SolarPACES 2024, 30th International Conference on Concentrating Solar Power, Thermal, and Chemical Energy Systems

Solar Industrial Process Heat and Thermal Desalination

https://doi.org/10.52825/solarpaces.v3i.2391

Published: 25 Nov. 2025

Developments in Solar Heat Applications

SolarPACES

Dirk Krüger[1,*], Bärbel Epp[2], Timo Zippler[3], Jakob Leicht[4], Stefan Mehnert[5], Gregor Bern[5], Martin Scheuerer[6], Mark Schmitz[3], and Navina Konz[1]

[1]German Aerospace Center, Institute of Solar Research, Germany

[2]Solrico, Germany

[3]Solarlite CSP Technology GmbH, Germany

[4]AURA GmbH & Co. KG, Germany

[5]Fraunhofer Institute for Solar Energy Systems ISE, Germany

[6]Protarget AG, Germany

*Correspondence: Dirk Krüger, dirk.krueger@dlr.de

Abstract. The publication provides an insight into current developments in solar thermal process heat generation. In the first chapter, the experiences with the commissioning of a parabolic trough field at a chemical factory in Turnhout, Belgium are shared. Chapter 2 describes the layout of a parabolic trough field with pressurised water storage at a brewery in Seville, Spain. Finally, there is an overview of developments in solar thermal process heat: The share of concentrating collectors rised in 2023 and more developers signed heat supply contracts, mainly for large-scale solar industrial heat plants.

Keywords: Parabolic Trough, Process Heat, Balance of Plant

1. Experiences in operating a BoP for industrial heat

In Turnhout, Belgium, a 5539 m² solar field was commissioned to generate process heat for an industrial company. An overview of the installation was published in [1].

Exemplarily, data are provided for June 26th, 2024 (Figure 1). On this day only part of the solar field was operated to produce heat with interruptions in operation during noon. The storage system was not active.

The left y-axis shows the temperatures of the solar field circuit (primary) and the circuit to the customer (secondary) at the heat exchanger (HEX) as well as the volume flow and the difference between the average temperature on the primary and secondary side. The irradiation data (DNI) and power on the customer side are shown on the right y-axis.

The heat capacity of the heat transfer fluid on the secondary side is about 20% higher than on the solar field side (Helisol 5A unused). Around 1 MW of power was transferred during the phases of solar field operation. The maximum permitted temperature of 305°C was not exceeded. An increase in the volume flow in the secondary circuit is planned for higher outputs.

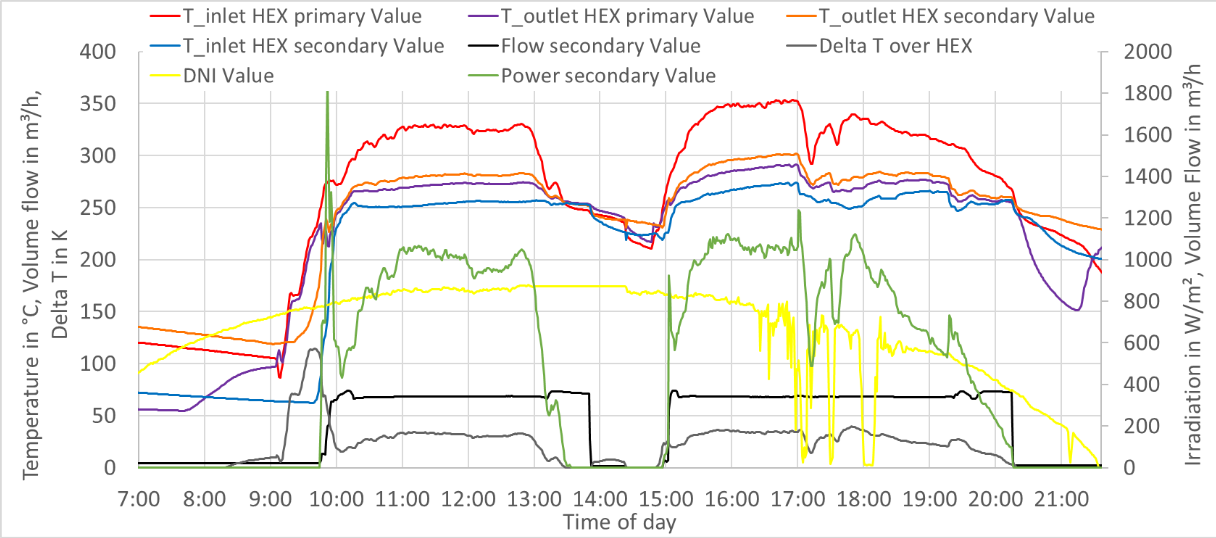

Figure 1. *Data during a day of operation*

When the system is started up, the solar field circuit is first heated up to approx. 250°C. As soon as this temperature is reached, the pump of the secondary circuit is switched on and run in short circuit (Figure 2) until the temperature at the inlet to the user circuit is sufficiently high. This is necessary because the pipe between the BoP and the user circuit has a large volume and would send a large amount of cold fluid into the user circuit.

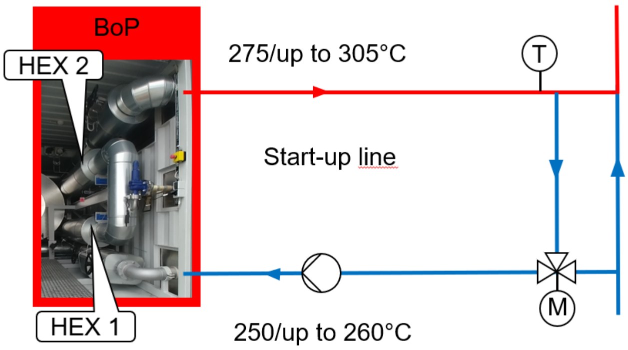

Figure 2. *Connection of BoP to consumer loop*

During commissioning, when the pump in the BoP, which pumps the volume flow through the primary circuit and thus the solar field, was started up, no pressure could be built up at first. The reason for this was that nitrogen from the expansion tank was drawn through the separator into the pipework when the system was at a standstill. The separator only forms a barrier against gases in one direction when it is filled with liquid. This means that gas enters the pipework on the suction side of the pump when the system is at a standstill. The reason for this is the arrangement of the separator in relation to the expansion tank. The arrangement is shown in Figure 3. The oil level in the expansion tank and the oil level in the separator are marked in blue. Figure 4 shows the status according to planning. When the system is at a standstill, e.g. overnight, the gas from the expansion tank enters the separator so that it is no longer filled with fluid. Figure 5 shows the state during start-up. The pump (partially) sucks in gas and can no longer build up pressure.

The problem can be solved by placing the expansion tank above the separator. Then no gas from the expansion tank can get into the separator. In the project, however, the expansion tank was to be installed in the container and the separator could not be positioned lower, which meant that the system could be completely installed in the container.

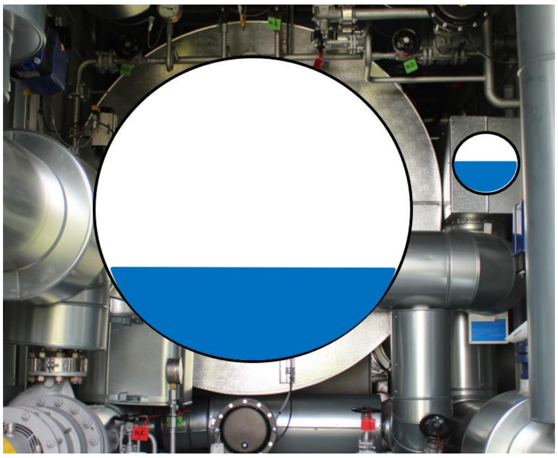

Figure 3. *Fluid levels in expansion tank (left) and gas separator (right)*

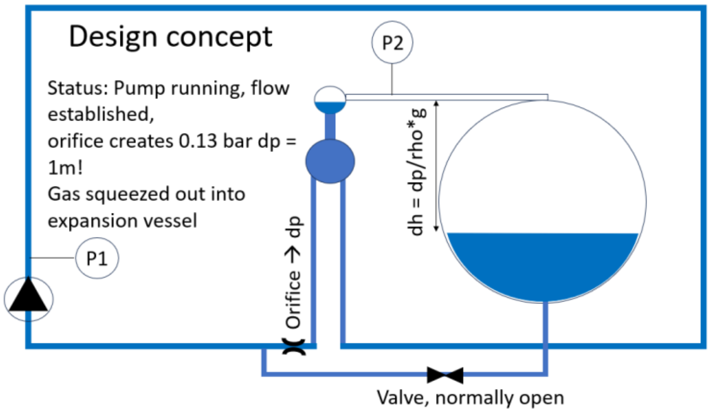

Figure 4. *Status as designed, pump operation with fixed current, gas is forced into the separator*

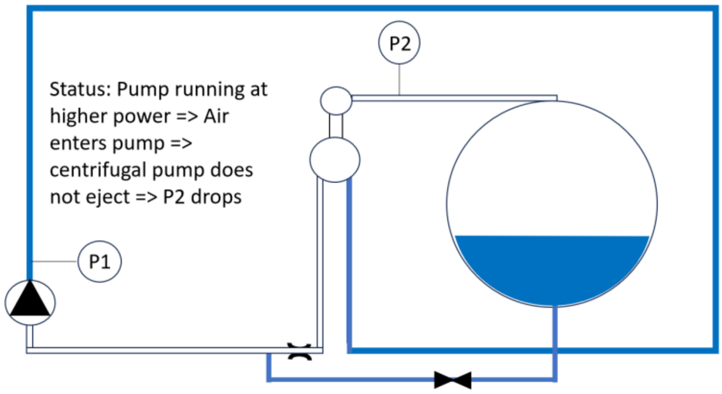

Figure 5. *Status at start-up, air inlet due to gas intrusion from the expansion vessel into the separator*

The temperature measurements in the BoP revealed that the measuring accuracy of the sensors is not sufficiently precise for balancing the heat flows. A clear source of error for this has not yet been found. However, immersion sleeves are used in industrial environments. One possibility could be that the sensors are not immersed deep enough in the medium. They were inserted vertically into the pipework and the thermowells protrude far out of the insulation, which leads to cooling at the tip of the thermowell. To remedy this, temperature measurements can be taken at the pipe bends with a longer immersion depth. As PT-100s with 2 or 3-wire connections are involved, the cable length of the wiring can also lead to incorrect results. The accuracy class and the reading on the analogue side of the PLC card also influence the accuracy.

Orifice plate measurements were used to measure the volume flow. In addition to the low measuring accuracy due to the measuring principle, there is also an uncertainty in the parameterisation. The physical material values (viscosity and density) of the heat transfer medium are required to determine the volume flow. With the Helisol, however, these initially change during hot operation. According to the manufacturer, conditioning is complete when the medium has been operated at 425°C for at least 720 hours. However, the maximum intended operating temperature in the system is only 390°C. It is only reached at the end of the collector array and in the storage tank when it is in use. It is therefore still unclear after what operating time the conversion is complete. The material data are therefore between those for fresh and used Helisol 5A.

At 250°C and 10 bar pressure, the density is approx. 5% lower and the heat capacity approx. 3% higher. When calculating the system output, however, they partly cancel each other out, so that there is only a difference of approx. 2% between unused and used oil.

Automation remains a challenge especially in combination with storage of heat and is time consuming during commissioning.

2. Solar thermal heat integration in Europe’s largest solar process heat field

Between June and October 2023, a solar field in Seville with an aperture area of 43,414 m² was put into operation to generate process heat for the Heineken brewery. There is a pressurised water line at about 110/145° for processes on the consumer side. On the solar field side, pressurised water is also used as a heat transfer medium, which is heated up to 210°C in the solar field in order to store heat in 8 pressurised water tanks (Figure 6, right) of about 100 m³ each with temperature stratification. Two tanks are always connected in parallel, recognisable by the manifolds. The limitation to 210°C is necessary in order to remain within the PN40 pressure rating. Above this pressure rating, fittings become considerably more expensive. The solar field is arranged in 3 fields with a total of 17 loops, whereby the loop lengths are partly irregular with 30 to 40 modules per loop in order to adapt to the contours of the plot. Controlling the outlet temperature is correspondingly demanding. The collector modules have an aperture width of 5.77 m and a length of 12 m. Due to space limitations the rows have a distance of less than 2 times the aperture width between the pylons.

The demand fluctuations in the brewery are between 10 and 20 MW due to batch processes. Brewing does not take place on Saturdays and Sundays, which means that consumption is considerably lower on these days. The system achieves an annual solar coverage of approx. 50% according to Heineken/Solarlite [2].

Figure 6. *Left: Solar collectors at Heineken plant in Sevilla operated by ENGIE (Source DLR), Right: Balance of plant and 8 storage tanks (Source DLR)*

Figure 7 shows the solar field with an approximate east-west orientation, the storage tanks, the power transfer station and the line to the feed-in point at the Heineken brewery. The solar field is divided into two parts so that it fits better into the plot. The storage tanks are also located next to the power transfer station (see also Figure 4).

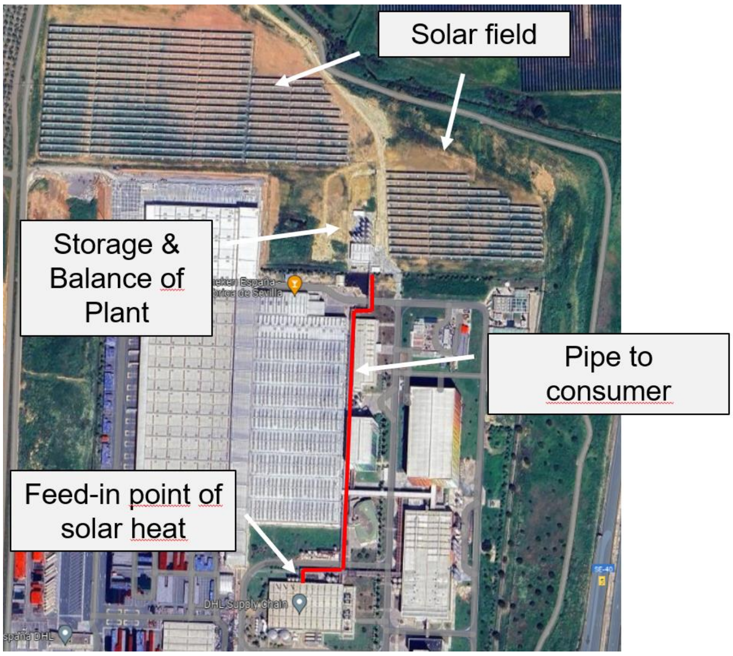

Figure 7. *Overview of the solar thermal plant (Google maps)*

3. New developments in the solar process heat market

The world market for solar process heat continues to pick up speed. In 2023, the newly installed capacity tripled compared to the two previous years according to the survey carried out by the German agency solrico. The project developers reported 116 systems with a capacity of 94 MW. A year earlier there were also 116 systems but with only 31 MW of capacity newly commissioned worldwide. The growth was essentially based on two countries: The Netherlands led the world market 2023 with 43 new systems and Spain installed by far the largest SHIP capacity last year (49 MW) (figure 8).

The first Solar Industrial Heat Outlook 2023-2026 [4] published in September 2023, described two fundamental trends: The share of concentrating collectors will rise and more developers will sign heat supply contracts, mainly for large-scale solar industrial heat plants. Both trends were confirmed by the current world SHIP market survey carried out in the first quarter of 2024.

The trend towards solutions with concentrating collectors can be clearly seen in Figure 9. It shows the distribution of collector technology within the total newly installed SHIP capacity of 94 MW worldwide. The three concentrating collector technologies parabolic troughs, Fresnel collectors or concentrating dish collectors were used in 43 % of newly installed SHIP capacity (figure 9). For comparison, this was only 16 % in 2022.

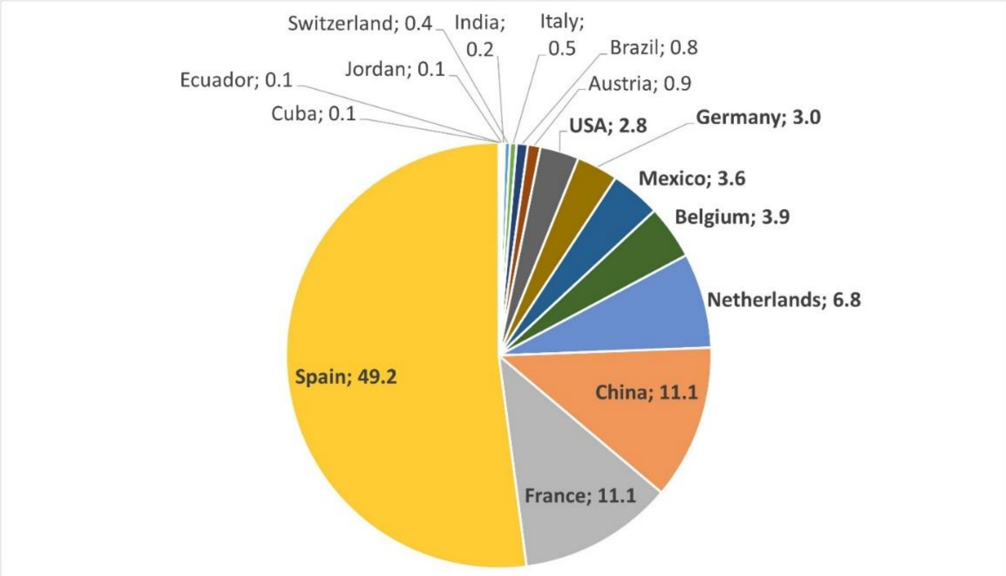

Figure 8. *SHIP capacity additions in 2023 in MW per country. (Total: 94 MWth) Source: [3]*

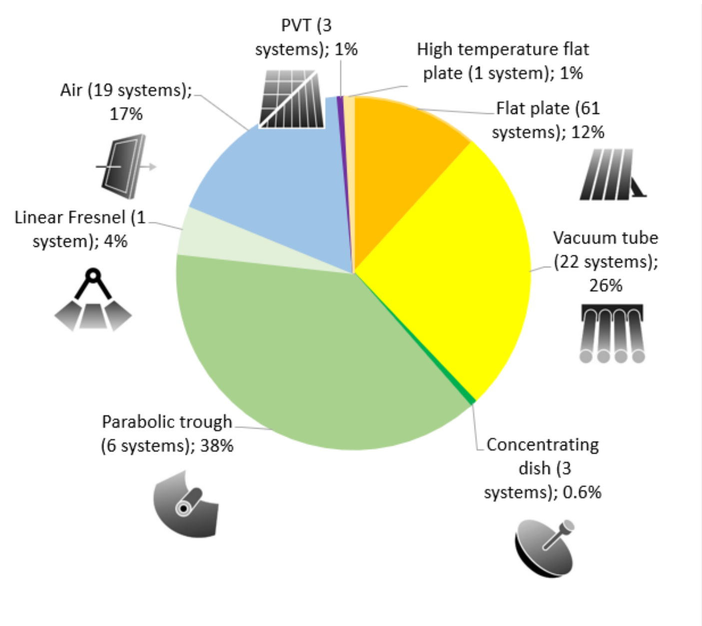

Figure 9. *Distribution of collector type area in the SHIP world market 2023 (Total: 94 MW_{th}) [3]*

Six large-scale projects with a total capacity of 52 MW were realized in 2023 with heat supply contracts. The remaining plants were realized on the basis of turnkey delivery contracts. The share of solar thermal capacity realised as an energy service company model was therefore 55 %, which is significantly higher than in previous years (2 % in 2022 and 33 % in 2021). Besides the Heineken plant mentioned in the previous chapter, three more significant plants were commissioned under heat purchase agreements in 2023 (see table 1).

***Table 1.** Selected solar process heat plants commissioned in 2023 under heat purchase agreements Source: Survey 2024 of the companies listed on the SHIP Supplier World Map*

	Client: Lactalis (dairy) Site: Verdun, France Project developer: New Heat (France) Collector type: Flat plate collectors Collector field: 15,000 m^2 / 10.5 MW$_{th}$ Solar heat temp.: 80 °C Commissioning: March 2023 Business model: Special Purpose Vehicle as ESCO Photo: NewHeat
	Client: Heineken (brewery) Site: Valencia, Spain Project developer: Solatom (Spain) Collector type: Linear Fresnel collector Collector field: 6,000 m^2 / 3 MW$_{th}$ Solar heat temp.: 220 C° Commissioning: September 2023 Business model: Heat purchase agreement with CSIN (Spain) Photo: Solatom
	Client: Ball Corp (packaging) Site: California (USA) Project developer: SOLID Solar Energy Systems (A) Collector type: Flat plate collectors Collector field: 4,000 m^2 / 2.8 MW$_{th}$ Solar heat temp.: 70 °C Commissioning: May 2023 Business model: Heat purchase agreement with Tigi Solar (Israel) Photo: SOLID Solar Energy Systems

Food, Beverage, Textile and Chemical/Pharmaceutical are the industrial sectors which will see most deployment of solar process heat plants in the coming year. Figure 10 lists 62 announced projects by September 2023 by industry sector – divided according to the location of the client, within and outside Europe.

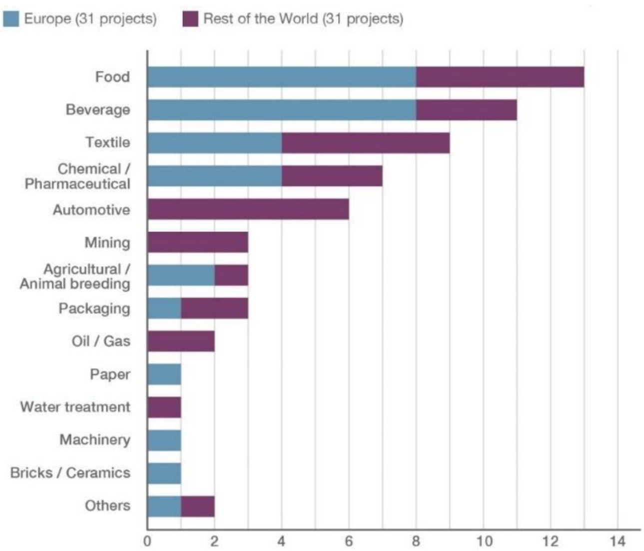

***Figure 10.** Range of industrial clients that have plans to install a solar industrial heat solutions in the period 2024 to 2026 (Status: September 2023). [4]*

Data availability statement

Data are available from the authors.

Author contributions

D. Krüger contributed to the chapters 'Experience in operating a BoP for industrial heat' and 'Solar thermal heat integration in Europe's largest solar process heat field'. B. Epp wrote the section 'New developments in the solar process heat market'. T. Zippler, J. Leicht, M. Schmitz and Navina Konz contributed content to the chapter 'Experiences in operating a BoP for industrial heat'. S. Mehnert, G. Bern and M. Scheuerer reviewed the paper.

Competing interests

The authors declare that they have no competing interests.

Funding

The authors acknowledge the financial support by the German Federal Ministry for Economic Affairs and Climate Action under contract no. 03ETW021. The sole responsibility for the contents lies with the authors.

References

[1] D. Krüger, J. Leicht, S. Fahr, B. Epp, J. Krüger, S. Bonleitner, A. Burger, K.-J. Riffelmann, J. Stengler (2024). Standardized Balance of Plant Engineering for Solar Process Heat. SolarPACES 2022, 28th International Conference on Concentrating Solar Power and Chemical Energy Systems, SolarPACES Conference Proceedings, https://doi.org/10.52825/solarpaces.v1i.690
[2] Website: https://www.solarlite.de/en/project_heinekensevilla.cfm, visited on 7th of September 2024
[3] B. Epp. "Solarthermalworld.org" The Netherlands and Spain drive SHIP market 2023. https://solarthermalworld.org/news/the-netherlands-and-spain-drive-ship-market-2023/ (August 2024)
[4] B. Epp. "Solarthermalworld.org" Promising Solar Industrial Heat Outlook 2023-2026. https://solarthermalworld.org/news/promising-solar-industrial-heat-outlook-2023-2026/ (August 2024)