EuroSun2026

SIMULATION OF PARABOLIC TROUGH COLLECTORS IN TRNSYS AND COMPARISON WITH MEASUREMENT DATA

Summary

A TRNSYS simulation model has been developed using measurement data from a parabolic trough collector plant in Limassol, Cyprus. The first comparison step focused on the collector loop. Deviations between simulation and measurement can partly be explained to the uncertain influence of soiling, which is particularly significant in the dusty environment of Cyprus. In addition, a second parabolic trough field in Turnhout, Belgium will be used for further comparisons of simulation results and measurement data. As the complete system in Turnhout will be fully operational from March 2026, comprehensive comparisons can be carried out once corresponding measurement data become available. The next steps include the simulation of the solar loop and the heat generation of an entire solar district heating (SDH) system. The comparison results are planned to be finalized in time for EuroSun 2026.

Keywords: concentrated solar thermal, parabolic trough collectors, TRNSYS, solar district heating, SDH,

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

Addressed audience: city planners, civil engineers, energy providing companies, district heating turn-key providers, research institutes

1. Introduction

Studies conducted within the IEA SHC Task 68 and a national research project demonstrate that parabolic trough collectors can deliver temperatures above 100 °C more efficiently than standard collectors like flat plate or evacuated tube collectors (IEA SHC Task 68 RA1, 2024).

In order to support the effective planning, design and optimization of SDH systems, it is crucial to identify which simulation and calculation tools are currently used in the sector. Based on a survey which has been conducted within IEA SHC Task 68, many planners and researchers rely on their in-house tools, although the majority stated that they use TRNSYS as their primary simulation software, see Fig. 1(IEA SHC Task 68 RA2, 2025) (TRNSYS, 2026). On the one hand, the wide availability of suitable tools is promising. On the other hand, there is no guarantee for the accuracy and reliability of the results obtained with them. To ensure accurate simulations, it is essential to validate common tools using measurement data from real plants.

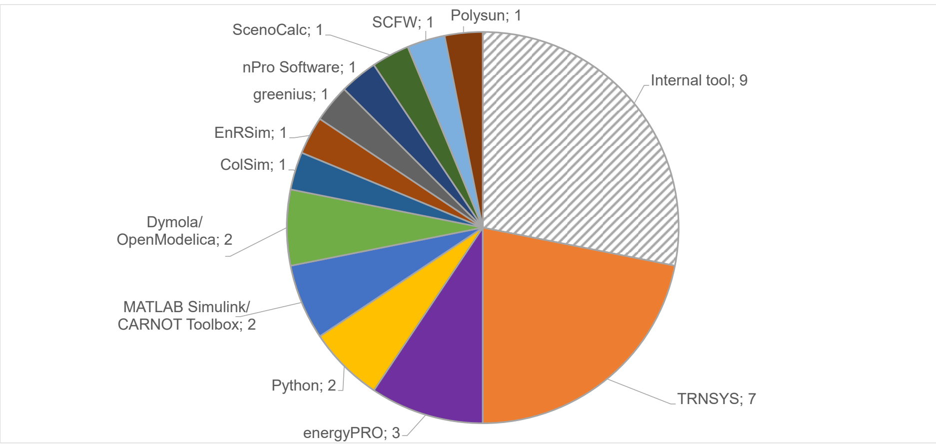

Fig. 1: Overview of tools for which the survey was completed (IEA SHC Task 68 RA2, 2025)

2. Description of the CST plant in Cyprus

In a national research project, the further development of the project's simulation and calculation tools is planned. For comparison of simulation results in TRNSYS with measurement data, the concentrating solar thermal (CST) plant in Limassol, Cyprus, is used. The project's consortium has direct access to the facility, including data logging, data processing, and system monitoring.

Since 2020, a parabolic trough system has been in operation in Limassol, Cyprus, serving the industrial process of the beverage producer KEAN. The installation consists of two collector rows with a total of eight collector modules and a gross collector area of 288 m². Each row is 48 m long, with an aperture width of 3 m. The collector rows are not aligned exactly along the north–south axis but show a deviation of 23.85°.

The parabolic trough used, the PT950 model from Protarget, can achieve temperatures of up to 425 °C, with a nominal thermal output of 125 kW in total. The annual heat production of the plant is approximately 306 MWh/a. The heat transfer fluid (HTF) used is the thermal oil Heliosol XA. The parabolic trough heats the HTF to over 350 °C and, depending on demand, either stores it temporarily in a concrete thermal energy storage system (CTES) or feeds directly to a steam generator. In the steam generator, the feed water is heated to the required level of about 190 °C to saturated steam.

Fig. 2 shows the hydraulic system of the plant. Depending on the plant's operating mode, the HTF can therefore be used either via storage (valve V5 in Figure 4 is open) or directly for steam generation (valve V5 in Figure 4 is closed). The resulting steam is then supplied to the industrial process. The cooled HTF is recirculated within the system and reheated in the parabolic trough field (Panayiotis et al., 2021).

The collector tracking operates in discrete steps every couple seconds and is driven by a hydraulic tracking system. In addition to the collectors, a weather station is installed. It includes an anemometer, an irradiometer, temperature and humidity sensors, and a rain gauge.

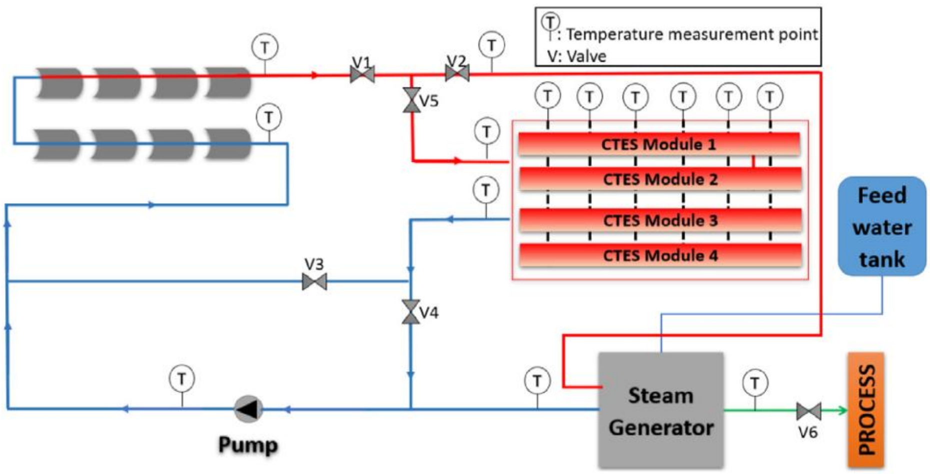

Fig. 2: Hydraulic system of CST plant in Cyprus (Panayiotis et al., 2021)

3. First Simulation results

Since the plant in Cyprus does not operate year-round and its operation strongly depends on industrial production schedules and maintenance activities, the current simulation state is performed using individual operating days, which are simulated and compared to the measured data.

In Fig. 3, the supply and return temperatures of the thermal oil are shown on the left axis, while the thermal output of the collector loop is shown on the right axis. The temperature curves are presented as solid lines, and the thermal power curves as dashed lines. This figure shows the result from 4:00 to 20:00 on 21 March 2024. The temperatures are displayed both as measured data (plant, red lines) and as TRNSYS simulation results (brown lines). Since the return temperature of the oil is directly imported into TRNSYS as an input, it appears only as plant data in the figure (light blue line). This day was selected on which there was both morning cloud cover and more beam radiation in the afternoon.

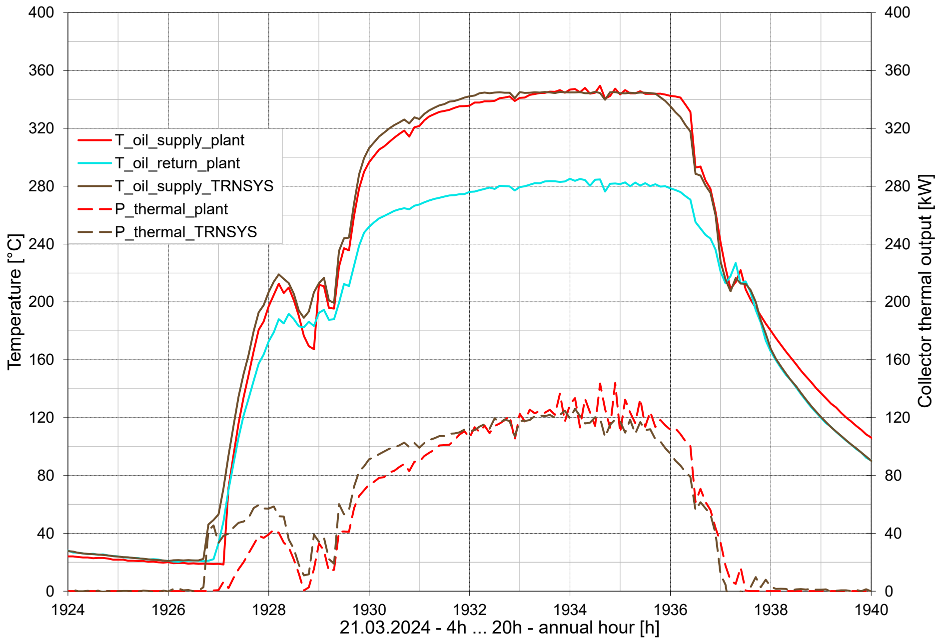

Fig. 3: Comparison day (21 March 2024): measurement data and TRNSYS simulation results for the supply and return temperatures and thermal output of the parabolic trough system

The resulting supply temperatures, which in parabolic trough systems depend strongly on direct irradiance, fluctuate due to temporary cloud cover. The largest deviation between measured and simulated supply temperatures occurs at 08:45 (hour 1928.75). Later in the day, the supply temperatures are closer to each other, although the simulated values are generally slightly higher than the measured ones. The simulated temperatures show a smoother profile because an ideal temperature controller is implemented in TRNSYS. An additional reason for temperature deviations is related to the operational behavior of the plant itself. If the steam demand on the customer side fluctuates, this leads to pressure fluctuations in the boiler, which affects the oil supply temperature, as the temperature difference between the oil and steam changes.

For the thermal output, the simulated values exceed the measurement values until 12:00 (hour 1932). This can be explained by the mass flow conditions of the collector loop. Since the thermal output in TRNSYS is calculated directly from the temperatures, the resulting profile exhibits less fluctuation compared to the measured data. This is due to the fact that the TRNSYS temperature profiles are inherently smoother as mentioned before.

Taking into account the assumptions and uncertainties in the TRNSYS model, the correlation between simulation and measurement is sufficiently accurate for first comparisons. With additional measurement and plant operating information, which are not considered yet, the simulation model can be further refined. At the current stage of the project, the measurement data are being continuously processed. Furthermore, a second CST plant in Belgium is being used for extended TRNSYS simulation comparisons. As a result, further progress in the TRNSYS model development is anticipated by the time of the EuroSun conference, supported by the ongoing developments within the project.

4. References

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