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P&D SolarEmmi

Solar thermal energy generation for a Swiss dairy

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The authors bear the entire responsibility for the content of this report and for the conclusions drawn therefrom.

Zusammenfassung

In diesem Projekt wird ein neuartiger Vakuum-Flachkollektor von TVP in den Produktionsprozess einer Käserei integriert und seine Leistung analysiert und bewertet. Wirtschaftliche Kennzahlen wie die levelized cost of heat (LCoH) und levelized cost of carbon abatement (LCCA) werden ebenfalls untersucht. Das System ist seit Oktober 2023 demontiert, da es bei der Installation ein Problem mit zu langen Schrauben gab, wodurch das Dach durchlöchert wurde und undicht war. Die Anlage soll jedoch in der ersten Hälfte des Jahres 2024 wieder in Betrieb genommen werden. Die bisherigen Auswertungen zeigen, dass die Anlage funktioniert und im ersten Jahr 38.7 MWh Solarwärme in den Prozess eingespeist wurden. Dies bedeutet jedoch, dass die Anlage nur etwa 50 % der geplanten Leistung erbringt. Eine Analyse hat gezeigt, dass eine nachträglich installierte Wärmerückgewinnung den Ertrag der PVT-Anlage deutlich verringerte. Des Weiteren sind Sekundär- und Primärseiten noch nicht gut aufeinander abgestimmt. Da die Anlage derzeit abgebaut wird, besteht nun die Möglichkeit, dies im Rahmen der Möglichkeiten zu korrigieren um

Résumé

Dans ce projet, un nouveau type de collecteur plat sous vide de TVP est intégré dans le processus de production d'une fromagerie et ses performances sont analysées et évaluées. Les KPI économiques tels que le coût de la chaleur nivelé (LCoH) et le coût nivelé de la réduction du carbone (LCCA) seront également examinés. Le système est démantelé depuis octobre 2023, en raison d'un problème lors de l'installation, les vis étant trop longues, ce qui a provoqué la perforation du toit et des fuites. Le système doit toutefois être remis en service au cours du premier semestre 2024. Les évaluations réalisées jusqu'à présent montrent que le système fonctionne et que 38.7 MWh de chaleur solaire ont été injectés dans le processus au cours de la première année. Toutefois, cela signifie que le système ne produit qu'environ 50 % par rapport à la conception. Une analyse a montré qu'un système de récupération de chaleur installé ultérieurement a considérablement réduit le rendement du système PVT. En outre, les côtés secondaire et primaire ne sont pas encore bien harmonisés. Le système étant actuellement en cours de démantèlement, il est maintenant possible d'y remédier dans la mesure du possible.

Summary

In this project, a new type of vacuum flat plate collector from TVP is integrated into the production process of a cheese dairy and its performance is analysed and evaluated. Economic KPIs such as levelized cost of heat (LCoH) and levelized cost of carbon abatement (LCCA) will also be examined. The system has been dismantled since October 2023, as there was a problem during installation with the screws being too long, which caused the roof to perforate and leak. However, the system is to be put back into operation in the first half of 2024. The evaluations so far show that the system is working and 38.7 MWh of solar heat was fed into the process in the first year. However, this means that the system only produces around 50 % compared to the design. An analysis has shown that a later installed heat recovery system significantly reduced the yield of the PVT system. Furthermore, the secondary and primary sides are not yet well harmonised. As the system is currently being dismantled, there is now an opportunity to correct this as far as possible.

Contents

Abbreviations

EvaSP	EVAluation of Solar Process heat	
EFON	Emmi FONdue	
EFPC	Evacuated Flat Plate Collector	
HEX	Heat exchanger	
HSLU	Hochschule Luzern	
HTF	Heat transfer fluid	Here: Tap water
(P)HX, HE	(Plate) heat exchanger	
IAM	Incidence angle modifier	-
i.E.	im Emmental	
LCCA	Levelized Cost of Carbon Abatement	CHF/t$CO_{2\text{-eq}}$
LCoH	Levelized Cost of Heat	CHF/kWh
O&M	Operation & Maintenance (cost)	CHF
P&ID	Piping & Instrumentation Diagram	-
SHIP	Solar Heat for Industrial Processes	
c_p	Specific heat capacity	kJ/kgK
E	Energy	kWh
Em	Emissions	t$CO_{2\text{-eq}}$
Ex	Exergy	kWh
Gt	Global tilted irradiation	kW
h	Specific enthalpy	kJ/kg
I	Investment cost	CHF
ρ	Density	kg/m^3
q	Heat	kW
S	Subsidies	CHF
s	Specific entropy	kJ/kgK
t	Time	s
T	Discount rate	%
T	Temperature	°C
θ	Angle between the sun and the collector plane	°
h	Solar collector field efficiency	-
V	Volume	m^3
y	Expected lifetime	years

1 Introduction

1.1 Background information and current situation

Emmi is one of the biggest dairy producers in Switzerland and has committed to netZero 2050. Emmi wants to reduce its carbon footprint by 60 % compared to 2014 until 2027. Industry consumes 14 % of Switzerland's heat production, of which the food industry requires 12 % or roughly 8.8 PJ (2016). This heat is generated using fossil fuels by two-thirds, most of which is natural gas. The food industry, and particularly dairies, often require temperatures around or below 100°C, which are very well suited for solar heat [1].

The aim of this project is to demonstrate the large potential of solar process heat at one of the production sites in Langnau, where among other things fondue and processes cheese is produced. The dairy has an energy demand of 2'946 MWh electricity and 2'956 MWh heat per year (2019). In a first step, a 263-kW heat pump was installed in 2008, to replace part of the fossil burner. A solar thermal system is now installed to further reduce the emissions by 55 $tCO_{2\text{-eq}}$/a. In a future phase, the installed fossil burners will be completely replaced by a combination of different technologies, e.g., high-temperature heat pumps, biomass (burners), and district heating. The path to complete decarbonization is still unclear, and Emmi is keen to find out more. Emmi has already participated in projects such as e.g. "BillySolar" [2], where HSLU carried out a Pinch Analysis of its processes in Langnau. This study also showed the heat demand and suitability of the Langnau plant for solar thermal.

The Evacuated Flat Plate Collectors (EFPC) of TVP Solar show a high performance of over 60 % solar radiation to heat efficiency at 100 °C in standardized tests [3]. On-site performance has been demonstrated in high irradiation areas and is being tested for integration into district heating systems [4]. To date, the system has not been scientifically tested for on-site integration into an industrial process. This plant could serve as a model not only for the other Emmi plants (around 20 in Switzerland and several abroad), but also for other industrial companies in the food sector, thus contributing to the decarbonization of heat in Switzerland.

Furthermore, the results and lessons learnt of this P&D can be used for planning and analyzing further SHIP plants and at the same time knowledge already gained from other projects like "BillySolar" [2], used to optimize the plant.

1.2 Purpose of the project

The goals of the P&D SolarEmmi project are:

- Demonstration of the collector field's efficiency integrated in an industrial process
- Assessment of the plant and verification of the expected solar yield and cost. A yield of 164 MWh/a is expected due to PolySun-Simulations. 166 CHF/t $CO_{2\text{-eq}}$ is calculated as expected Levelized Cost of Carbon Abatement (LCCA).
- Levelized Cost of Heat (LCoH), LCCA and operation & maintenance (O&M) cost will be calculated.

To reach these goals, a monitoring concept was included during planning of the plant, which follows the monitoring concept of the EvaSP-Projects [5]. The data analysis tool from EvaSP has been extended to include the plant in Langnau plant to facilitate the forthcoming evaluation. The data is recorded in minute resolution, and the cost data is provided by Emmi to enable the calculation of the above-mentioned values. The results will be compared to the initial simulations and with the other EvaSP plants.

2 Description of facility

The core of the EFON[1] SHIP[2] plant in Langnau i.E. consists of 109 panels (MT-Power v4 SK, made by TVP solar), aligned along the roof axis at 5.4° west and tilted at 35° from the horizontal axis. This gives a total aperture area of 214 m^2, designed for a peak power of 145 kW at Tm 105 °C. The panels are installed in six strings of 1 x 21, 4 x 18, and 1 x 16 panels. The Tichelmann system is used to automatically balance the heat transfer fluid (HTF) flows through the different strings is used. Shading of the system by roof structure can occur in the first (southernmost) string around midday in winter and in string number 6 at sunrise in sum-mer. The plant is designed for primary side temperatures of 55 °C and 95 °C for solar side HTF feed and return and 5.5 m^3h^{-1} and 3.5 m^3h^{-1} for solar primary and secondary side respectively. Deviations from these values due to temperature control in the fluid circuit are discussed in section 2.3.5.

The chosen heat transfer fluid is tap water which is operated under pressure (2.5 - 4.5 bar). The plant layout can be found in Annex B and the P&ID is attached in Annex A of this report.

The heat demand is connected via a plate heat exchanger (HE-002, design: 155 kW) and a storage tank (25 m^3, make Jenni). The plate heat exchanger can be hydraulically bypassed during start-up or overheating periods using a 3-way-valve.

Overheating protection is guaranteed using an active cooling system, which consists of a 170 kW dry cooler placed parallel to the solar loop (primary side) at the outlet of the collector field. It can be activated using two 2-way-valves. A safety valve protects the plant against overpressure and releases at 4 bars. A fill- and drain system and an expansion vessel keep the pressure steady when the density of the HTF changes. The entire HTF piping is made of stainless steel and is insulated with 100 mm rock wool.

The secondary side of HE-002 is designed by Planair SA and connects the heat exchanger with the storage tank though 54 mm diameter tubes. The 25 m3 buffer tank is 5.25 m tall, measures 2.6 m in diameter and is equipped with 4 in-, 2 outlets and a safety-, and vent valve. Each connection uses a flow breaker designed by Jenni AG.

The other side of the buffer tank is equipped with three consecutive expansion vessels, a safety valve and two process connections, which are connected in parallel. The installation is shown schematically in Annex C. One of the process connections consists of a plate heat exchanger and preheats Emmi's purified water supply. The other is connected to the domes-tic hot water storage tank via a heating coil in the tank WW3. The return from both heat ex-changers is collected and returned to the buffer tank. This can be done at three different heights to ensure stratification, depending on the temperature inside the tank.

Flow sensors are mounted in-line on the solar primary and secondary side, and upstream of each of the two process heat exchangers. Pressure sensors are mounted up-, and downstream of each pump. A tilted pyranometer is used to measure the incoming solar radiation and is mounted next to the plant with the same orientation as the panels. Shading of the sensor by roof structures is not possible. Temperature sensors are distributed throughout the system. A detailed list of sensors can be found in the List of Signals in Table 3, the sensor types are listed in Table 4, the locations are drawn in the P&ID shown in Annex.

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[1] Emmi FONdue

[2] Solar Heat for Industrial Processes

Table 1: Collector and collector field data

Longitude	7.78885	°
Latitude	46.93727	°
Altitude	756	m
Row distance	1.95	m
Azimuth	5.4	°
Tilt	35	°
Aperture width collector	0.9436	m
Gross width collector	0.975	m
Optical efficiency a0	0.732	-
First thermal loss a1	0.5	-
Second thermal loss a2	0.006	-
Total field aperture area	214.14	m^2

As mentioned, the solar thermal plant provides two processes with solar heat. The properties are shown in Table 2, more detailed information will be provided after the final results of the current pinch analysis are available. As it can be seen there is a demand of 155 MWh/a for process 1 and 239 MWh/a for process 2. In total almost 400 MWh/a are needed of which around 150 MWh/a is covered by the heat recovery system. This leaves 250 MWh/for the solar thermal system. Due to the fluctuating energy production and the problems described in chapter 2.3, the majority of these 250 MWh are covered by steam and only 66 MWh per year of heat are generated by the solar thermal system.

Table 2: Energy demand and heat sources of the two processes connected to the solar thermal system.

Heat Source	Process 1 “Reinwasser”	Process 2 “Brauchwarmwasser”
Steam [MWh/a]	112	64
Heat recovery [MWh/a]	27	125
Solar thermal energy [MWh/a]	16	50
Total energy demand [MWh/a]	155	239

3 Procedures and Methodology

3.1 Methodology

The performance of the plant is monitored by parameter measurement and assessed by means of energy balances, energy and exergy loss and efficiency calculations. All calculations are made using one-minute time steps and then added up to calculate the respective daily, monthly, and yearly values. Most of the evaluation code was made during the project EvaSP and adapted and extended for this project. The collected data points are listed in Table 3, sensor information can be found in Table 4. The locations are indicated in the P&ID which is added in the Annex, chapter 9.2.

Energy flow calculations Q:

$$Q_i = \rho \cdot c_p \cdot \dot{V} \cdot (T_{in} - T_{out}) \qquad \text{Eq 1}$$

With i = sol, prim, sec, proc. (as shown in boundaries in Figure and Table 5). Basic energy calculations are performed using the temperature difference at the following location pairs:

- Inlet & outlet of all collector strings (primary side, collectors)
- Inlet & outlet of the solar field (primary side, solar field)
- Primary side in & outlet of HE-002 (primary side)
- Secondary side in & outlet of HE-002 (also used as energy input for the buffer tank) (secondary side)
- Inlet & outlet of the buffer tank on process side (process side)

Whereas the HTF properties ($\rho(T)$, $c_p(T)$) are calculated for values at the mean temperature of the temperature pair at steady state, using data from ISO9806:2013 and thermofluidprop (1):

$$\rho_{t1} = \rho(\,(T_{in}(t1) - T_{out}(t1))/2) \qquad \text{Eq 2}$$

Solar field efficiency calculation η:

The solar field efficiency is calculated for the entire field and each solar string individually. The solar irradiation is calculated using the Global Tilted irradiation H_T and summed up over the minute-wise time steps. A threshold angle of 10° and a threshold irradiation of 15 W/m^2 is used. The resulting efficiency then is:

$$\eta = {}^{Q_{sol}}/_{H_T} \qquad \text{Eq 3}$$

Shading, Incidence Angle Modifier (IAM) and end losses:

No end losses apply for the used evacuated flat plate collectors.

IAM losses are calculated using IAM data from solar keymark (2), using Matlab's curve fitting toolbox and the following formula (3):

$$IAM = 1 - tan^{4.409}\left(\frac{\theta}{1.9}\right) \quad \text{with} \quad 1 > IAM > 0 \qquad \text{Eq 4}$$

Row shading is calculated following the geometric calculation from *Duffie et al*. (4), using the geometric data from Table 1, and evaluated in minute-wise resolution for all strings separately. Shading from roof structures is not evaluated. The sun position is calculated acc. to *Reda et Andreas* (5).

Exergy loss calculation Ex:

Exergy calculations use $T0$ = 25°C, $p0$ = 1.01325 bar as reference. Exergy loss calculations use the difference between the daily sum of exergy of two streams (e.g. before and after the storage tank).

$$Ex = \dot{V} \cdot \rho \cdot ((h - h0) - T0 \cdot (s - s0)) \qquad \text{Eq 5}$$

with h as specific enthalpy and s as specific entropy are taken from thermofluidprop (1).

Heat exchanger exergy efficiency calculation $\eta_{ex,f}$:

The functional exergy efficiency calculation uses the following definition (6):

$$\eta_{ex,f} = \frac{Ex_{c,out} - Ex_{c,in}}{Ex_{h,in} - Ex_{h,out}} \qquad \text{Eq 6}$$

with the cold stream index c and hot stream index h of the heat exchanger.

LCoH calculation

The levelized cost of heat calculation use two different sets of parameters: $LCoH_{SPF}$ use 3 % discount rate, 1 % O&M cost and 20 years of lifetime. $LCoH_{Emmi}$ uses 0 % discount rate, no maintenance cost and 15 years of lifetime. The cost is then calculated using:

$$LCoH = \frac{I_0 + S_0 + \sum_{i=0}^{y} \frac{O\&M_i}{(1+t)^i}}{\sum_{i=0}^{y} \frac{E_i}{(1+t)^i}} \qquad \text{Eq 7}$$

With I investment costs, S subsidies and the index 0 for the initial investment cost and the index i for the following years up to the lifetime y.

LCCA

LCCA cost represents the cost per omitted amount of emitted greenhouse gases, here in CHF/$tCO_{2\text{-}eq}$. It is calculated as following:

$$LCCA = \frac{I_0 + S_0 + \sum_{i=0}^{y} \frac{\Delta O\&M_i + \Delta C_{fuel,i}}{(1+t)^i}}{\sum_{i=0}^{y} \frac{\Delta Em_i}{(1+t)^i}} \qquad \text{Eq 8}$$

With Δ for the difference in cost ($O\&M$, C_{fuel}) and difference in emitted greenhouse gases (Em, in $CO_{2\text{-}eq}$) between the original and the displacing (solar) system (7).

O&M cost

O&M cost are collected and cumulated by Emmi. They include time of personnel and spare part cost.

Pressure loss calculation

Pressure loss is calculated using the zeta-value-method and the formula of Colebrook.

$$\frac{1}{\sqrt{\lambda}} = -2\,log\left[\frac{2.51}{\Re\sqrt{\lambda}} + 0.269\frac{k}{d_i}\right] \qquad \text{Eq 9}$$

With λ as friction factor, $\Re$ as the Reynolds number, k as the roughness factor in [m], and d_i as the inner pipe diameter. The pipe pressure loss in [m] is then:

$$h = \frac{\left(\frac{l\lambda}{d_i} + \zeta\right) c^2}{2 * 9.81}$$ Eq 10

With h as pressure loss [m] (meters of water column), l the pipe length [m], ζ the sum of the individual Zeta values and c_a the flow velocity [m/s]. This pressure loss is then added to the pressure loss of all equipment and instrumentation in the pipe, e.g. heat exchangers, flow meters etc.

Uncertainty calculation

Uncertainty calculation is done using standard uncertainty propagation methods. Measurement uncertainties are taken from the respective data sheets. Used uncertainty of solar position is ±0.0003 °, of collector tilt angle ±0.5 °, collector azimuth ±0.2 °, collector geometric dimensions ±0.001 m, collector string distance ±0.02 m.

Table 3 List of all collected data points

Name	Location / Description	Unit
Date, Time		min
SOL_2W-001	Solar field to Dry Cooler	0/1
SOL_2W-002	Solar field to 3W-001	0/1
SOL_2W-003	Fill connection	0/1
SOL_3W-001	Solar field to HE-002	0/1
SOL_DC001_RUN	Dry Cooler run status	0/1
SOL_Durchfluss_Reinwasser 169T1	Process: clean water at HE	l/h
SOL_Durchfluss_Warmwasser_3 168T7	Process: hot water 3 at HE	l/h
SOL_FT-001	Solar field	m^3/h
SOL_FT-002	Secondary solar side	m^3/h
SOL_IT-001	Irradiation on the roof, collector plane	W/m^2
SOL_Leistung_WT_Reinwasser	Process: clean water at HE	kW
SOL_Leistung_WT_Warmwasser_3	Process: hot water 3 at HE	kW
SOL_PT-001	Solar field	bar
SOL_PT-002	Secondary solar side	bar
SOL_Temp_Reinwasser_nach_PWT_Solar	Process: clean water after HE	°C
SOL_Temp_Reinwasser_vor_PWT_Solar	Process: clean water before HE	°C
SOL_Temp_RL 167T3	From process (mixed) to solar storage	°C
SOL_Temp_Speicher_mitte 166T5	Storage: middle	°C
SOL_Temp_Speicher_oben 166T7	Storage: upper	°C
SOL_Temp_Speicher_unten 166T3	Storage: lower	°C
SOL_Temp_Speicher_zuoberst 167T1	Storage: top	°C
SOL_Temp_Speicher_zuunterst 166T1	Storage: bottom	°C
SOL_Temp_VL 168T3	From storage to process	°C

SOL_Temp_WT_Reinwasser 169T3	after HE clean water to solar storage	°C
SOL_Temp_WT_WW3 167T5	after HE hot water 3 to solar storage	°C
SOL_TOT_Reinwasser	clean water heating across HE	kW/h
SOL_TOT_Warmwasserspeicher_3	hot water 3 heating across HE	kW/h
SOL_TT-001	Solar field before 3W-001	°C
SOL_TT-002	Solar field after pump	°C
SOL_TT-003	Solar field before HE-002	°C
SOL_TT-004	Solar field after HE-002	°C
SOL_TT-005	Ambient	°C
SOL_TT-006	Solar field after field outlet	°C
SOL_TT-007	Solar field before field inlet	°C
SOL_TT-008	Secondary side between pump and HE-002	°C
SOL_TT-009	Secondary side after HE-002	°C
SOL_TT-013	Solar field outlet string 6	°C
SOL_TT-014	Solar field outlet string 5	°C
SOL_TT-015	Solar field outlet string 4	°C
SOL_TT-016	Solar field outlet string 3	°C
SOL_TT-017	Solar field outlet string 2	°C
SOL_TT-018	Solar field outlet string 1	°C
TT/Temp: Temperature Transmitter, 2W/3W: Valves; Durchfluss/FT: Flow Transmitter		
PT: Pressure Transmitter; TOT/Energy: Energy totalizer; HE: heat exchanger; IT: Irradiation Transmitter		

Table 4 Sensor types, producers, and their accuracies

Measurement	Sensor Type	Make	Precision
Temperature	PT100	E+H TMR3X	A-Type
Flow	Vortex	Yokogawa Yewflo	±0.75 %
Pressure	Piezoresistive	Keller Series 21	± 3 % of range
Irradiation	Pyranometer	MTX	2^{nd} class

3.2 Boundaries

To understand the evaluations better, it is good to have an overview about the system boundaries. In this project it is especially crucial because Emmi and TVP "split" the responsibilities between primary side (TVP) and secondary + process side (Emmi) which is challenging for the overall system performance. In Figure 1 is a simplified scheme of the Emmi plant in Langnau is shown, Table 5 explains the corresponding heat counters. The scheme is divided by different boundaries. To understand the solar thermal system and to be able to run it in an optimal way its crucial to understand the boundary "Complete System". Therefore, it is good to have all the heat meters seen in Figure 1 which include flow – and return temperature, flowrate and energy. Furthermore, all the drawn components like pumps, storages, heat exchangers and processes and their characteristics need to be known.

According to the proposal, the interim report focuses more on the primary side and analyses the performance of the vacuum flat-plate collectors. In the case of reconstruction, the aim is to focus more on the overall system in order to optimize the use of solar process heat. This will then be done as part of the final report.

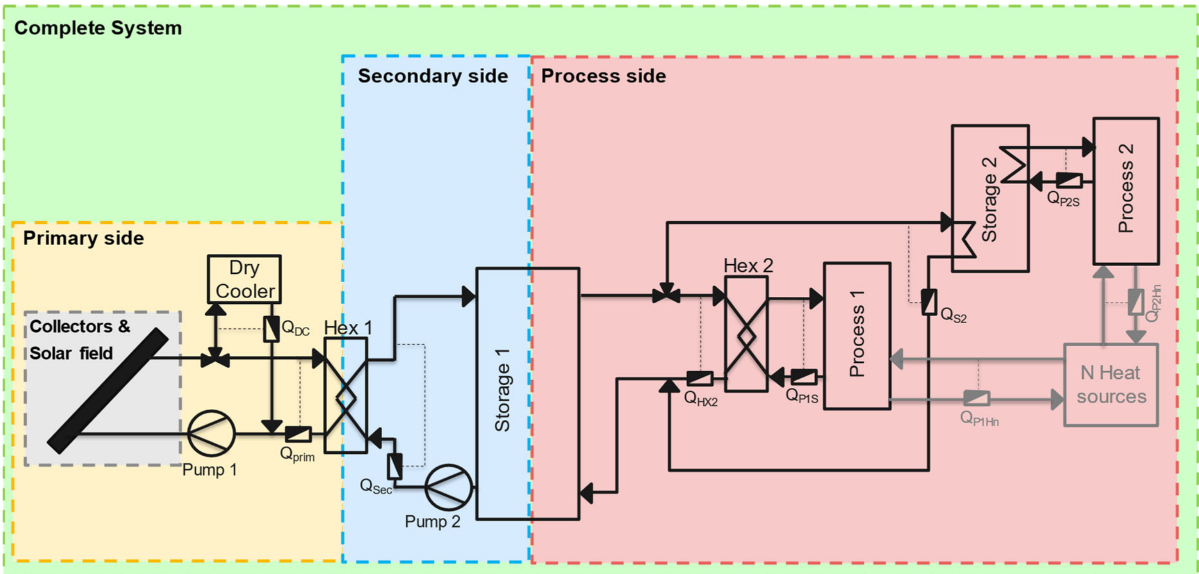

Figure 1: Simplified scheme with the parts of interest for the evaluation of the Emmi-Plant with system boundaries.

As can be seen in Table 4, some information is missing in order to analyze the overall system completely. In addition to the missing data from some heat meters, it is also crucial to better understand the processes and obtain data with better temporal resolution. This is currently being clarified with the people responsible at Emmi and Flimatec, which were doing a pinch analysis and present the results and suggested measures in May 2024. The data of the processes will be available soon and will be shown in the final report.

Table 5: Heat meters seen in Figure 1

Heat meter	Description	Data available
Q_{Prim}	Primary loop	Yes
Q_{DC}	Dry cooler	Yes
Q_{SEC}	Secondary loop	Yes
Q_{HX2}	Between storage 1 and hex 2	Yes
Q_{P1S}	Between hex 2 and process 1	No
Q_{S2}	Between storage 1 and storage 2	Yes
Q_{PS2}	Between storage 2 and process 2	No
Q_{P1H1}	Between heat recovery and process 1	Yes
Q_{P2H1}	Between heat recovery and process 2	Yes
Q_{P1H2}	Between steam and process 1	No*
Q_{P2H2}	Between steam and process 2	No*

* Values for steam from pinch analysis available

4 Activities and results

The following results describe the evaluation of the previous measurement data from almost one year and the conclusions drawn from it.

4.1 Energetic assessment

Energy flows were calculated at various locations and can be seen in Table 6 and in Figure 2. The locations are:

- Irradiated energy onto the collector H_T
- Energy flow at the collector field in- and outlet (Using TT-006 and TT-007) Q_{sol}
- Energy flow upstream of the solar heat exchanger HE-002 (using TT-003 and TT-004) Q_{prim}
- Energy flow downstream of the solar heat exchanger HE-002 (using TT-009 and TT-008) Q_{sec}
- Energy flow between the storage tank and the process heat exchangers (using 168T3 and 167T3 Q_{proc}
- Energy flow calculations on the process sides of the hot water tank WW3 and Emmis clean water heat exchanger were not possible due to a lack of temperature sensors.

Table 6 Energy flows at different locations of the solar thermal system. HT is measured by the pyranometer. The data of August 2022 and June 2023 were omitted from the totals, since they contain obvious errors: in August due to the start-up procedure, in June die to construction work on the active cooler. The pyranometer's accuracy is ±4.5 % (2.5 % non-linearity and 2 % non-stability over 1 year)

[MWh]	Irradiation H_T	Solar field yield Q_{sol}	Primary side HX Q_{prim}	Secondary side HX Q_{sec}	Process side Q_{proc}
08/22	35.5	19.4	15.0	12.9	10.8
09/22	24.8	11.0	8.44	8.72	7.33
10/22	20.6	10.4	9.42	9.63	7.35
11/22	10.4	3.9	3.43	3.44	2.70
12/22	6.10	1.30	1.06	1.06	0.56
01/23	6.91	1.33	1.09	1.08	0.54
02/23	18.7	9.31	7.46	7.72	5.44
03/23	19.9	9.29	6.54	6.88	4.74
04/23	22.8	10.8	6.39	6.64	4.50
05/23	27.4	8.81	6.94	7.65	5.50
06/23	36.5	5.87	4.59	10.4	8.94
Total	157.6	66.14	50.77	52.82	38.66
Total efficiency	100%	42.0%	32.2%	33.5%	24.5%

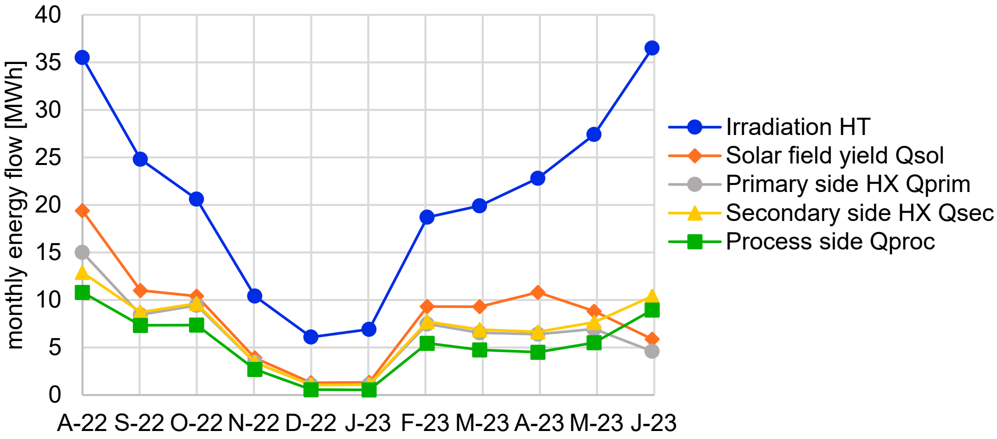

Figure 2 Monthly energy flows [MWh] from August 2022 to June 2023. The data is taken from Table 6, where more information is given.

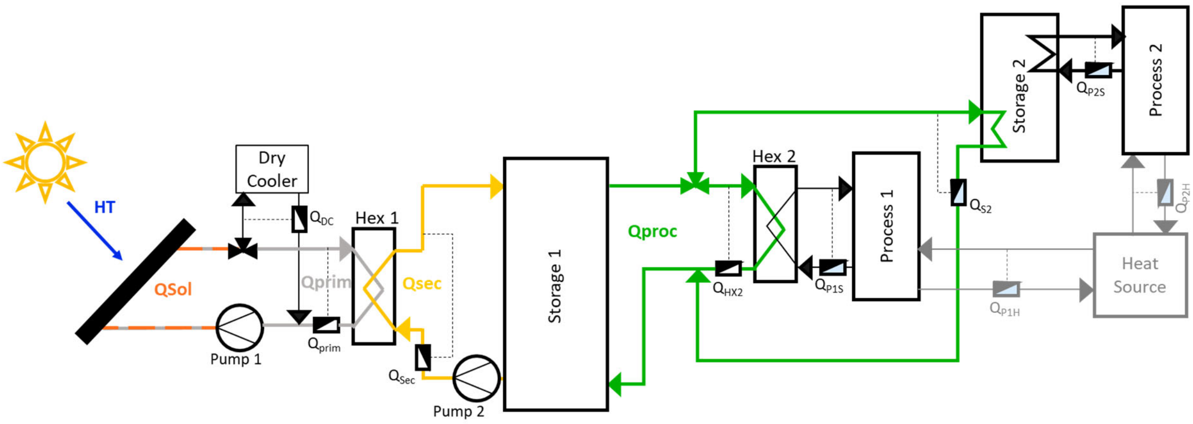

Figure 3: Corresponding heat flows to Figure 2

The monthly analysis clearly shows the seasonality of the solar heat gains and the energy losses between the different measurement locations. The data in August 2022 includes errors caused by the start-up procedure. The data in June 2023 (and 2nd half of May) is also unreliable, due to construction work. The large difference between Q_{sol} and Q_{prim} is also due to thermal inertia of the rather long piping, but mainly due the frequent activation of the active cooler to avoid overheating of the collector field. More than 20 % of Q_{sol} is lost to the surroundings that way. This topic is treated in-depth in 4.5.

Q_{sec} frequently shows higher values than Q_{prim}. The two measurement locations are only separated by the heat exchanger HE-002 and the only difference between the two values should be the heat exchanger losses. As Q_{sec} is located downstream of Q_{prim}, it should be lower. However, the difference is within the measurement uncertainties of the sensors (up to ±3.5 % depending on the temperature difference between the sensors and the sensor temperature itself, with a mean uncertainty of ±1.9 % for Q_{sec} over the months measured). Recalibration of these sensors may improve the accuracy of the values.

Daily efficiencies were evaluated to identify complications and low heat gain operating conditions. These are shown in Figure 4 and Figure 5. In 2022, the efficiency of the collector field is between 0 and 30 % on days with low irradiation (H_T< 400 kWh/day) but reaches efficiencies between 50 % and 60 % on days with higher intensities (H_T> 800 kWh). The low efficiency on days with low irradiation can be explained by the thermal inertia of the solar field. The two yellow outliers on the bottom right are measured during the start-up period. The few winter days with 200 kWh to 400 kWh irradiation but zero gain were probably days with snow-covered collectors.

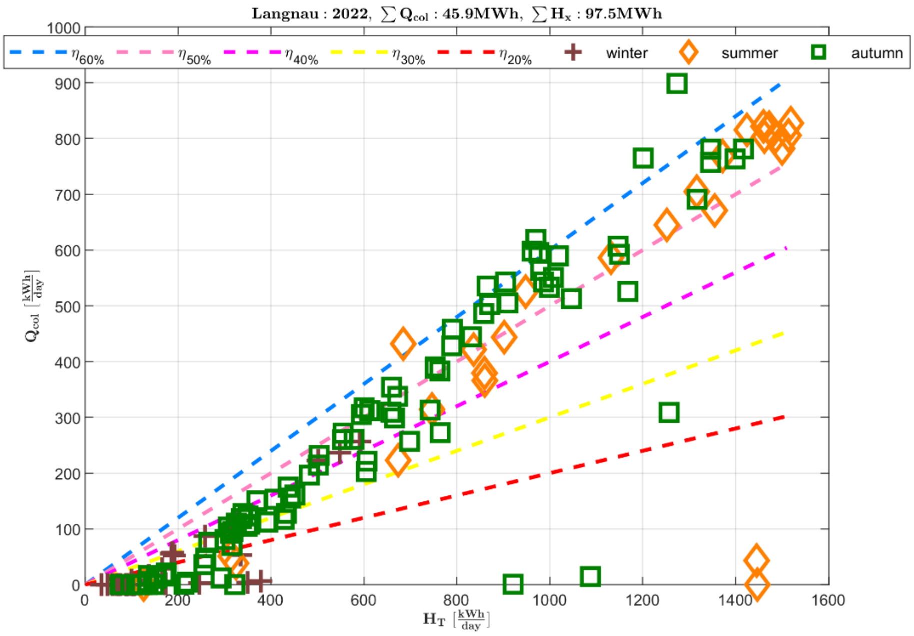

Figure 4 Daily irradiation-to-heat efficiencies (HT vs. Qsol) after the collector field for the evaluated days of 2022. Each mark represents one day, with indication of the season it is in.

A few snow-covered winter days can also be seen in 2023. The overall efficiencies in 2023 are comparable to those in 2022. The low efficiencies of the three orange circles in the lower-right of Figure 5 are due to a stagnation event from 27. 29. Mai, which will be discussed in 4.4. The green diamonds on the lower right are due to construction work in June. There, additional acoustic noise damping was fitted to the active cooler. To prevent overheating during this time, half of the collector field was covered with cardboard.

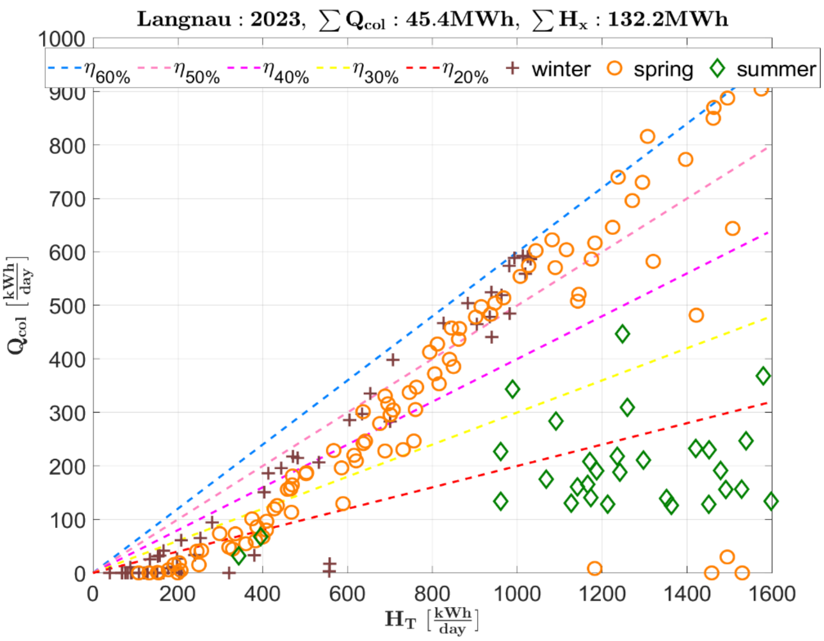

Figure 5 Daily irradiation-to-heat-efficiencies of the collectors for January to June 2023. The low efficiencies of the tree orange circles on the bottom-right are due to a stagnation event from 27. 29. Mai, the green diamonds on the lower right are due to construction work, when half of the collector field was covered.

4.2 Individual collector row gains

As additional error-checking measure, the energy gains of the individual collector strings were calculated and compared. The calculation assumes an evenly distributed flow of the heat transfer fluid in the strings. To facilitate the comparison, the specific heat gains $q_{row}i$ (i= 1 … 6) were normalized with the overall specific heat gain of the collector field (q_{sun}). The resulting normalized heat gains should be close to 1 for evenly distributed flow rates and energy gain. As an example, the resulting values for April and May 2023 are shown in Figure 6. The values in April show the expected behavior: they are randomly spread with a mean value slightly above 1, which indicates some heat loss from the temperature sensor of the individual rows to the one of the collected total stream. The values for May however show a different behavior: the ones for row 1-5 are close to each other and close to 1, while the values for row 6 are much higher up to the 17. of May and 0 between 17.5. and 28.5. This indicates an uneven flow distribution during this month. In the first part of the month, the flow of row 6 was likely lower than the other rows, leading to a higher outlet temperature and therefore to higher calculated, virtual heat gains. The drop to 0 indicates the start of the construction work and covering of this row, leading to a temperature difference of 0 (inlet-outlet) during these days.

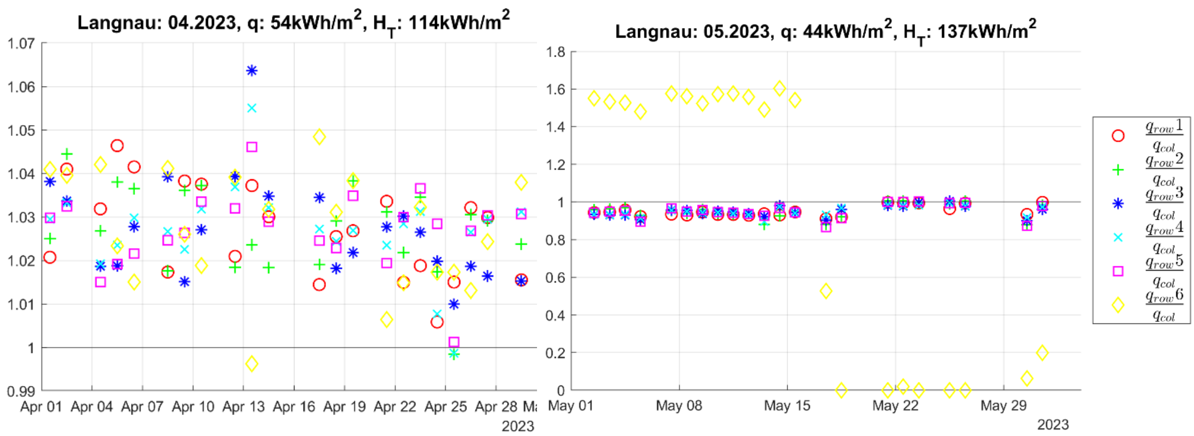

Figure 6: Daily normalized specific collector row gains $q_{row,i}$ for April 2023 (left) and May 2023 (right).

4.3 Exergetic evaluation

Calculation of exergy losses of individual components was made again in minute-wise resolution for the solar primary side, the solar heat exchanger, the solar secondary side including buffer tank, the mixing point of the collector rows and the mixing point of the two process heat exchanger returns. As with the energy calculations in 4.1, August 2022 and June 2023 was omitted. Looking at the data in Figure 7, it becomes clear that the available data is not accurate enough to calculate reliable numbers, as e.g. negative losses in the HX are physically impossible. However, it seems that the exergy losses of the storage tank (including some piping from and to the measurement points) are the largest share of exergy loss during the winter months, while the losses on primary side (most likely due to the active cooler) are the largest of the system during the summer months.

The inaccuracies of the measurements do not fulfil the requirements to accurately calculate the efficiency of the solar heat exchanger. The measured temperatures on secondary side are frequently higher compared to the ones on primary side, which would result in unrealistic efficiencies above 100 %.

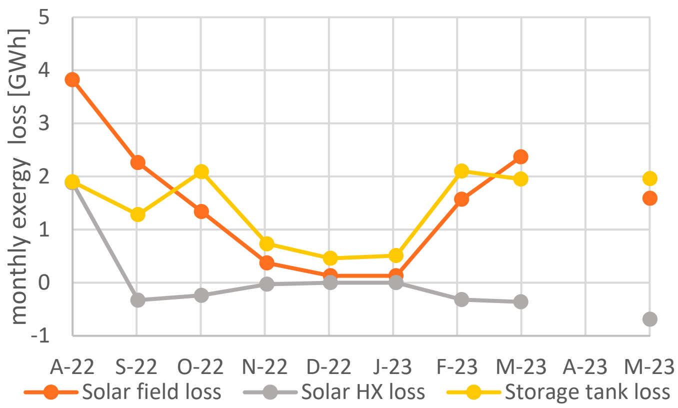

Figure 7: Calculated exergy loss at selected locations of the solar system

4.4 Overheating event in May 2023

On Monday, 27.5.2023, temperatures exceeding the design temperature of 150 °C were detected in the individual row temperatures. The highest detected temperature was 182.74 °C ± 0.52 °C, measured in the first collector row sensor. At the same time both the primary and secondary flowmeters indicate a no-flow condition from May 27 to May 30. This no-flow condition caused the stagnation inside of the solar collectors and the measured elevated temperatures. Also, the sensors TT-002 and TT-006 (T_{field} in Figure 8) displayed 150 °C; which is most likely the highest value they are able to display. The temperatures are shown in Figure 8. During this event, the pressures measured reached maximum values of 5.97 bar (PT-001), 8.81 bar (PT-002), 5.99 bar (PT-003) and 3.82 bar (PT-005). This is noteworthy since the safety valve nearby PT-001 releases at 4 bar, the pipe nearby PT-002 operates at a normal pressure of 4.5 bar, the pipe nearby PT-003 operates usually at 2.5 bar and the safety valve of the secondary loop where PT-005 is located releases at 3 bar. During the event, the level indicator of the safety valve overflow tank TK-002 fluctuated strongly between minimum and maximum values of 0.16 m and 1.66 m. The pump P-002 started when the system pressure decreased to low pressure condition after cooling down, increasing the system pressure back to normal operation level. Similar events occurred on the 28.5. and on the 31.5.

Temperatures and pressures like these do not harm the used high-temperature collectors. Also, since the used heat transfer fluid is pressurized water, it cannot be damaged from the temperature or heat. It could however be that certain gaskets were damaged during this event and the system should be checked for leakages.

Currently, TVP checks the reason for the stop of all pumps simultaneously.

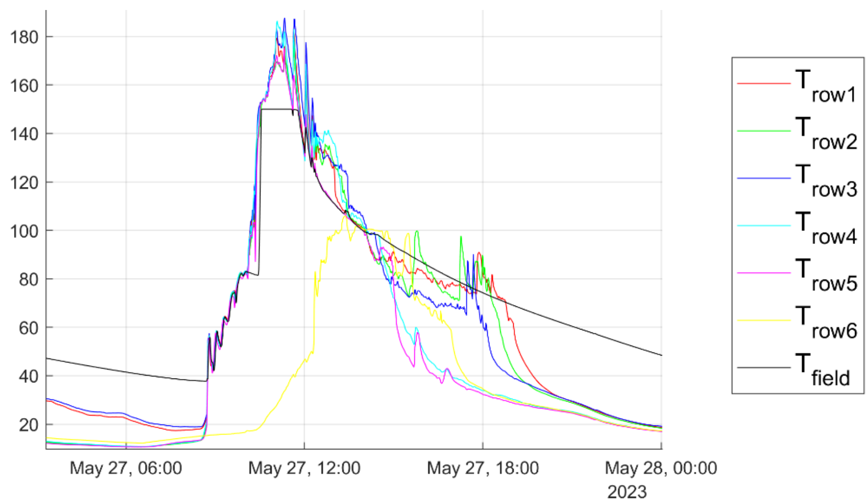

Figure 8: Collector row temperatures measured on the 27.5.2023. The peak temperature reached 187.73 °C ±0.52 °C in row 3. The horizontal line of T_{field} between 11 and 12 a.m. is assumed to be a display cut-off.

4.5 Overheating events during high-irradiation days

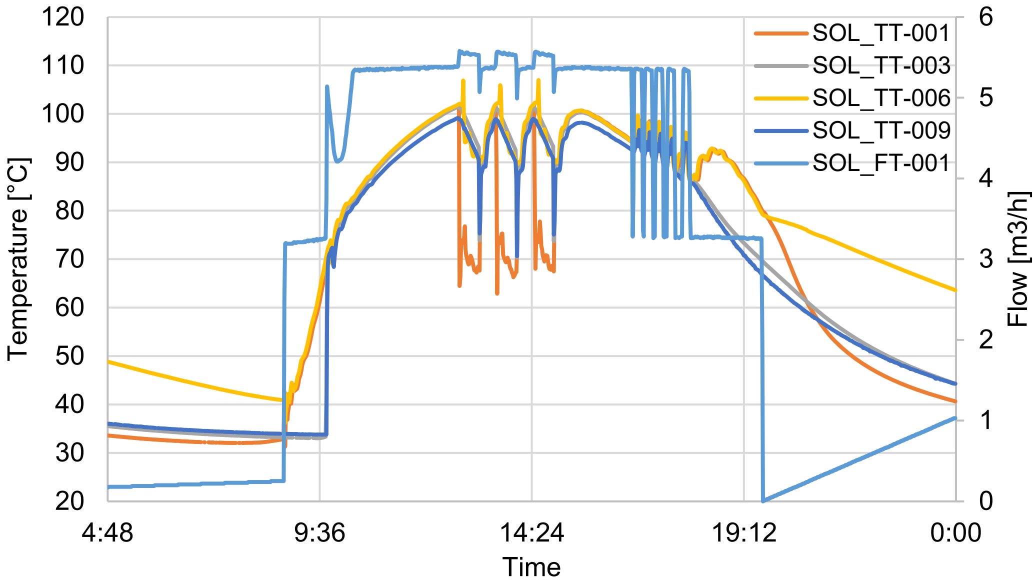

Figure 9 Temperature and flow profile of selected temperature sensors and the primary circuit on the 23.08.2023. The system changes to overheating protection mode three times between 13:00 and 15:00. The entire solar gain during overheating mode is ejected to ambient via the dry cooler. The increase in temperature in TT-001 and TT-006 after 18:00 is due to temperature and density induced circulation (natural convection) in the pipes. The increase in flow after 19:15 origins from the data analysis tool and is ignored during calculations.

On days with increased irradiation, temperatures in the solar system rise above 100 °C, causing the system to enter overheat mode. In overheating mode, all of the solar gain is dissipated to the ambient air through an active ventilated dry cooler. This happens frequently, with a total heat loss to ambient of 7.66 MWh in the period between January and June 2023. This equals to 16.9 % of the heat generated by the collectors during this period. The heat cannot be sufficiently removed by the system, which is one of the most common failures in solar thermal systems (8). In this case, either one of the pumps or the heat exchangers is too small to transfer the heat to the process and/or the storage. In the case of the Langnau plant, the origin of this is in the design phase. During this phase, the cold design temperature was defined to be 55 °C. There might have been a misunderstanding at which location the design temperature is defined: it is indicated in TVP's P&ID on the cold primary (solar field) side of the solar heat exchanger; whereas Emmi's process used to run at this temperature as well. In between are two heat exchangers, the buffer tank and a considerable distance of piping, all of which contribute to a temperature difference between these positions. Consequently, the temperature difference across the solar heat exchanger is smaller than planned, leading to a lower amount of heat transferred. Secondly, heat recovery measures were implemented in the process at the same time as the plant was planned, increasing the process temperature from 55 °C to rather 65 °C. This further increases the cold side temperature at the solar heat exchanger, reducing the temperature and hence the transferred heat.

Now, the plant needs to run under the adapted conditions. Assuming an irradiation of 1000 W/m^2 on the surface of 214 m^2, a c_p of 4.2 kJ/kgK and a temperature difference of 30 K (65 to 95 °C), a volume flow of 6.18 m^3/h is needed to remove the entire heat. However, given that irradiation above 900 W/m^2 does not happen too frequently (compare Figure 10) and that the heat exchanger will be too small eventually, a flow of 5.5 m^3/h is considered sufficient.

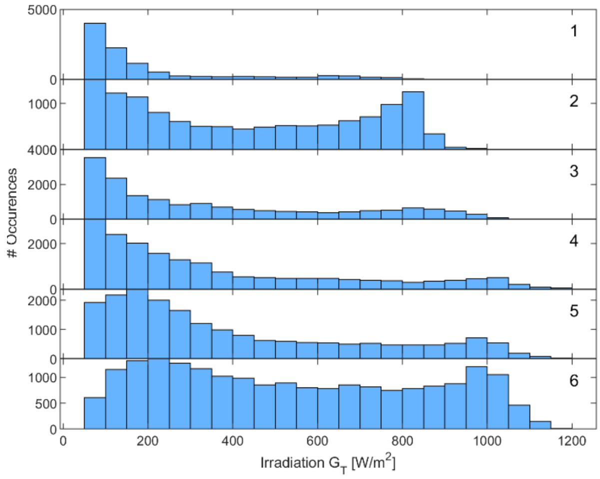

Figure 10 Irradiation histogram for January to June (1-6) in 2023. Most frequent is an irradiation around 200 W/m^2, with an additional peak at 800 and 1000 W/m^2 in February (2) and in June (6).

As a first and simple countermeasure, TVP replaced the secondary side pump (P-003) to increase the volume flow in the secondary loop. This change increased the flow measured at FT-002 from ~2.6 to ~3.6 m^3/h (compare Figure 11). This flow is still lower compared with was derived from pressure drop calculations. Applying Eq 9 and Eq 10 to the system, a pressure drop of 9.7 m can be found[3]. According to the pump power curve, a flow of more than 9 m^3/h should be possible at this pressure drop; the desired flow of 5.5 m^3/h should be reached even with a pressure head of 11 m (compare with Figure 12). It is currently assumed that the updated control set point of the new pump was reset during an electric black-out of the digital control system in May 2023. The set points and the control of the pump is currently rechecked by TVP.

Sharp peaks in the histogram indicate fixed-flow control modes, where the pump power is independent of the fluid temperature and solar irradiation. A matched-flow control mode, where the pump power and hence the fluid flow rate is adjusted to keep a steady output fluid temperature of the system could be checked. This slightly reduces the efficiency of the solar field due to higher field temperatures but increases the temperature difference across the heat exchangers and increases the storage capacity of the storage tank due to higher inflow temperatures.

[3] 5.2 m loss due to HE-002, 3.1 m due to FE-002 and 0.5 m due to piping. 10 % (0.9 m) safety is added.

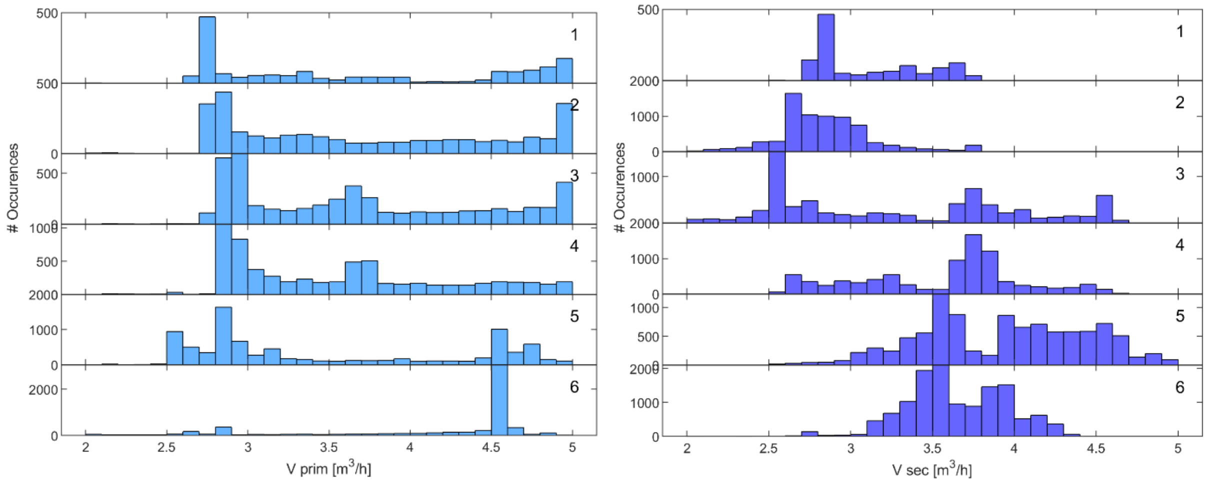

Figure 11 left: Primary side flow histogram for January through June (1-6) in 2023. Right: Secondary side flow histogram for January through June (1-6) in 2023. While the primary side flow pattern seems to be evenly spread between 2.6 m^3/h and 5 m^3/h with a peak at 2.7 m^3/h, the secondary side flow shows a peak at 2.6 m^3/h before the change and a peak at 3.6 m^3/h after the change.

Further, it would be a possibility to increase the heat transfer area of the solar plate heat exchanger HE-002. Increasing the number of plates simultaneously reduces the heat exchangers pressure drop and increases the heat transfer area.

Another helpful change would be to change the current binary on/off-operation mode of the dry cooler to a temperature controlled divided flow mode. Currently, during overheating protection mode, the entire solar gain is ejected to ambient, and no energy is transferred to the buffer tank. For example, in a temperature controlled divided flow mode, the dry cooler ejects only the heat above 100 °C, such that the remaining heat still can be used for the process. This could be done e.g. using a three-way valve instead of two two-way valves at the dry cooler inlet. According to TVP, a divided flow mode using two two-way valves is impossible to integrate into the current control scheme.

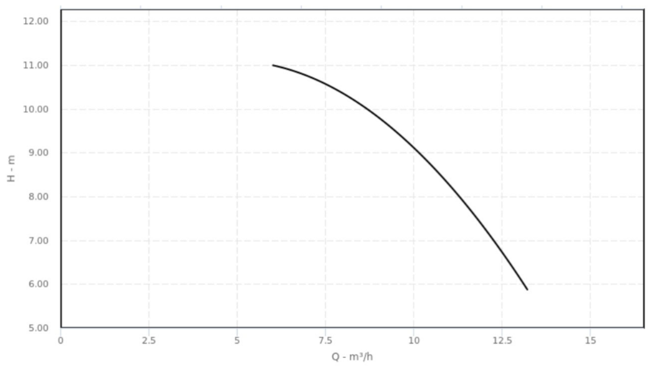

Figure 12 Pump flow curve of the replacement pump. From: Calpeda data sheet.

5 Evaluation of results to date

This chapter was added after the review meeting in Q4 2023, as there were some important points open and there had been a change of personnel on the part of SPF and TVP in the meantime. Furthermore, the system has been dismantled in Q4 23 because the screw connections perforated the roof waterproof layer during installation, which is why it is leaking and now needs to be renovated. However, Emmi plans to rebuild the plant in the first half of 2024.

Both TVP and SPF assumed an annual yield of around 160 MWh from the solar thermal system based on simulation. However, this was all before a heat recovery system was implemented that feeds the same processes as the solar thermal system. Ideally, however, a heat recovery system is installed first, as this has priority over the solar thermal system. In other words, if there is not enough demand for both heat sources, the heat recovery system is used first. The system at Emmi Langnau is currently in such a situation. To counteract this, it could be tried to optimise the thermal system or find other heat sinks. Flimatec is looking for further heat sinks in their Pinch-Analysis, i.e., consumers for the heat from the solar thermal system like space heating. Optimisation of the solar thermal system is done by TVP with the help of SPF. SPF has developed the following proposals for this:

1. a higher temperature in the storage tank. The actual process and storage tank temperatures are almost identical, resulting in a lower storage capacity. However, higher temperatures above 95 °C require an increase in pressure so that the boiling point of water is not exceeded. The effects of a higher temperature could also be simulated, as they can improve the overall performance of the system to a degree that would justify further investment. According to the company Jenni, the manufacture of the storage tank, a pressure up to 3 bar and temperatures around 105 °C are possible.

2. the integration of the solar thermal system with the domestic hot water tank could be improved. Right now, it the heat goes in the third tank, which can be seen in Figure 13. The drawback of this solution is that in this tank is also the steam intake, in case the power of the heat recovery and of the solar thermal plant are not sufficient. Once the loading via steam is active, the storage tank temperature, where the solar thermal should feed, will rise to a level which makes it very difficult for the solar thermal to feed in as well or take over once its power is sufficient. A possible improvement could be to change the solar thermal connection to the upper part of “tank two” in Figure 13, as there is an available flange. A disadvantage could be a malfunction of the heat recovery system, which may then not be able to feed in well, which would result in additional cost to get rid of the excess heat in this system.

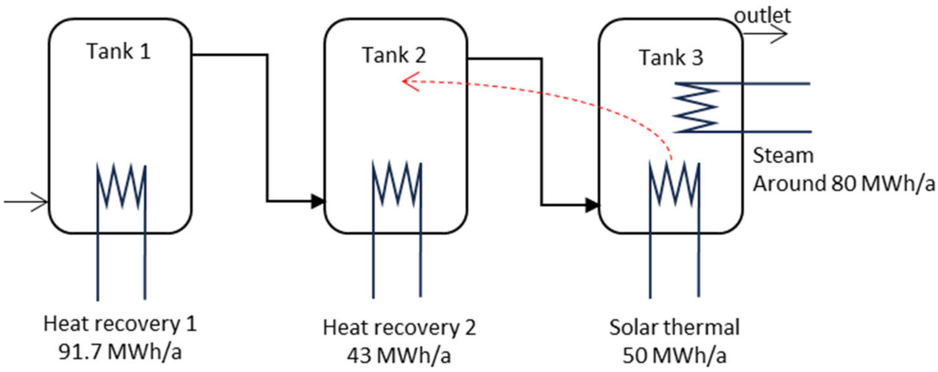

Figure 13: Solar thermal integration in domestic hot water tanks (each 5.8 m^3). The integration could be shifted to the top of the second tank (dashed line).

3. the size and position of the process heat exchangers could also play a key role in increasing solar output. First, the heat exchanger between the storage tank and the process is very small (no data sheet available) compared to the heat exchanger on the primary side, as it can be seen in Figure 14. The logarithmic mean temperature difference or the global heat transfer coefficient are important design parameters that should be considered in the selection of heat exchangers in solar thermal systems. A

simulation of the complete process could quickly show which dimensions would enable an optimal energy transfer.

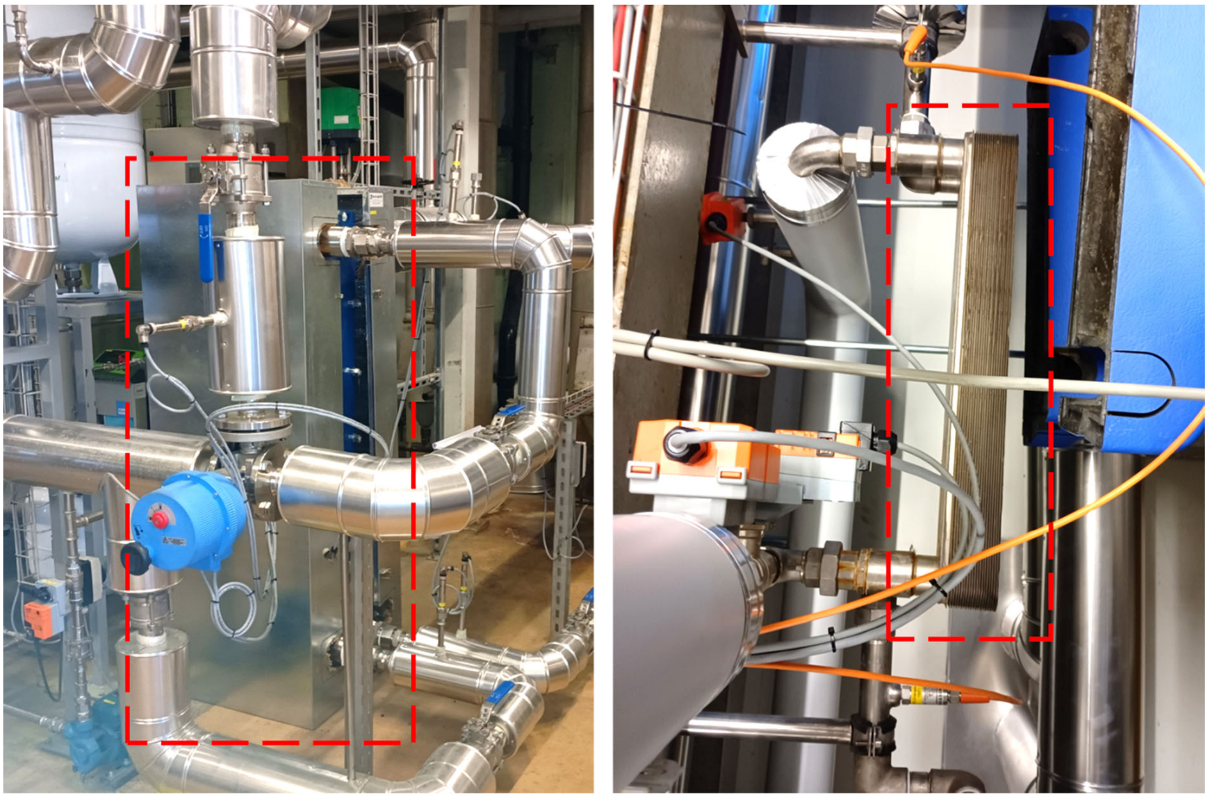

Figure 14: Heat exchanger primary side left, heat exchanger process side right. To get a better size comparison, one can take the orange valves as a guide.

To summarize, it can be said that it looks like that due to the different demand and the different temperatures, the system only supplies around half of the originally simulated heat to the process. In total the heat recovery delivered 152 MWh to the processes (Pinch-Analysis currently in progress by a third company) and the solar thermal system delivered 66 MWh per year. Which adjustments need to be made and whether new components (heat exchangers, pumps) are required can only be determined by means of a detailed dynamic simulation of the entire system. An alternative solution could be to identify new heat sinks for the solar thermal system.

6 Next steps

On the way to NetZero Emmi works on a strategy with the energy consulting company Flimatec which could foresee further heat sinks for the solar thermal plant like space heating and cleaning in place. Flimatec will present their results of the pinch analysis in May 2024. The outcome will be summarized in the final report. The solar thermal powerplant will be reassembled by TVP in May/June 2024. Discussions are ongoing between Emmi, TVP, Flimatec and SPF to improve the performance. SPF furthermore offers to help with dynamic simulations if requested from Emmi as this will enable a precises assessment of the complete process, help dimensioning all necessary equipment and allow to explore different integration strategies.

In addition, the objectives are discussed regarding the economic parameters mentioned and clarified with Emmi how and whether the costs incurred as a result of the reconstruction should be taken into account.

The monitoring period is planned to be around one year within the project “SolarEmmi” and even longer in a simultaneous project from SPF “EvaSP-III” [13], which focusses on solar process heat plants (SHIP) in Switzerland. The delay caused by the dismantling and reassembly of the solar installation leads to a postponement of the originally planned end of the project from mid-2024 to probably mid-2025.

7 Publications

The following dissemination activities were made:

- Presentation AEE Wärmetagung, Pratteln, 2023.
- Press release of Emmi (Appendix 9.4), 2023.
- LinkedIn Post (URL below), 2023.
- Webpage posts of Emmi, SPF and TVP, 2023.
- SFOE/Innosuisse DeCarbCH via the Scientific Advisory Group (Members: Stefan Bertsch, Beat Wellig, Stephan Mathez, Laura Ding, Frederic Maurer, Carina Alles, Men Wirz)

Emmi	https://group.emmi.com/che/en/media-investors/media-releases/emmi-commissions-a-pioneering-solar-thermal-plant
LinkedIn	https://www.linkedin.com/posts/spf-institut-f%C3%BCr-solartechnik_emmi-commissions-a-pioneering-solar-thermal-activity-7031234197998424064-R6in?utm_source=share&utm_medium=member_desktop
SPF	www.spf.ch/solaremmi

The dissemination activities caused some media response, for example:

Energate Messenger	https://www.energate-messenger.ch/news/227968/emmi-installiert-erste-industriell-genutzte-solarthermische-anlage-der-schweiz
EKZ-Energieberatung:	https://www.energie-experten.ch/de/business/detail/solarthermie-aufschwung-durch-neue-anwendungen.html
Startup Ticker	https://www.startupticker.ch/en/news/tvp-ueberzeugt-ersten-schweizer-industriekunden
Lebensmittel Technologie	https://www.lebensmittel-technologie.ch/news/detail/emmi-mit-solarthermischer-pionieranlage/
Bauernzeitung	https://www.bauernzeitung.ch/artikel/organisationen-firmen/emmi-erhitzt-wasser-zur-fondue-herstellung-neu-per-sonne-448465
CleantechALPS	https://www.cleantech-alps.com/de/actualites/news/details/la-technologie-de-tvp-solar-utilisee-par-le-groupe-emmi-0-2242
Houseofswitzerland	https://houseofswitzerland.org/de/swissstories/umwelt/mit-schweizer-technologie-fuer-die-klimakrise-gewappnet
Be-connected	https://www.be-connected.ch/news/emmi-installiert-solarthermische-anlage
Market Screener	https://www.marketscreener.com/quote/stock/EMMI-AG-97604/news/Emmi-commissions-a-pioneering-solar-thermal-plant-42250838/
Food Aktuell	https://www.foodaktuell.ch/2020/07/21/industrie-vertraut-auf-solarwaerme/

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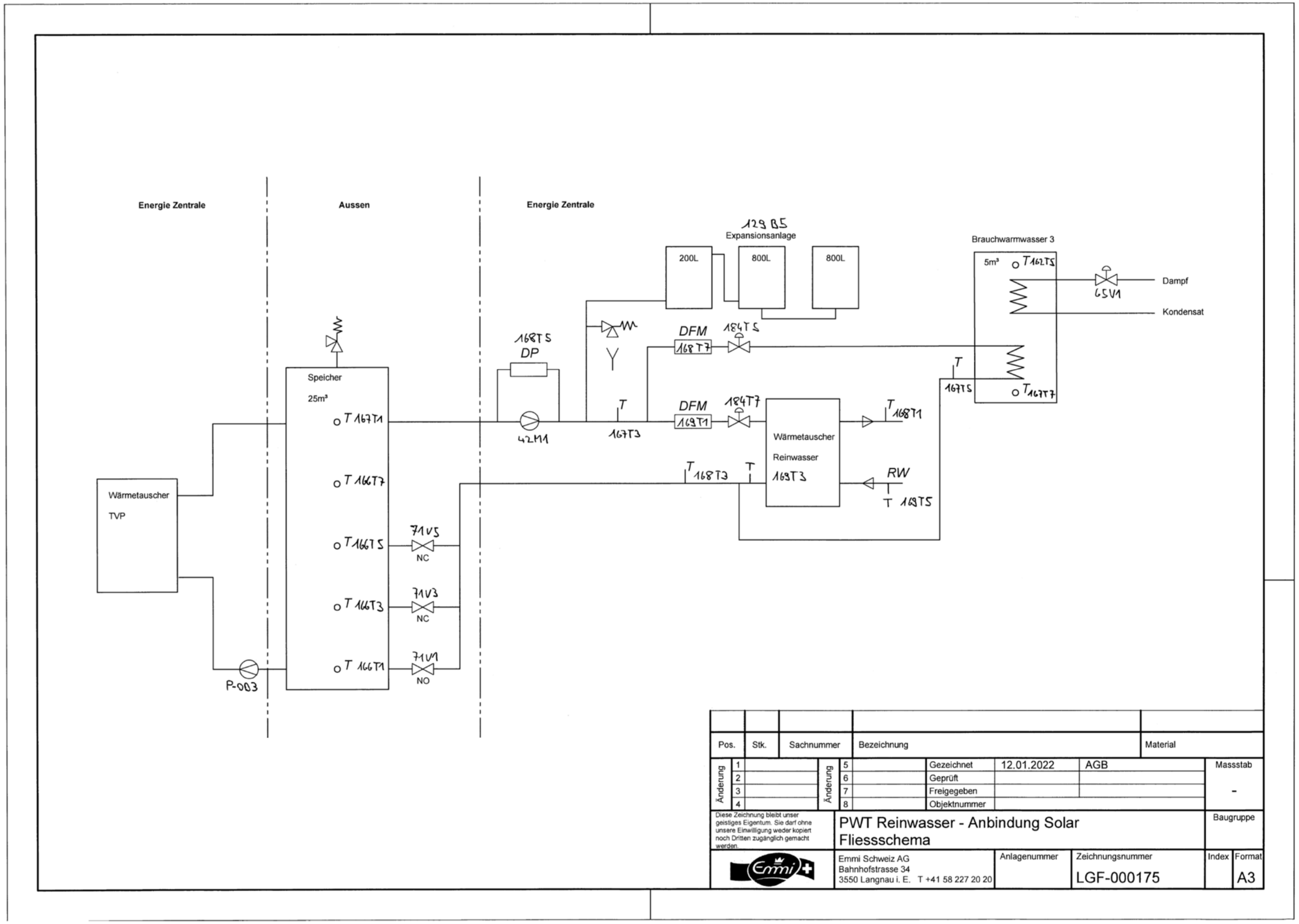
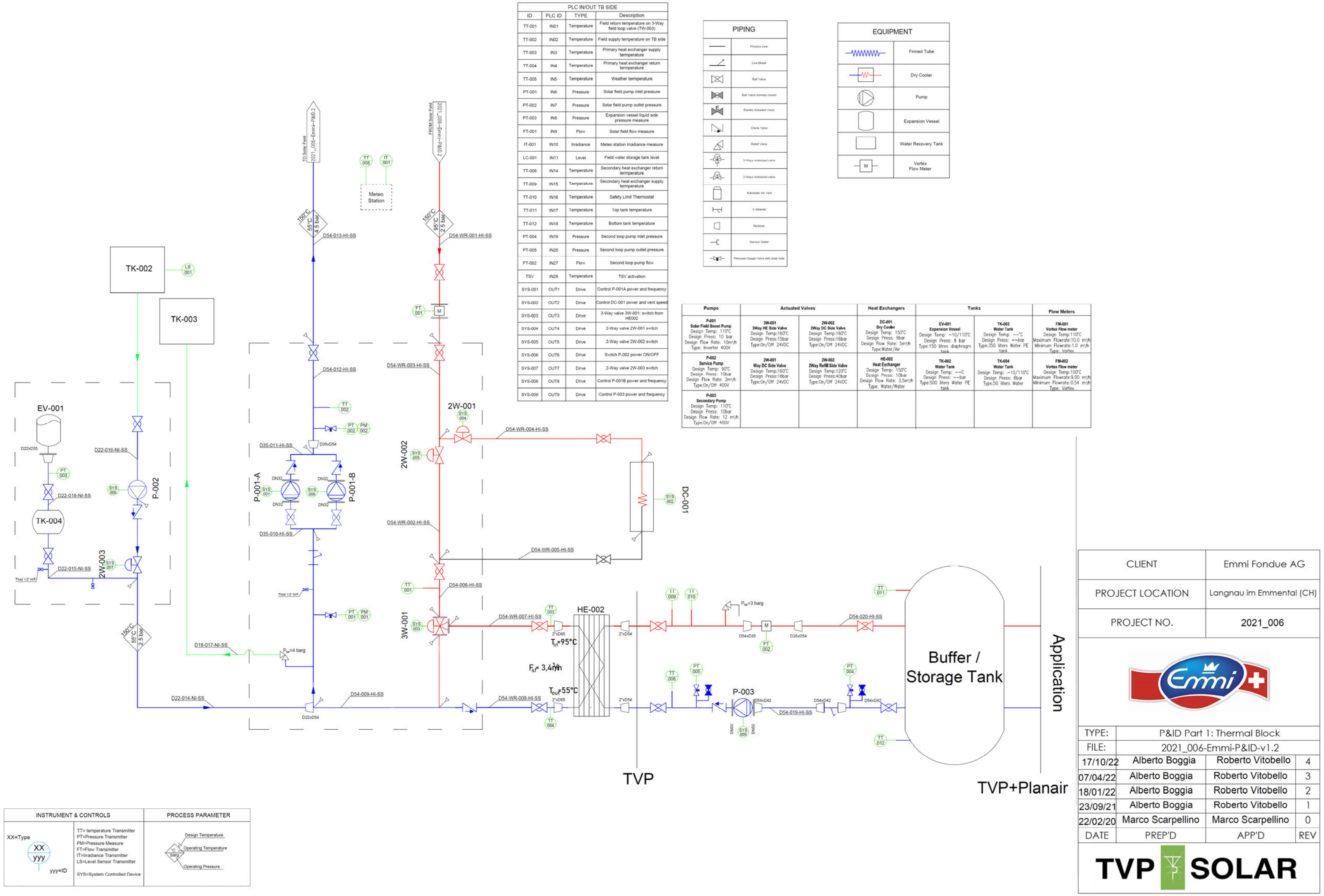
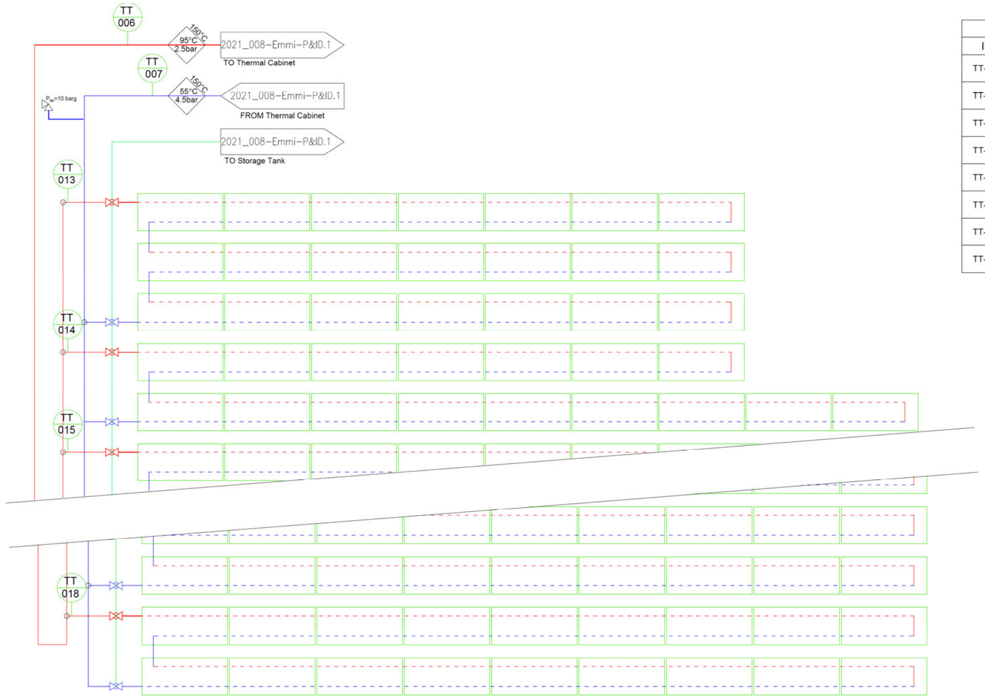
9 Appendix

9.1 Process Integration Scheme

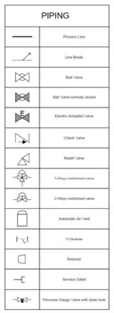


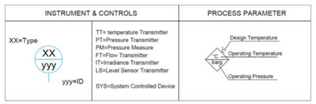
9.2 Solar thermal plant layout

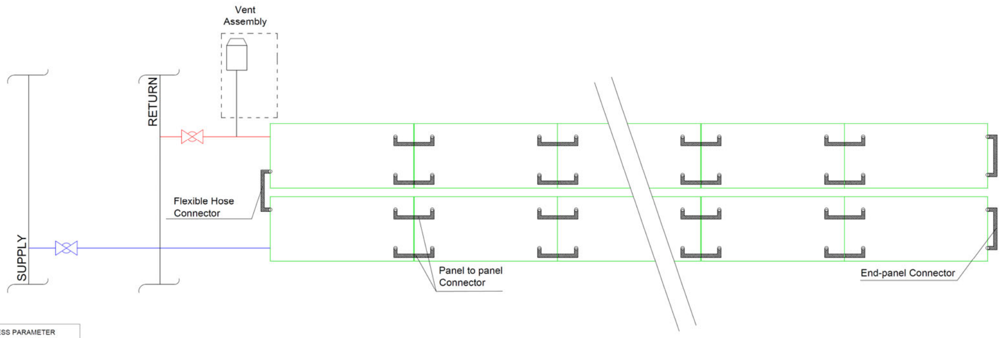




PLC IN/OUT SOLAR FIELD SIDE			
ID	PLC ID	TYPE	Description
TT-006	IN12	Temperature	Field return temperature on the array
TT-007	IN13	Temperature	Field supply temperature on the array
TT-013	IN21	Temperature	1st string return temperature
TT-014	IN22	Temperature	2nd string return temperature
TT-015	IN23	Temperature	3rd string return temperature
TT-016	IN24	Temperature	4th string return temperature
TT-017	IN25	Temperature	5th string return temperature
TT-018	IN26	Temperature	6th string return temperature







PIPING ARRANGEMENT FOR PANEL

CLIENT	Emmi Fondue AG
PROJECT LOCATION	Langnau im Emmental (CH)
PROJECT NO.	2021_006

TYPE:	P&ID Part 2: Solar Field		
FILE:	2021_006-Emmi-P&ID-v1.2		
17/10/22	Alberto Boggia	Roberto Vitobello	4
07/0422	Alberto Boggia	Roberto Vitobello	3
18/01/22	Alberto Boggia	Roberto Vitobello	2
23/09/21	Alberto Boggia	Roberto Vitobello	1
22/02/20	Marco Scarpellino	Marco Scarpellino	0
DATE	PREP'D	APP'D	REV

TVP SOLAR

9.3 Commissioning: Minor defects to solve

Date. 12.8.2022

N.ro	Description	Correction Deadline
1	Removing all material from the roof and car parking area	31/08/2022 solved
2	Performance check with the change applied to the primary pump regulation	02/09/2022 31/12/2022 request for more data
3	Procedure in the event of extraordinary events	02/09/2022 not solved
4	Updating of data recording	02/09/2022 solved
5	Secondary loop regulation pump	30/09/2022 31/12/2022 request for more data
6	After noise testing by Emmi to identify the noise level of Dry Cooler to be reduced, installation of acoustic barriers and reduce the noise minimum 10 decibels	30/09/2022 31/10/2022 new deadline
7	Replace of six temperature sensors on the strings	30/09/2022 31/10/2022 new deadline
8	Restoring the 30% glycol mixture	30/09/2022 solved
9	All the documentation will be provided in German	30/12/2022
10	Possibility of switching the HMI language to German will be introduced	30/12/2022
11	Insulation quality check	31/03/2023
12	Checking water leaks on the roof	28/07/2023
13	Primary pump regulation does not work	30/09/2022 connection with point 2
14	Dry Cooler operation not satisfied. This results in a large loss of energy	30/09/2022 connection with point 2
15	Automatic venting of the dry cooler piping after glycol refill	30/09/2022 solved
16	Insulation cover leaking.	30/09/2022 Isoteam will be contact for a sitesurvey
17	Pressure transmitter PT-002 does not correspond to pressure gauge.	30/09/2022 solved
18	Wrong scaling FT-001 resulting in incorrect power calculation.	Already changed

9.4 Media Release

Media release

Emmi commissions a pioneering solar thermal plant

Lucerne/Satigny/La Sagne, 9 November 2022 – Emmi has become the first private Swiss company to commission an industrial solar thermal plant from Geneva manufacturer TVP Solar. At the Langnau production site, the pioneering system, equipped with around 100 solar thermal collectors, converts sunlight into CO_2-free heat. In this way, Emmi is further decarbonising and diversifying its energy supply, putting it on course for its netZERO 2050 reduction path.

The Emmi production facility in Langnau, where the popular Gerber fondue is made, among other things, was the first in Switzerland to install an industrially operated solar thermal system in collaboration with the Geneva-based company TVP Solar SA. The innovative high-vacuum solar thermal collectors distributed over some 210 m^2 of roof space produce some of the high-temperature process water required each day for the production of fondue, raclette and cheese-spread specialities by absorbing sunlight and converting it into heat. Unlike a photovoltaic system, which produces electricity, the solar system generates heat very efficiently and constantly throughout the year.

“The new solar thermal system reduces our dependence on fossil fuels, secures a portion of our energy supply and stabilises our energy costs. In this way, we can prevent bottlenecks in our energy supply and also contribute to climate protection,” says Gerold Schatt, Head of Group Sustainability at Emmi.

Moving away from fossil fuels

Installation of the solar thermal system marks a further step along Emmi’s netZERO 2050 reduction path and helps achieve the interim goal of reducing internal greenhouse gas emissions by 60% by 2027. In addition to the use of district heating, photovoltaic systems and biomass at other production sites, Emmi is now decarbonising some of its heating consumption through solar thermal energy at the Langnau site. With this renewable thermal energy, the company annually saves around 21,000 litres of heating oil and reduces CO_2 emissions by 55 tonnes per year. Further benefits include significantly lower costs per megawatt hour of thermal energy, less dependence on fossil fuels, and thus a more stable energy supply.

Swiss decarbonisation solution

The solar thermal system implemented by Geneva-based provider TVP Solar represents a first for Swiss industry. TVP Solar has already demonstrated the effectiveness of its solar thermal systems with the heating network of Services Industriels de Genève (SIG) and selected projects abroad.

and positions Emmi as a pioneer in emissions reduction. We are committed to helping local operators reduce their emissions and diversify their energy supply," explains Piero Abbate, CEO of TVP Solar. He adds: "The Swiss Federal Office of Energy (SFOE) played an important role in implementation of the project. Even broader support from the federal government is needed to achieve faster and more widespread decarbonisation in Swiss companies."

The project at Emmi Langnau, which serves as a pilot scheme for Switzerland, was subsidised by the SFOE and supported with funds from the Swiss Climate Foundation. Further support has been provided by the Institute for Solar Technology SPF within the framework of the Pilot and Demonstration Programme run by the SFOE.

Integration in existing processes

Smooth operation of the project was also facilitated by Planair SA, an engineering firm specialising in the transition to alternative energy sources and decarbonisation. Planair identified the energy-intensive aspects of the manufacturing process and designed a plant optimised for environmental and economic benefits. The emphasis was on hot water preparation and preheating of the feed water for steam generation.

"Planair established the technical link between the TVP solar plant and Emmi's existing facilities, allowing for seamless integration into the existing production processes and requirements at Emmi Langnau AG," explains François Bauer, CEO of Planair.

A "plug and play" project

Against the background of an insecure energy supply and high energy costs, environmentally friendly solar thermal energy represents an efficient, secure and attractively priced energy source. Emmi is currently reviewing the possibility of introducing solar thermal energy at other production sites.

Facts and figures on the pioneering plant at Emmi Langnau

- More than one-third of CO_2 emissions in Switzerland come from heat processing
- 109 TVP flat-plate collectors with a gross surface area of 214 m^2
- Output of 145 KW-th
- Heat generation of 95° C all year round, even in winter
- 55 tonnes of CO_2 savings per year or 1,375 tonnes over the 25-year operational life of the system
- Expected solar thermal yield: 163 MWh-th/year or 764 kWh/m^2/year

Downloads and further information

- Images of the solar thermal power plant at Emmi Langnau
- General image material from Emmi

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About Emmi

Emmi is the leading manufacturer of high-quality dairy products in Switzerland. The roots of the company date back to 1907, when it was founded by dairy farmer cooperatives in the Lucerne region. With its focused strategy, innovative products and brand concepts established in Switzerland and beyond, such as Emmi Caffè Latte and Kaltbach cheese, Emmi has grown into an internationally active, listed group (EMMN) with a strong local presence in 15 countries.

Emmi's business model is traditionally based on a careful approach to nature, animals and people. In this way, Emmi creates the best dairy moments, today and for generations to come, while also contributing to value creation in rural regions. The company distributes its quality products in around 60 countries and manufactures these at over 30 of its own production sites in nine countries. With more than 9,000 employees, around 70% of whom work outside Switzerland, the Emmi Group generated sales of CHF 3.9 billion in 2021.

About TVP Solar

TVP Solar SA is a Swiss company that designs, develops, manufactures and markets innovative high-vacuum solar thermal collectors based on patented technology.

TVP has revolutionised the solar energy sector, enabling the decarbonisation of industrial processes on a large scale. TVP has deployed projects in more than nine countries on three continents, supplying carbon-neutral renewable heat sources, the most cost-effective thermal energy available today, and thus reducing operating costs and CO2 emissions while ensuring a reliable energy supply. For more information, please visit www.tvpsolar.com.

About Planair

Since it was founded in 1985, Planair AG has been committed to improving energy efficiency, the use of renewable energy sources and protection of the environment. Its multidisciplinary staff develops and implements innovative solutions in the fields of energy efficiency, renewable energies and environmental protection.

Throughout the years, Planair SA has continued to professionalise the services it offers and adapt them to an expanding client base: public authorities, industrial companies, real estate management companies, private individuals, architects, institutional investors, and others. As a consulting engineering firm and member of the Swiss Society of Engineers & Architects (SIA), Planair is a fully independent and neutral advisor, engaged to defend the best interests of its clients.

With six offices in Western Switzerland (NE, VD, GE, JU, FR, VS) and three in France (Valdahon, Chambéry and Lyon), the Planair team today boasts over one hundred multidisciplinary employees (engineers, planners, scientific specialists, economists, programmers, general services staff) who develop and implement innovative solutions in the areas of energy efficiency, renewable energy sources, decarbonisation and environmental protection.