2024 HIGHLIGHTS

Task 68 - Efficient Solar District Heating Systems

THE ISSUE

Heat is the largest energy end-use, accounting for 50% of global final energy consumption in 2021 and contributing to 40% of global carbon dioxide (CO_2) emissions. Of the total heat produced, about 46% was consumed in buildings for space and water heating. Regarding the heat supply of buildings, district heating systems play an important role and are well-established in many countries since they typically enable efficient resource utilization. However, most district heating networks in Europe and worldwide still operate with supply temperatures over 80 to 120°C (medium-high temperature), which is still typically produced by caloric power plants. Currently operating solar district heating (SDH) systems are normally installed with flat-plate collectors, providing either heat at lower temperatures or lower efficiency in the case of higher temperature requirements. SHC Task 68 is therefore investigating how to increase the efficiency of SDH systems and support the dissemination of such systems.

OUR WORK

SHC Task 68 provides a high-quality and powerful platform for practitioners and scientists to elaborate on the latest benefits and challenges of SDH systems. It elaborates on options and measures how to further increase the efficiency of solar district heating (SDH) systems when providing the desired temperatures needed by currently operated district heating systems by investigating how:

- To efficiently provide heat at the desired temperature either directly by solar (e.g., combining flat-plate collectors with other solar collectors) or indirectly by combining solar collectors with other technologies (e.g., solar collectors with heat pumps).
- To take the next step in digitalization measures to allow for more efficient data preparation and utilization.
- To make SDH systems more competitive and more appealing by exploring new business models and ways to reduce costs.
- To raise awareness of solar technologies and disseminate the knowledge.

Finally, SHC Task 68 aims to create synergies between the IEA Technology Collaboration Programme on District Heating and Cooling, including Combined Heat and Power (IEA DHC).

Participating Countries

Austria
China
Denmark
Germany
Italy
Netherlands
Poland
Spain
Sweden
United Kingdom

Task Period	2022 – 2025
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KEY RESULTS IN 2024

Collector efficiency curves

There is a wide range of solar thermal technologies and products used for SDH with medium-high temperatures. While most of the collectors can be analyzed using the Solar Keymark certification, the consideration provides only limited insights into system integration and higher mean collector temperatures (+75 °C). The report RA1 highlights various aspects of different collector technologies, including the system integration of solar thermal collectors, supply temperatures, and their geometrical features. Additionally, it examines the basic functionalities, advantages, applications, efficiency and some installation examples.

Based on parameters from the Solar Keymark certificates and manufacturer information for the collectors, efficiency can be determined as a function of the difference between the mean collector temperature and the ambient temperature. With increasing collector temperatures, the temperature difference to the ambient air also increases, leading to higher thermal losses and a reduction of collector efficiency.

Figure 1 shows the efficiency curves of flat-plate collectors, which are in a similar range. The data is based on information under steady state or quasi dynamic conditions and relates to the gross area in each case for a global radiation of 1000 W/m². It is noticeable that when the temperature difference exceeds approximately 100 K, efficiency declines significantly. The efficiency of parabolic trough collectors decreases far less with increasing temperature differences compared to flat-plate collectors. In the best case for large-scale parabolic troughs, the efficiency remains almost constant over the specified temperature range. At a temperature difference of 200 K, their efficiency is approximately 74 %. The comparison also shows that flat-plate collectors are particularly well-suited for lower collector temperatures compared to parabolic troughs. This is due to the high optical efficiency of the flat-plate collectors, resulting from their relatively large absorber surface.

Gross thermal yield comparison

Solar Keymark certificates provide the gross thermal yield (GTY) for one year at the reference locations Athens, Davos, Stockholm, and Würzburg for average collector temperatures up to 75 °C. To ensure a fair comparison, the diagram displays not individual products but rather technologies. The collectors shown represent typical characteristics of the respective technology. The data is based on Solar Keymark certificates, manufacturer information, and ScenoCalc calculations for mean collector temperatures of 100 °C.

Figure 2 shows the GTY for the location Würzburg, Germany. The High-vacuum flat plate (HVFP) collector delivers the highest specific yield at a mean collector temperature of 25 °C. As the collector temperature increases, the yield of the flat plate collector (Standard FP) falls more sharply than with the HVFP, evacuated tube with compound parabolic concentrator (CPC) and the small parabolic trough (Small PTC). The large parabolic trough (Large PTC) ensures relatively constant specific yields over the shown collector temperatures. Especially at average collector temperatures of more than 75 °C, there is an advantage over the CPC collector. These results are directly connected to the efficiency curves of the technologies. In general, the yield is higher at lower collector temperatures because thermal losses are lower with a smaller temperature difference to the ambient. This is particularly important for the system integration of solar collectors to optimize the solar thermal output, the system efficiency and therefore the levelized cost of heat.

The GTY figure is not intended to be used for planning a system, but rather to compare collector technologies based on their annual thermal output in a generalized way. Depending on other parameters such as user profiles or available space, the effective output can deviate considerably from the GTY. For large systems, it can be assumed that the generated solar energy is almost completely absorbed by the system. Therefore, the GTY parameters are good approximations of the effective annual yield.

(Reference: Tamm et. al., Solar Collector Technologies for District Heating, IEA SHC Task 68 report RA1, 2024, https://doi.org/10.18777/ieashc-task68-2024-0002)

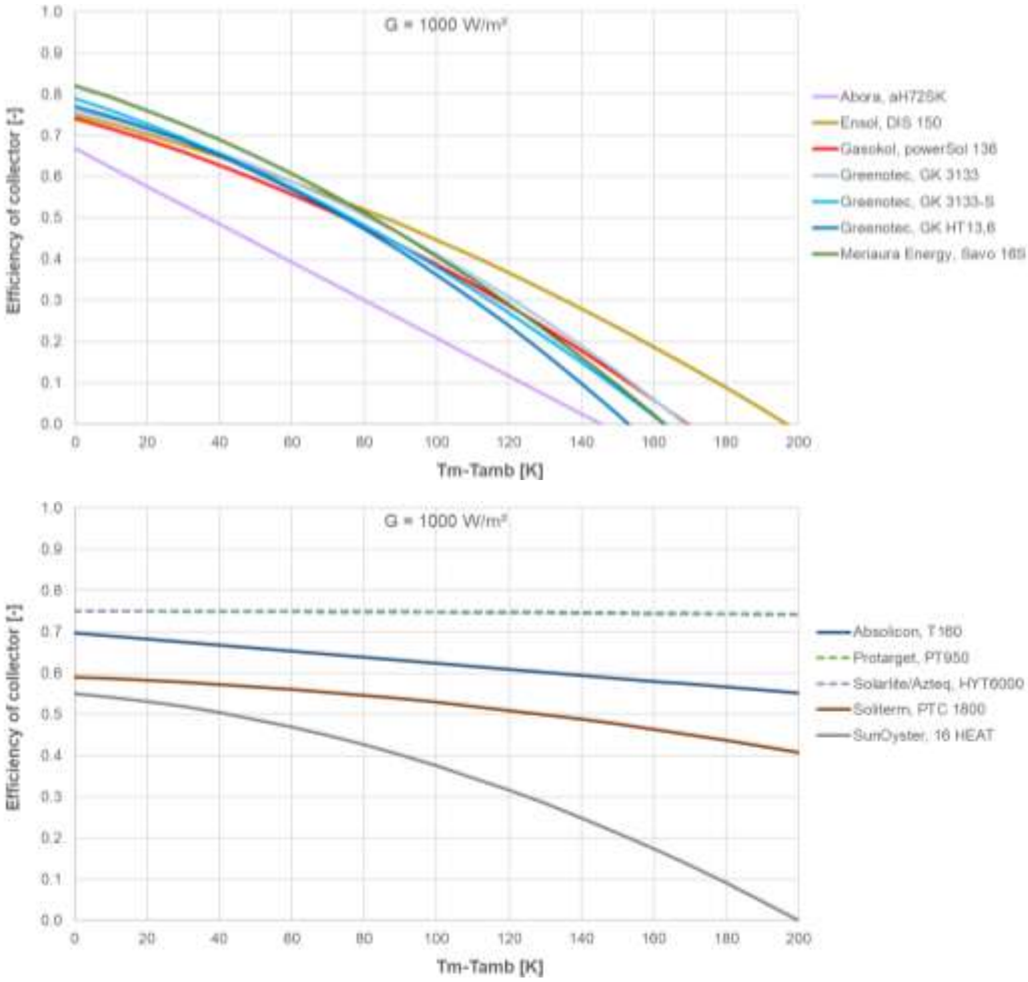

Figure 1: Selected efficiency curves for flat-plate collectors (above) and parabolic trough collectors (below). Solid lines are based on Solar Keymark certificates and dotted lines are based on manufacturer information. Dotted curves for Protarget and Solarlite/ Azteq are overlapping

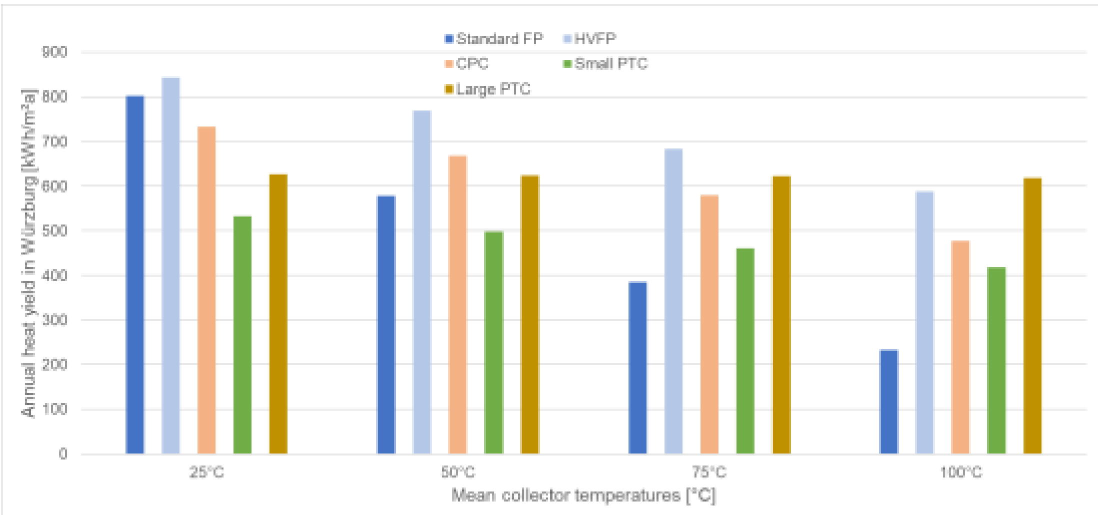

Figure 2 Comparison of gross thermal yield in Würzburg, Germany, for different operating temperatures based on manufacturer information, Solar Keymark certificates (up to 75 °C) and ScenoCalc calculations (at 100 °C)

SunPeek: Open-Source Software for Checking the Performance of Solar Thermal Plants

ISO 24194:2022 is the first ISO standard specifically designed to assess the operational performance of solar thermal collector arrays and is likely to have substantial impact on the entire solar thermal industry. It introduces the *Power Check* - a method that can be used for monitoring ongoing plant operation and for checking performance guarantees.

However, its practical use is presently limited, as initial applications indicate a need for clarification, and it exists as a mere paper description, rendering it less accessible for plant designers and operators. Furthermore, any implementation necessitates practical decisions regarding data handling and algorithm implementation. Closed-source implementations, lacking a traceable and transparent framework, could lead to inconsistent results.

As a result, a work group related to Task 68 introduced the software **SunPeek.** It is an open-source software that provides a reference implementation of the ISO 24194 Power Check. The software is freely accessible for both scientific and commercial purposes. Using a user-friendly web-interface or a standalone Python library, user can configure plants, upload data, and easily execute the Power check method. More information is available at https://sunpeek.org/ while a free online demo is available at https://demo.sunpeek.org.

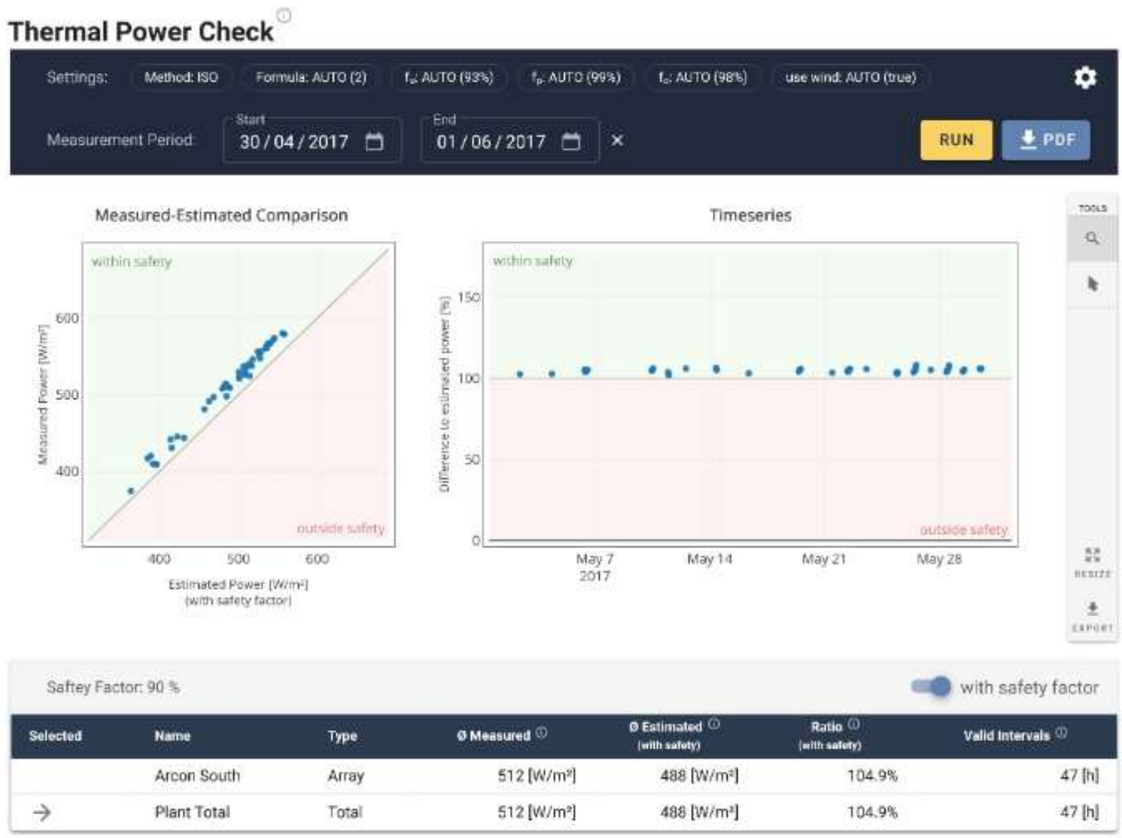

Figure 3: Screenshot of the SunPeek Web-UI with results of the ISO 24194 Power Check using the public dataset "Fernheizwerk". The left plot illustrates a comparison between measured and estimated hourly performance values; the right plot depicts the evolution of performance values over time.

(Reference: Tschopp, D. et al., SunPeek Open-Source Software for ISO 24194 Performance Assessment and Monitoring of Large-Scale Solar Thermal Plants, International Sustainable Energy Conference - Proceedings, 2024, https://doi.org/10.52825/isec.v1i.1248.).

Efficient Data Management and Validation – Report RB1 published

Solar thermal plants have proven to be a successful technology in providing heat for district heating networks. To ensure the efficient operation of such plants and to achieve optimal coordination with other heat generation units, thorough monitoring, quality control, and system control are required. However, these tasks strongly depend on **accessible and reliable measurement data**, which are often unavailable.

Thus, the Task 68 team focused on providing guidelines for data gathering, storage, distribution, and validation to ensure measurement data can be fully utilized. The results are presented in the subtask report RB1 covering every step from sensor selection to permanent data storage:

- *Required Data* - The report first lists recommended measurements for analysing solar-thermal plants. In total, about 60 measurements have been identified (depending on setup and some of them optional – see Figure 4). In addition, multiple meta-information is listed (e.g. unit of measurement, sensor position), which is needed to successfully interpret the data.
- *Data Gathering & Distribution* – To provide helpful insights on recording and parsing measurement data, the report lists recommendations regarding data logging and shows proven examples for data distribution architectures, including both on-site data analysis and cloud solutions.
- *Data Storage* – Data storage is needed to easily store and fetch the data on demand. The report shows which data storage technologies are currently in use based on a survey, revealing that CSV files are still the most common data storage format (most common and simple), with some participants working with relational databases (improved flexibility) and some with timeseries databases (improved query speed). For each type of database type, interviews with user were conducted to share their experience.
- *Data Validation* – Finally, data can only be used successfully if valid data is used. Hence, the report lists and shortly describes different validation algorithms and pre-processing algorithms that were identified based on literature research.

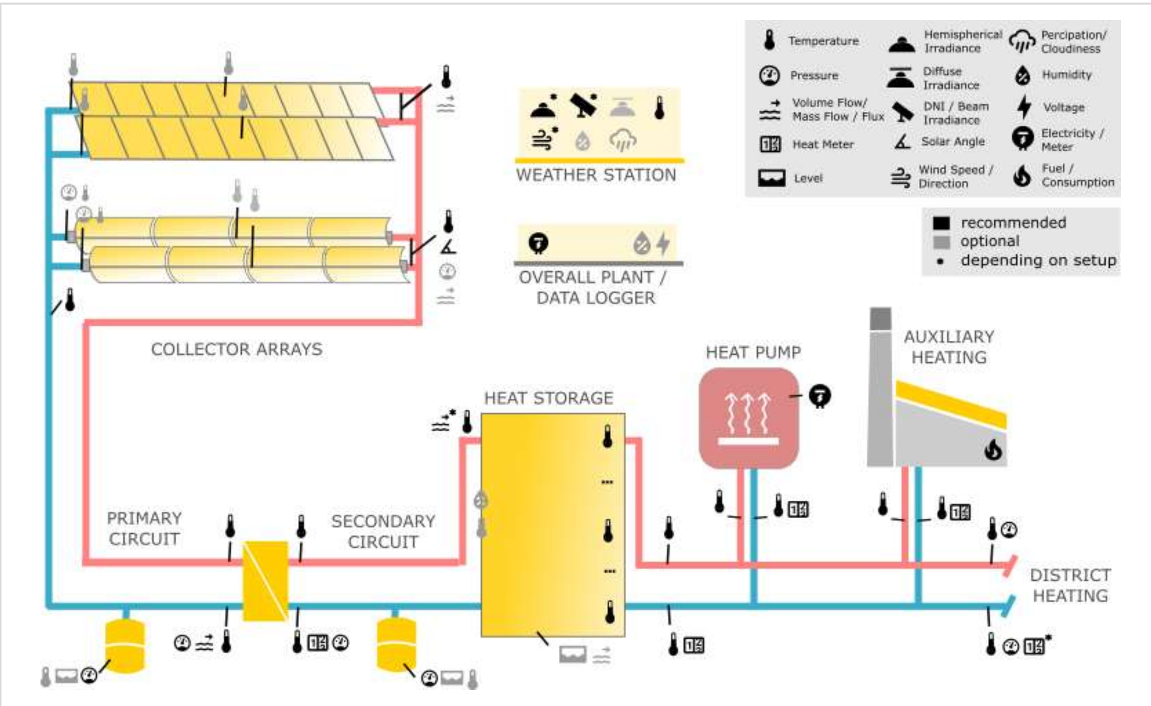

Figure 4: Overview of recommended measurements in a solar district heating plant.

(Reference: Feierl et. al., Efficient Gathering, Storing, Distributing and Validation of Data, IEA SHC Task 68 report RB1, 2024, https://doi.org/10.18777/ieashc-task68-2024-0001).