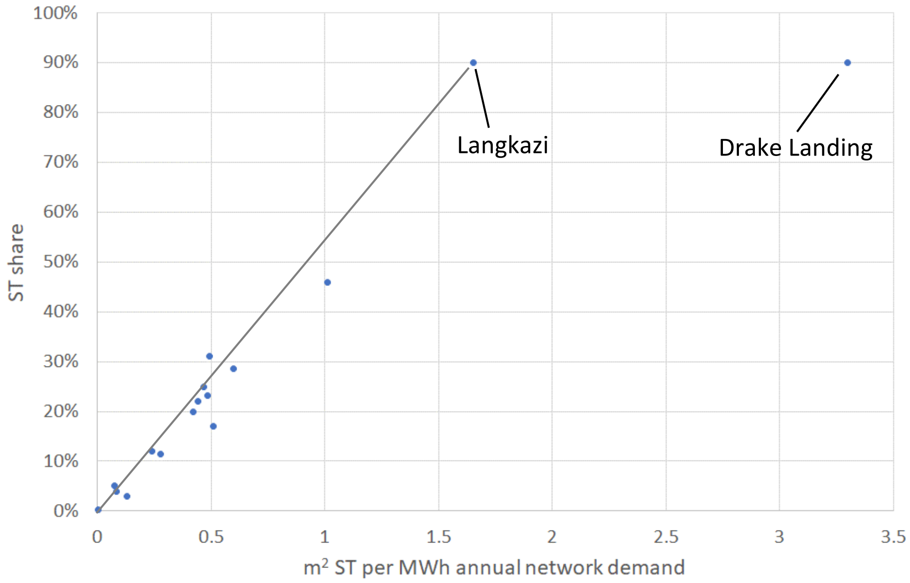


*Figure 5. Annual ST share vs. collector area per network demand (Source: AIT)*

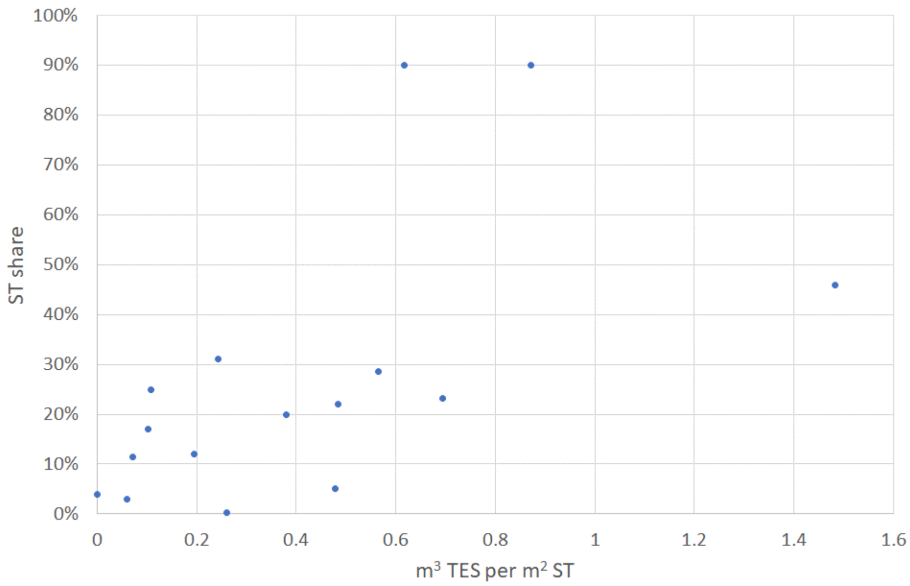


*Figure 6. Annual ST share vs. storage volume per collector area (Source: AIT)*

Figure 7 reports the annual operating hours and the full-load equivalent hours of the ST plants (full load is here intended as the typical maximum ST power at normal operation). The operating hours range from almost 2000 to 3000 per year, with the exception of more than 5500 hours per year in Langkazi. The average ratio of full-load equivalent to operating hours is 0.3.

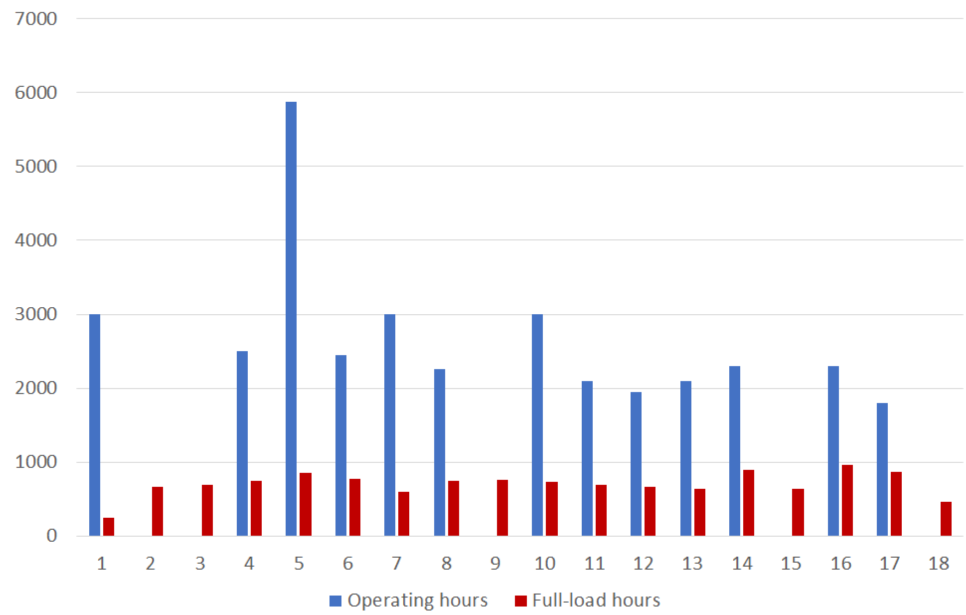


*Figure 7. Annual operating and full-load equivalent hours of the analyzed ST plants (Source: AIT)*

Figure 8 shows the specific capital costs (including planning and construction). Since in most cases the data is sensitive, just the values of 5 systems are known. They range from 200 to 560 €/$m^2$, with an average value of 420 €/$m^2$.

The operation and maintenance costs are known just for two Danish systems (Dronninglund and Silkeborg), where they are in the range 1-2 €/MWh, and for Châteaubriant, where they result about 11 €/MWh.

The LCOH is known for 7 systems. It ranges between 30 and 45 €/MWh, with an average of 36 €/MWh. However, the collected values are difficult to compare because not all the criteria for their calculation are known and they may differ from case to case (especially the considered interest rate, which significantly affects the LCOH).

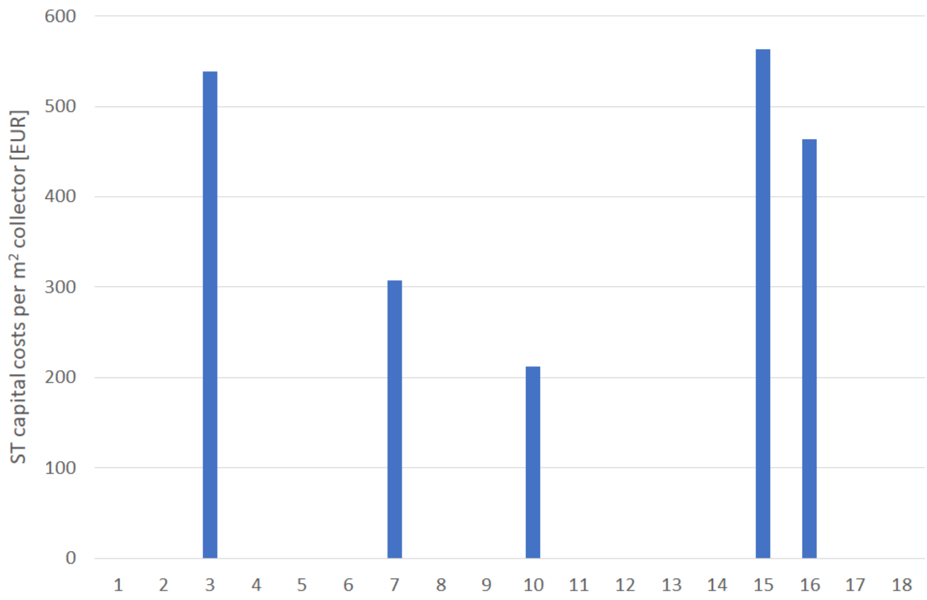


*Figure 8. Specific capital costs of the analyzed ST systems, including planning and construction (Source: AIT)*

## Highlights

The highlights of the here presented analysis are:

- Flat plat collectors are installed in all the analyzed examples except Brønderslev;
- Parabolic troughs are installed in Brønderslev and Taars;
- Storage tanks is the most used storage technology, pit storages are used in Langkazi and Dronninglund, and borehole storage in Drake Landing;
- Two of the analyzed systems, characterized by high network supply temperatures, are integrated with a return-to-return scheme (Graz Mitte and Châteaubriant);
- The annual ST production ranges from 330 and 614 kWh/m$^2$, with an average value of 478 kWh/m$^2$;
- The full-load equivalent hours range from 250 to 900 per year, with an average value of 700;
- The GHI-based efficiency ranges from 31% to 60%, with an average value of 43%;
- Langkazi and Drake Landing show the maximum values of GHI (respectively 1990 and 1374 kWh/m$^2$) and a ST share above 90%;
- A linear trendline with slope 55%/(m$^2$/MWh) is easily recognizable for the relationship of ST share vs. installed area per network demand (only Drake Landing falls clearly outside of this trendline);
- The annual operating hours are in range 1800-3000, with the exception of more than 5500 hours per year in Langkazi;

- The average ratio of annual full-load equivalent to annual operating hours is 0.3;
- With some approximation, it is possible to recognize an increasing trend of annual full-load equivalent hours vs. TES volume per ST area;
- The investment costs range from 200 to 560 €/$m^2$ including planning and construction, with an average value of 420 €/$m^2$;
- The known operation and maintenance costs of the Danish installations are very low (1-2 €/MWh);
- The LCOH ranges from 30 to 45 €/MWh, with an average value of 36 €/MWh (although, the collected values are difficult to compare because the homogeneity of the calculation assumptions is not sure).