Yield Assessment for Large-Scale Solar Thermal Plants

Summary

Large-scale solar thermal plants offer decarbonized, locally generated, and cost-effective heat for neighbourhoods, district heating networks, and industrial processes. By 2030, an estimated 41% of EU's district heating demand could be met by renewables including solar thermal energy (IEA (a), 2024). Despite this potential, solar thermal face market barriers including limited provider competition and lack of reliable decision tools. This project addresses these challenges by developing standardized yield prediction methods for concentrating collectors: Power Check (PC), Daily Yield Check (DYC), and Annual Yield Check (AYC) according to ISO/FDIS 24194 (ISO/FDIS 24194, 2025). The methods reduce investment risks and enhance market competitiveness through standardized performance verification. Validation is demonstrated through field measurements at two demonstration systems, providing practical evidence of performance and reliability. Results show standardized yield assessment increases stakeholder confidence and accelerates deployment through quality assurance.

Keywords: large-scale solar thermal plants, district heating, process heat, yield assessment, performance monitoring, standardization

Field of application for the findings: Sustainable and Efficient Districts | Sustainable Heat for Industrial Process | Solar Thermal and PVT Collectors and Solar Loop Components | Solar Resources and Energy Meteorology

Addressed audience: city planes, civil engineers, energy providing companies, district heating turn-key providers, financiers, risk managers

1. Introduction

Despite their substantial decarbonization potential, large-scale solar thermal plants face market and institutional barriers, particularly the absence of standardized, reliable performance verification, insufficient risk mitigation instruments and challenges in integrating plants into hybrid energy systems. This article presents the development, validation, and application of straightforward methods for verifying the predicted annual yield of large-scale solar thermal plants. It outlines the normative status of these methods as well as implementation examples and operational experience gained with demo-systems. The methods were developed within a public funded research project and implemented in ISO/FDIS 24194 (ISO/FDIS 24194, 2025). The work was supported by IEA SHC Task 68 – Efficient Solar District Heating (IEA (b) 2024, IEA 2025) and the international standards committee ISO TC 180.

The primary objective of this method development was to provide simplified procedures for yield assessment of large-scale solar thermal systems, including concentrating and tracking collectors. Applying these methods increases stakeholder confidence through quality and efficiency assurance and through standardization, reduce investment risks, and thereby strengthen the competitiveness of large-scale solar thermal plants.

2. Research Background

The projekt is implemented by a consortium of research institutes, engineering offices, and technology providers including an advisory board comprising representing the perspective of the most relevant market participants form industry, which supports the project by critically reviewing the research, disseminating the results, and integrating the findings into market activities.

It provides planners, municipal utilities, heating network operators, and industrial companies with a comprehensive service package so that they can incorporate and implement solar thermal systems into their heating plans. A central contribution of the project is the development, validation, and application of straightforward methods for verifying the predicted annual yield as well as the operational analysis of large-scale solar thermal plants. The thermal yields of two demo-systems based on field measurements are quantified by the consortium. The measurement data and the application of the developed yield-analysis methods, provide validation and practical evidence of the performance and reliability in the future-oriented fields of solar district heating and solar process heat.

3. Method development

Three output characteristics were investigated in the project and are described in ISO/FDIS 24194 (ISO/DIS 24194, 2025). The Power Check (PC) and Daily Yield Check (DYC) were further developed for application to concentrating collectors, while the Annual Yield Check (AYC) is a newly developed method for verifying the annual yield of large-scale solar thermal plants. To develop and validate these yield-assessment methods, and to demonstrate the performance and functionality of large-scale solar thermal are continuously monitored.

Remaining challenges are in the detailed fitting between expected field output and real performance. To enable meaningful cross-checks with low effort and cost, simplified protocols are needed. Also, the measurement effort shall be as minimal as possible, raising the research question of what uncertainty is tolerable and agreeable for the purpose of the application. Two different entities apply the principles of the methods within their in-house tools and compare the results. The differences assumptions and defaults are discussed. Therewith, providing an insight for improvement of the method in the next revision and fostering the confidence level and robustness of the method.

4. Results Demonstration-Plant

Monitoring data from the year 2024 has been analyzed. This data was provided by the plant operator and recorded using sensors already installed by the manufacturer, consisting of a rotating shadow band radiometer (CSPS Twin-RSI), PT100-Sensors in immersion sleeves, and an orifice plate. This is a typical measurement setup for these applications. The analysis showed that 868 kWh/m² of the annual direct irradiation of 1,949 kWh/m² could be utilized during 190 production days in 2024, leading to an annual yield of 370 kWh/m² and a system efficiency of 42.6 %.

To put this result into context, a measurement uncertainty analysis was carried out for the used instrumentation. The two-wire cabling of the PT100 sensors and the use of an RSI for irradiance measurement were identified as particularly unfavorable factors. Under these conditions, the total uncertainty is estimated around 11% of the measured value. This demonstrates that safety margins for guaranteed field yields also depend on the measurement technology applied and its installation conditions. In this case, there is room for improvement by using at least three-wire PT100 cabling and by thoroughly checking, calibrating and correcting the RSI measurements.

The overall plant evaluation revealed a deviation of 0.85° between the actual north–south orientation of the collectors and the orientation stored in the control system. This misalignment results in yield losses compared to the expected output, particularly in the morning hours and more pronounced in spring and autumn.

The site's coastal location leads to dusty and salty ambient conditions, which increase soiling effects on the collector's surface. Nevertheless, the data analysis indicates that mirror cleaning is carried out at irregular intervals. The study suggests that with more regular cleaning intervals every ten days and a minor adjustment of the control settings, an increase in the annual yield to 420 kWh/m² and a system efficiency of 48.4% can be anticipated, as given in Figure 1.

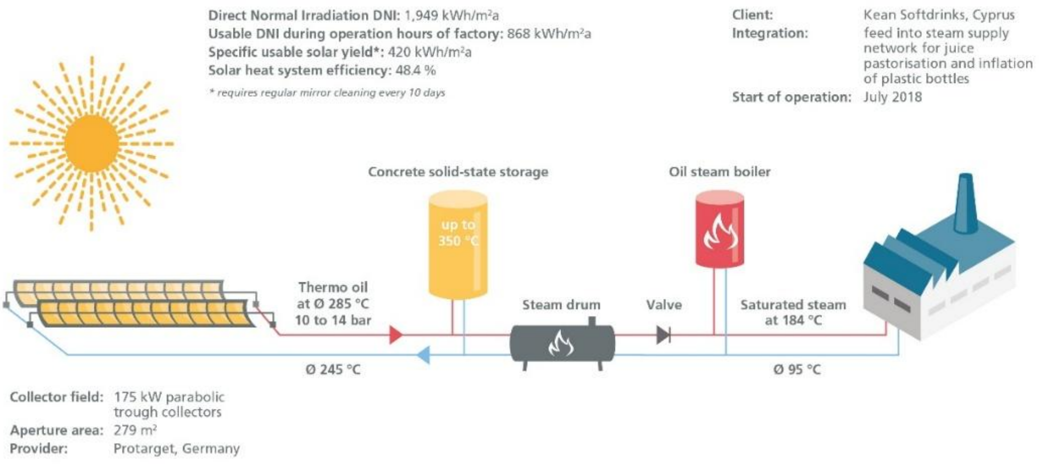

Figure 1: Schematic presentation of the demonstration plant (Source: Solrico)

5. Conclusion

The evaluation of the 2024 data has shown that the demonstration plant delivers the targeted temperatures of around 300 °C, even after six years of operation. Through the work carried out within the project, application-oriented methods for performance and yield assessment were developed. These methods are also applicable to tracking and concentrating collectors.

After successful validation, the methods were incorporated into ISO/DIS 24194 (ISO/DIS 24194, 2025) and are thus available to the market. This establishes the basis for a standardized yield assessment of large-scale solar thermal plants and builds confidence in the technology sector.

The data from the Demonstration-Pants will continuously be collected and evaluated to identify necessary corrections in plant operation and to support the continuous further development of the testing requirements.

The work carried out provides application-oriented methods for checking the field performance and yield. Method validation shows valid results for all three methods. This has created the basis for the uniform assessment of large-scale solar thermal plants. The paper will show the detailed data and results of the methods; Power Check (PC), Daily Yield Check (DYC) and Annual Yield Check (AYC).

6. Acknowledgements

The projects, under which the work presented in this paper has been conducted, was funded by the German Federal Ministry for Economy and Climate Action (BMWK). The authors of this publication are responsible for its contents.

Literature

IEA (a), 2024, IEA Renewables 2024, Solar Heat Europe, Press Release, 09/10/2024
IEA (b), 2024, IEA SHC Task 68, RB2: Guide to ISO 24194:2022 Power Check
IEA, 2025, IEA SHC Task 68, A3: Annual Yield Check of Large Scale Solar Thermal Systems
ISO/FDIS 24194, 2025, Solar energy — Collector fields — Check of performance