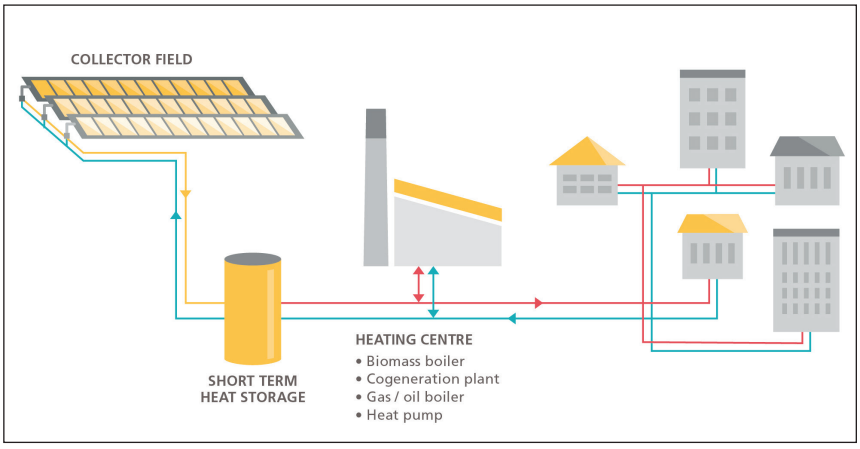
Integrating Large SHC Systems into District Heating and Cooling Networks

Integrating large-scale solar thermal plants into district heating and cooling grids is playing a crucial role in many countries' energy transformation to decarbonize their heating sector. Thermal networks offer a dual solution – increasing energy efficiency in urban areas and integrating renewable energies into the heat supply. The participants in IEA SHC Task 55: Integrating Large Solar Heating and Cooling Systems into District Heating and Cooling Networks worked from 2016–2020 on this topic with a holistic focus on solar systems that supply heating and cooling networks with high thermal shares

Renewable sources are a central component of the sustainable energy supply in the urban environment. Nowadays, traditional supply technologies and infrastructures are experiencing big challenges, resulting in significant changes in how energy is stored and distributed. In this evolution, new, economically attractive, and technologically innovating possibilities for solar thermal energy are emerging in European towns and beyond. One such option is large solar thermal plants. To seize this growing market opportunity, solar thermal district heating and cooling will need to optimize the integration and design of complex systems and develop targeted transformation strategies and new financing models.

These topics were the subject of the IEA SHC Task 55: Integrating Large Solar Heating and Cooling Systems into District Heating and Cooling Networks. An important innovation point of the Task was the analysis of solar systems supplying heating and cooling networks with high thermal shares. Contrarily to previous studies, in which solar thermal covered low network shares, the Task looked at a holistic approach for successful large-scale integration. This approach takes into consideration the evaluation of economically optimized transformation strategies of an entire network, a significant reduction of network operating temperatures, the development of efficient algorithms for operational optimization and control, the integration of seasonal thermal energy storage systems, and the analysis of the effect of decentral supply on the network hydraulics.



▲ **Figure 1. Solar district heating scheme.**

Participating Countries

Austria
Canada
China
Denmark
Finland
France
Germany
Spain
Sweden
United Kingdom

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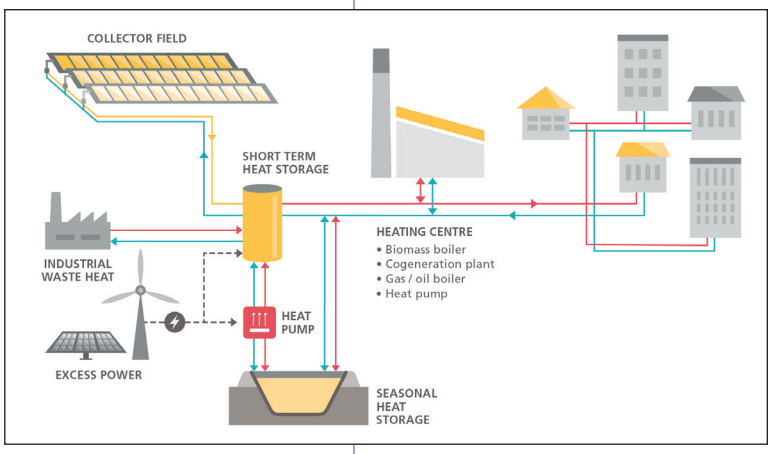
As explained by Sabine Putz, the Operating Agent of SHC Task 55, "lively know-how exchanges over more than four years of collaboration between industry and research built a shared basis for development activities of solar district heating and cooling." And, to provide full access to the Task's results, the participants summarized their findings in 27 Fact Sheets that you can download at https://task55.iea-shc.org/.

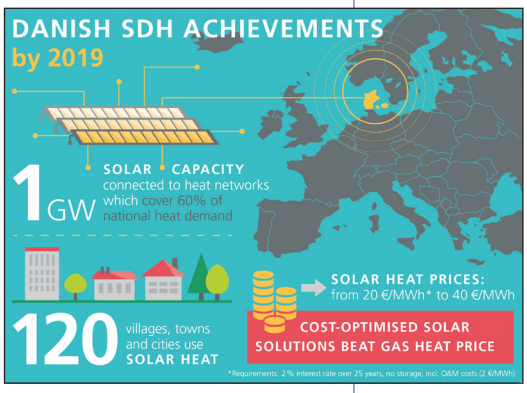


▲ **Figure 2. Example of a large-scale solar thermal system integration into district heating.**

Why Solar District Heating?

Large-scale solar thermal plants are used, mainly in Europe, to integrate a locally available, sustainable heat source into district heating networks, industrial processes, and thermally driven cooling systems. The expansion of their application is part of the energy transition occurring in countries, particularly as part of decarbonizing the heating sector. The concept of integrating large-scale solar thermal plants into district heating and cooling grids, which was investigated in SHC Task 55, plays a crucial role in this transformation as it enables synergies between thermal grids and solar thermal energy.

Solar heat networks are a proven and reliable technology based on more than 25 years of development, operation, and maintenance by operators and industry experts. In the last decade, interest in the economic deployment of solar thermal networks has grown tremendously, especially in Denmark, where 1 GW (>1.6 million m^2 collector area) of solar district heating was installed by 2019 (see Figure 3). However, despite the remarkable potential of large solar thermal systems, the heat contribution of solar thermal to heating and cooling in thermal grids is less than 1% worldwide. Given this fact, SHC Task 55 set the goal to support the growing market of solar district heating and cooling systems.

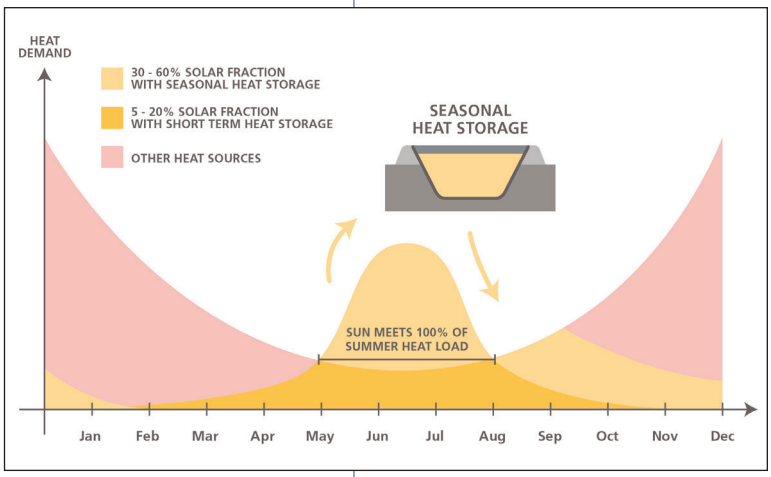


◀ **Figure 3. Key figures for solar district heating in Denmark in 2019.**

What About Storage?

Seasonal pit heat storages connected to large-scale solar plants for district heating are now in use in several countries throughout the world (e.g., Denmark, Germany, China). The concept is for seasonal storage, but has the possibility for shorter heat storage periods, as it provides quick charging and discharging.

In principle, pit heat storage is a large water reservoir for storing thermal energy. Water is an excellent medium for heat storage as it is cheap, non-toxic, and has a high heat capacity. The cost of water storage mainly consists of the parts surrounding the water, for example, the watertight tank and thermal insulation. For smaller storages (up to 5,000 m^3), an insulated steel tank is typically used, but for larger storages, a pit heat storage is considerably cheaper per m^3 water.



▲ **Figure 4. Seasonal storage principle.**

Based on the experiences from the implemented storages in Denmark, an extrapolated price curve is shown in Figure 5. The economy of scale is clear. Going from 60,000 m^3 to 500,000

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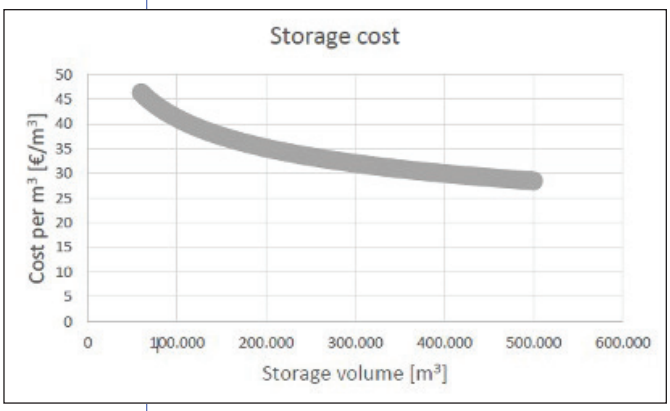
m^3, the expected specific costs are reduced by more than 20% (from approximately 50–30 €/m^3).

Is the Market Growing?

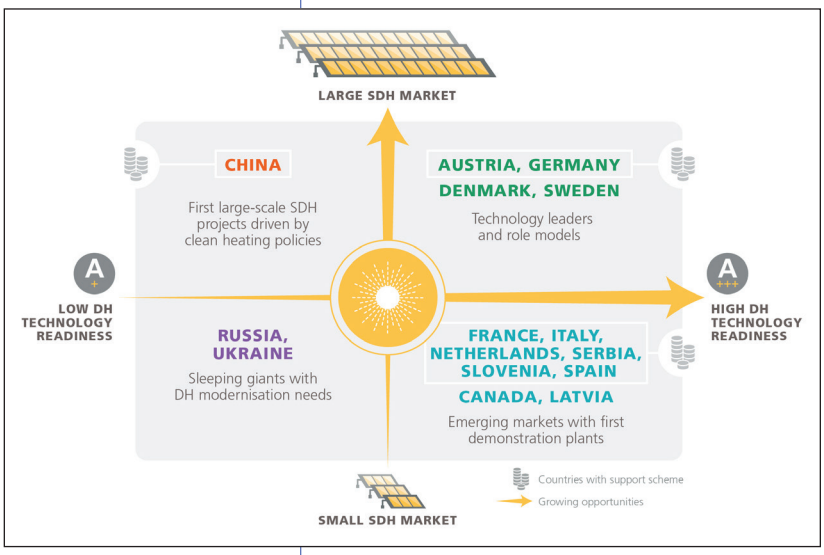
Solar district heating is steadily growing along with the number of megawatt-scale systems for district heating and industrial applications. Twenty-three large-scale solar thermal systems with about 228,900 m^2 (160 MWth) were installed in Europe in 2019. Of these installations, 15 were in Denmark (191,300 m^2), including five extensions of existing systems, six in Germany (14,700 m^2), one in Latvia (21,700 m^2), and one in Austria (1,200 m^2). With the addition of Denmark's new systems, that market grew a remarkable 170% in 2019.



▲ **Figure 5. Estimation of the costs for pit heat storage as a function of the size of the storage.** (Source: PlanEnergi)

During SHC Task 55, the installed collector area for solar district heating (SDH) has increased significantly. In 2016, the world's largest SDH collector area was built in Denmark, coming in at 157,000 m^2, followed by major projects in Tibet with 22,000 m^2 of collectors reaching solar fractions up to 100% of the space heating demand, and Germany's largest plant with 14,800 m^2 of collectors. It is expected that this trend of large-scale SDH systems will continue in the coming years and that these systems will become increasingly important for the decarbonization of the heat supply.

The chart below classifies several countries according to their attractiveness for SDH. The appeal of a national market is based on the technological readiness of its district heating sector.



▲ **Figure 6. Attractiveness of solar district heating in different countries.**

Conclusion and Outlook

Solar-assisted district heating and cooling networks form an essential part of a future-oriented renewable-based energy system, with high CO_2 savings and low operational costs. The integration of large-scale solar thermal plants into district heating or district cooling networks exploits the interactions between thermal networks and solar thermal, contributing to significant decarbonization of the heating sector.

Thermal grids offer the possibility of increasing energy efficiency in urban areas and integrating renewable energies into the heat supply. Solar thermal energy is essentially emission-free, fully renewable, always available, and cost-stable over the long term. Moreover, solar heat networks are a proven and reliable technology based on more than 25 years of experience of operators and industry experts regarding development, operation, and maintenance.

Financing solar district heating projects, however, can be complex. Especially if the construction of seasonal storages or heating networks is planned in addition to the large-scale solar thermal system as these are very capital-intensive investments. Since there is still a lack of broad practical experience, many stakeholders are still unclear and uncertain about the financing of solar thermal energy. A professional assessment of the risks is therefore indispensable for a viable financing concept. Transparent risk management is relevant for a large and diverse target group ranging from

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investors, lenders, bankers, and insurers to project developers, operators, and if applicable, end customers and political decision-makers. Although considered to play an essential role in the decarbonization of the heating sector, solar thermal energy needs very attractive funding instruments, particularly when using solar thermal energy in heating grids to accelerate its expansion.

Unfortunately, there is no patent remedy. Rather a differentiated approach is necessary to take into account the unique risks of each project due to their specific parameters, such as geographical location, model selection, participation structure, etc. Nevertheless, with each built plant, the wealth of experience gained and the contribution to a renewable energy transition is unquestionable.

If the goal of an almost climate-neutral supply of heat to buildings is to be achieved, there is no way around a massive expansion of the renewable district heating supply.

For the decarbonization of district heating, it will be important to use all the available renewable generation options and to combine them optimally according to the respective local conditions. In addition to the many individual measures, large-scale projects are indispensable, particularly in the area of district heating supported by solar thermal energy and solar thermal systems for housing blocks and neighborhoods.

Article contributed by Sabine Putz of SOLID, Austria, and the Operating Agent of Task 55: Integrating Large Solar Heating and Cooling Systems into District Heating and Cooling Networks, https://task55.iea-shc.org.

**A follow-on IEA SHC project on Efficient Solar District Heating Systems is scheduled to begin in January 2022. For more information on this new project, contact Viktor Unterberger, viktor.unterberger@best-research.eu.*