Techno-economic assessment of the use of hybrid solar collectors in industrial facilities – A case study for the agro-food industry sector

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Abstract

The PVT4EU project aims to develop two innovative hybrid solar collectors able to convert solar radiation into electricity and heat in a single device - photovoltaic-thermal collectors (PVT). One of those collectors, PVT-MG, aims to generate heat at temperatures up to 140 ºC, being able to supply electricity and low-temperature heat to industries. This work presents the results of a techno-economic assessment performed for a hybrid solar system using PVT-MG collectors to supply electricity and pre-heat the feedwater used by a boiler providing steam to a canned food production industrial facility located in Portugal. The techno-economic assessment was carried out in TRNSYS for a typical meteorological year using electricity and heat demand profiles obtained from data from a real industrial process. The system with the overall lowest relative LCOE has a solar fraction of 7,4% and a system degree of utilization of 21,7%, achieving a global annual productivity, at system level, of 396 kWh/m^2 (545 kWh/m^2 at collector level).

Keywords: Photovoltaic-thermal Collectors; Industrial Processes; Solar Energy; Techno-economic Assessment; Agro-food Industry

1. Introduction

The industry sector accounts for a considerable share of the energy consumption in the European Union (EU), having been responsible for 25,1% of the final energy consumption in the EU in 2022 (Eurostat, 2024) (and 34% worldwide (REN21, 2024)). The EU industrial sectors with higher energy consumption are the chemical and petrochemical industry (20,0%), the non-metallic minerals industry (14,5%), the paper, pulp and printing industry (13,5%), the food, beverages and tobacco industry (12,2%) and the iron and steel sector (10,2%) (Eurostat, 2024).

Detailed statistics of heat consumption in the EU industrial sector are unavailable, however, estimates based on survey methods combined with bottom-up models concluded that the share of heat in the final energy demand of the EU industries was 71% in 2012, 84% of which corresponds to process heat (Malico et al., 2019).

Figures 1 and 2 present the final energy demand for process heat and the share of temperature levels by industrial sector for the EU in 2012 (TrustEE, 2016). The Food, Beverages and Tobacco sector presented the highest share of heat demand at temperatures up to 100ºC and the third largest share of heat demand at temperatures up to 200 ºC. Moreover, the share of heat in the final energy consumption of this sector was estimated to be 62% (TrustEE, 2016). These characteristics make this sector a suitable target for the deployment of low-temperature renewable heat solutions.

The PVT4EU project is developing innovative solutions for photovoltaic-thermal collectors, hybrid solar collectors able to convert solar radiation into electricity and useful heat in a single device. One of those

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collectors (PVT-MG) aims to generate heat at temperatures up to 140 ºC, opening the possibility of its application to supply electricity and low-temperature heat to industries. Given its target operating temperature range, the application of this collector to the Food, Beverages, and Tobacco sector has high potential. Therefore, this industrial sector was selected to be used to develop case studies dealing with the application of PVT-MG collectors for production of electricity and heat in industrial sites, the first of which is presented in this paper.

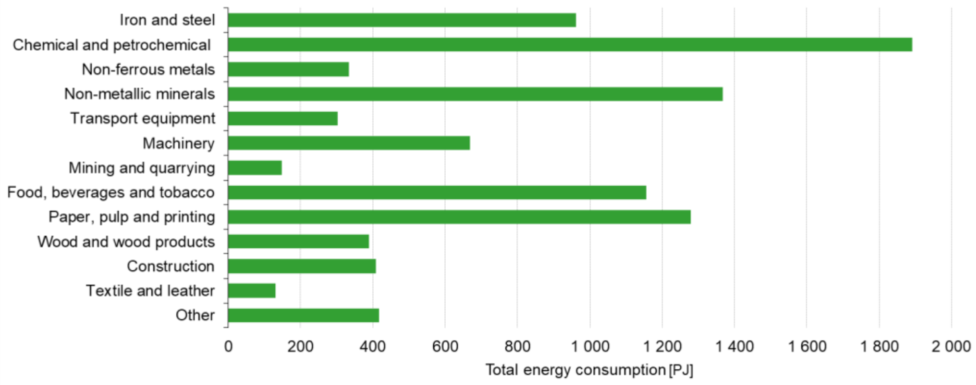

Figure 1: Total final energy consumption by industrial sector in the EU in 2022 (Eurostat, 2024).

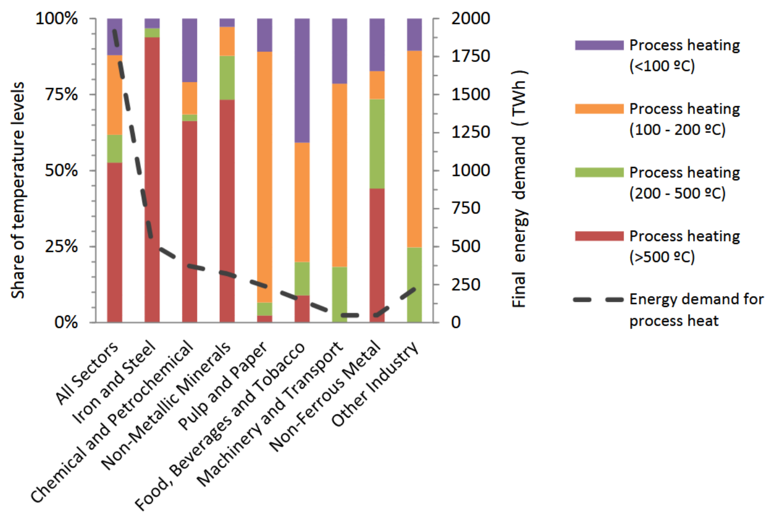

Figure 2: Final energy demand for process heat and share of temperature levels by industrial sector for EU in 2012 (TrustEE, 2016).

A simulation study was carried out to investigate the technical and economic performance of the application of the first version of the PVT-MG collector in a PVT system designed to pre-heat a boiler's feedwater line and provide electricity to an industrial facility of the agro-food sector located in Peniche, Portugal. Section 2 present the current version of the PVT-MG collector, section 3 presents the case study considered in this work, section 4 summarizes the main characteristics of the TRNSYS model used to carry out the simulation study, section 5 presents the main results for the technical and economic performance analysis and section 6 presents the main conclusions of this work.

2. The PVT-MG collector

The PVT-MG collector prototype is a non-imaging Concentrating Photovoltaic-Thermal (CPVT) collector based on the Double Maximum Reflector Concentrator (MaReCo) concept. It utilises a double set comprising a Compound Parabolic Concentrator (CPC) and a hybrid receiver, which consists of two photovoltaic (PV) strings – one positioned at the top of the receiver and another at the bottom – and a thermal absorber located between them (see Figure 3). The top PV string is illuminated directly by the solar radiation passing through the collector aperture, while the bottom string is illuminated by the solar radiation concentrated by the CPC.

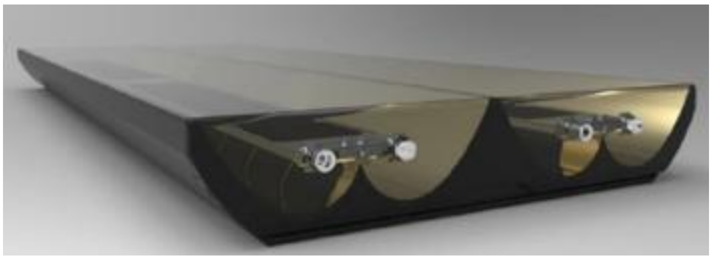

Figure 3: CAD rendering of the PVT-MG collector

3. PVT systems in the canned food industry – the case study

Data from a real industrial facility from the agro-food sector was used as the basis for the investigation of the application of the first prototype of the PVT-MG collector in PVT systems designed to pre-heat a boiler's feedwater line and provide electricity to an industrial facility of the agro-food sector.

A canned food production plant located in Peniche (Portugal), from ESIP - European Seafood Investments Portugal, S.A. from the Thai Union Group, was selected as a target for this case study. This facility uses a 5,6 MW_{th} gas boiler to generate steam at up to 8 bar for several process heating applications, including thawing, cooking, cleaning, and sterilisation. A fraction of the steam mass flow used in these processes is recovered as condensate and collected in a condensate tank where it is mixed up with makeup water to compensate for the water mass lost in purges and in processes using open-steam lines. The resulting mixture is pumped to the boiler as feedwater.

A simplified schematic of the existing steam generation and distribution network is presented in Figure 4. Points A, B and C identify potential points for integration of solar thermal energy in the boiler's feedwater line, namely: A – Heating of makeup water; B – Heating of the condensate tank; C – Heating of the boiler's feedwater.

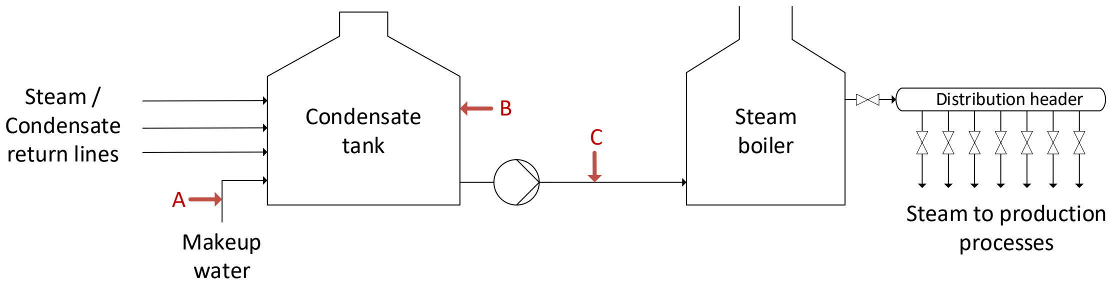

Figure 4: Simplified scheme of the existing steam generation and distribution network.

3.1. Energy demand profiles

Technical visits to the industrial facility were carried out to gather data from the steam generation and distribution network in order to determine the thermal energy demand associated with the pre-heating of the boiler's feedwater. This information, together with ESIP's operational data allowed the estimation of typical thermal and electric load profiles.

The electric power consumption profile of the industrial facility, from the grid, determined for each quarter-hour period of a typical day, oscillates between 390 kW and 795 kW for all months of the year except for the month of August, when it ranges between 110 kW and 395 kW. For all months the minimum power consumption occurs around the solar noon period due to the existence of a PV system connected to the plant's power grid, while the maximum occurs in the early morning hours and the evening / early night hours. The lower consumption during August is due to the summer holiday period, during which the production lines are stopped.

Figure 5 presents the hourly profile for the mass flow rate of steam produced in the boiler and the temperature of the feedwater at the outlet of the condensate tank for a typical week that was derived from data collected in a set of monitoring campaigns. The boiler operates 5 days of the week, 24h per day, between Monday 0h00 until Saturday 7h00, having a similar operation pattern across each day. The maximum steam mass flow rates (approximately 7000 kg/h) occur during the day, usually between 12h00 and 15h00. These periods are also associated with lower feedwater temperatures at the condensate tank outlet (approximately 40 ºC).

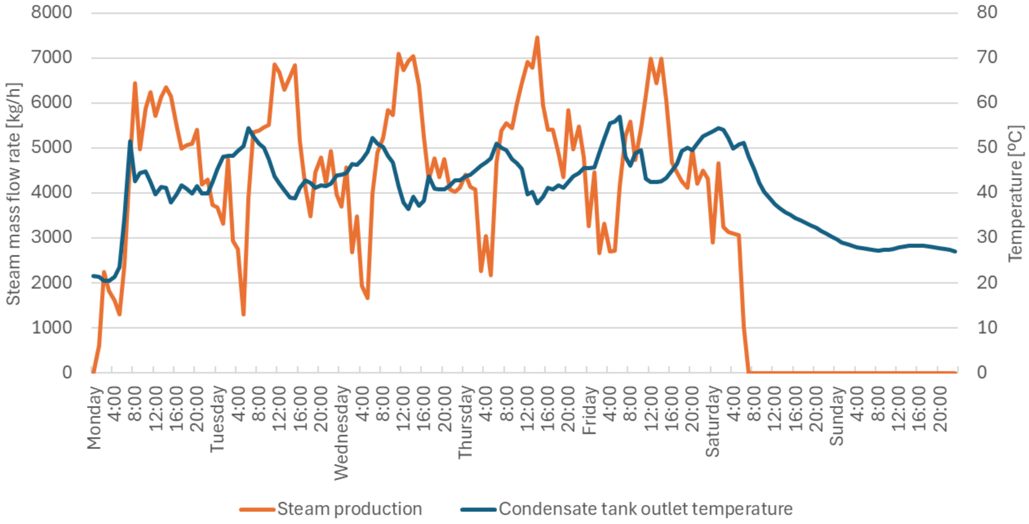

Figure 5: Steam production mass flow rate and feedwater temperature for a typical week of operation.

Knowing the average pressure of the steam generated by the boiler (7,7 bar) and the profile for the average feedwater temperature at the boiler's inlet (Figure 5) it is possible to estimate the thermal power required by the boiler pre-heating process. Figure 6 presents the average hourly profile of the pre-heating thermal power for a typical week of operation for three different scenarios: heating of the feedwater up to the saturation temperature (170 ºC); pre-heating up to 140 ºC; pre-heating up to 100 ºC.

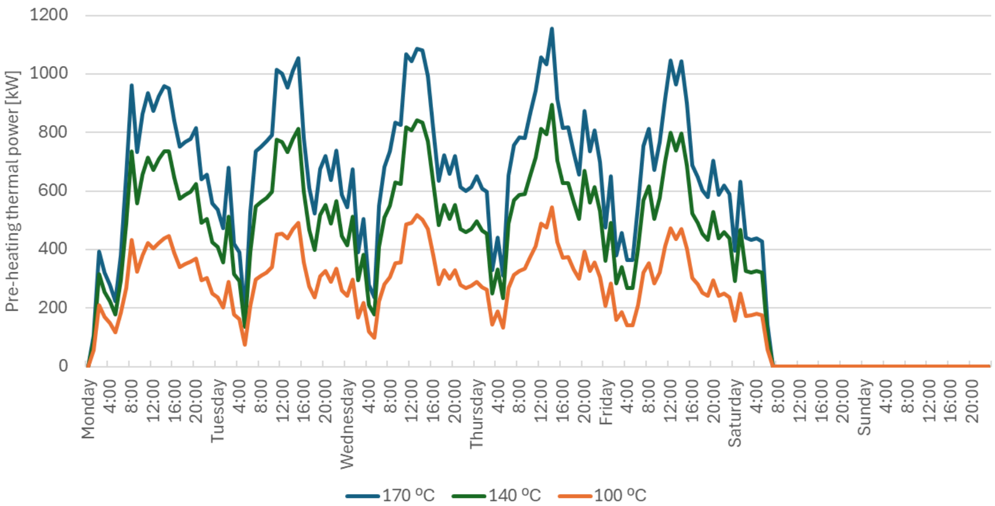

Figure 6: average hourly profile of the pre-heating thermal power for a typical week of operation.

The estimated pre-heating thermal power profiles follow a similar pattern as the steam production mass flow rate in the three scenarios. The thermal power estimated to be required to fully pre-heat the feedwater up to the saturation temperature at average operation pressure has a maximum value of 1156 kW and an average value of 682 kW, being the annual energy required for this process estimated to be 4,0 GWh. The estimates for pre-heating up to 140 ºC (the maximum operating temperature envisioned for the PVT-MG collectors) have a maximum thermal power requirement of 894 kW and an average of 519 kW, being the annual energy required for this pre-heating equal to 3,1 GWh. Finally, estimates for pre-heating the boiler feedwater up to 100 ºC yield a required maximum thermal power of 544 kW and an average thermal power, during operating periods, of 302 kW, being the annual energy for this process estimated to be equal to 1,8 GWh.

3.2. PVT system and integration point

The solar energy integration point considered in this study is the boiler's return line between the boiler's pump and the boiler's inlet (point C in Figure 4). PVT collectors located in the rooftop of the industrial building collect solar radiation and convert it into electricity and heat. The electricity generated by the PVT collectors is converted from DC to AC by two inverters after which it is injected in the facility's grid. If the temperature of the heat transfer fluid (HTF) at the bottom half of the thermal energy storage tank is lower than the temperature at the solar field (by a given temperature difference), it is pumped from the bottom of the storage tank through the PVT field, which is composed by parallel loops of serially connected PVT collectors, where it is heated. The hot heat transfer fluid is then stored in the storage tank. If the difference between the temperature of the HTF at the top of the storage tank and the temperature of the feedwater coming from the condensate tank is higher than a given temperature difference, the HTF is pumped from the storage tank through the hot side of a counterflow heat exchanger where it heats the boiler's feedwater that passes through the cold side of the heat exchanger before returning to the tank. The flow of the HTF at the heat exchanger is set by a variable speed pump, controlled by a system incorporating a differential controller and a PID controller that aims to maximise the heat transfer while minimising rapid variations of the feedwater's temperature.

The design point of the system assumes the PVT system will supply heat up to 110 ºC to the pre-heating heat exchanger in order to heat the boiler's feedwater up to 100ºC. The simplified hydraulic and electric scheme of the PVT system is presented in Figure 7.

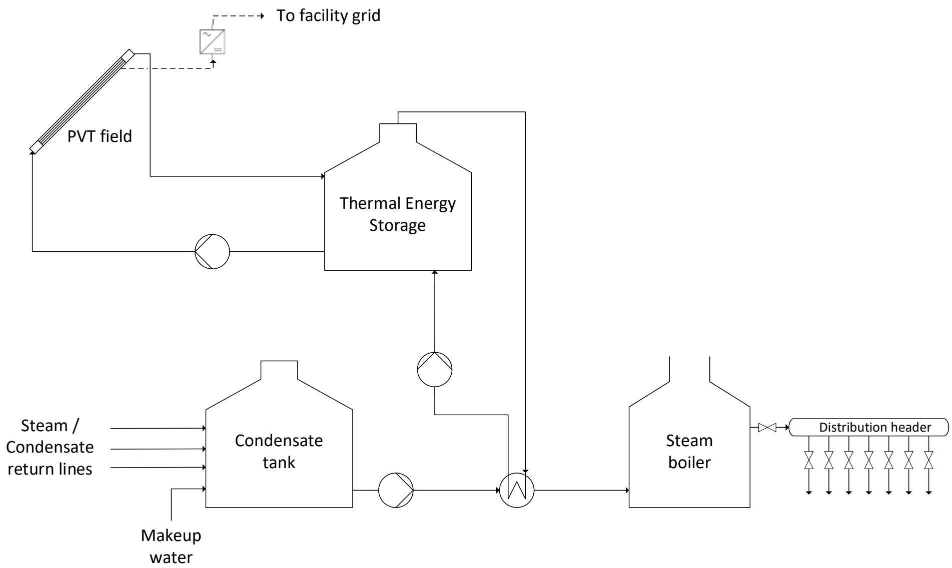

Figure 7: Simplified hydraulic and electric scheme of the PVT system and its integration in the industrial steam generation and distribution network.

4. Simulation model

A TRNSYS (Klein, 2017) model was developed to assess the behaviour and annual performance of the PVT feedwater pre-heating system. The model layout can be seen in Figure 8 and its main components are stated in Table 1. Detailed descriptions of the mathematical models of the TRNSYS model components can be found in the software documentation (Thornton, 2012 and Klein, 2019).

The PVT-MG collector is still under development, therefore, for the purposes of this work, performance parameters resulting from the experimental performance tests carried out within the PVT4EU project for a first prototype are used (Dannemand, 2025). The collector has a gross area of 2,57 m^2 and can be used with water or a water-glycol mixtures. This performance analysis assumes the use of a water / propylene glycol mixture (80/20) and the installation of the solar field in the facility rooftop, having an inclination of 30º and an azimuth of 225º.

The solar field pump imposes a constant volumetric flow rate in the solar field equal to 0,09 m^3/h per parallel loop. It operates whenever the temperature difference between the solar field and the bottom section of the thermal energy storage is equal or greater than 10 K. If the temperature of the storage tank exceeds 110 ºC the pump is commanded to stop in order to avoid excessive temperature in the storage tank.

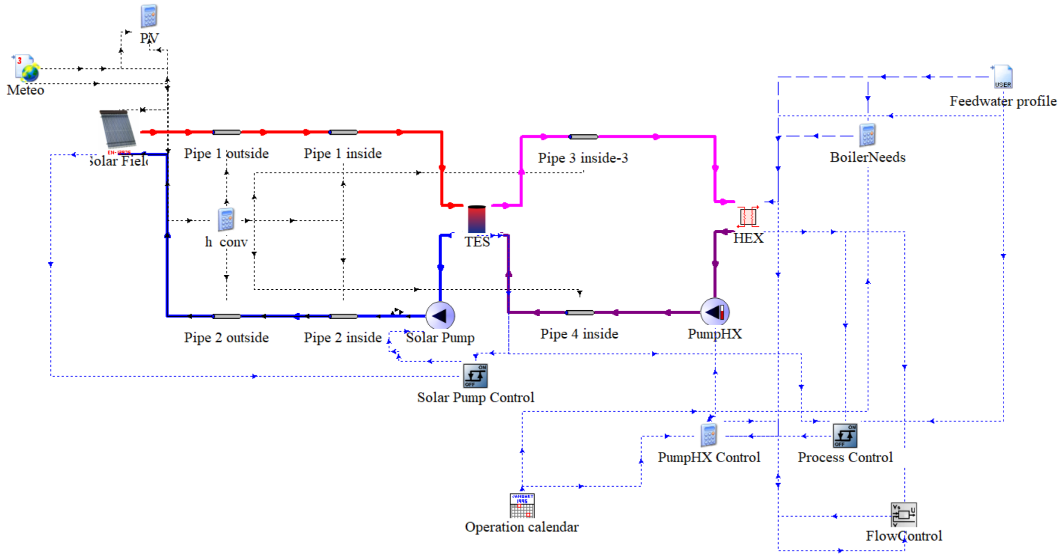

Figure 8: TRNSYS model layout of the boiler's feedwater PVT pre-heating system.

Table 1: main components of the TRNSYS model.

Name	Type	Description	Function
Meteo	15	Data reader and radiation processor	Reads and processes the meteorological file providing information on irradiance on the collector plane, ambient temperature, wind velocity, incidence and solar angle values
Solar Field	1288	PVT solar field – thermal model	Models the thermal performance of the PVT collector field following EN 12975 quasi-dynamic efficiency approach using experimental parameters for the PVT-MG collector (Dannemand, 2025), yielding outlet temperatures and the energy gain on the HTF
PV	Equation	PVT solar field – electric model	Models the electric performance of the PVT collector according to an experimental correlation for the PVT-MG collector (Dannemand, 2025), yielding the electric AC power generated by the PVT collectors after the inverter
Pipe (1, 2, 3 and 4 / inside and outside)	709	Circular fluid-filled pipes in indoor and outdoor conditions	Models the thermal losses of fluid flowing in a circular pipe for indoor and outdoor conditions using convection heat transfer coefficients calculated in h_conv, yielding the HTF temperature after the pipe
h_conv	Equation	Convection calculator	Calculation of convection heat transfer coefficients for circular pipes in indoor (natural convection) and outdoor (natural and forced convection) conditions
TES	158	Thermal energy storage tank	Models a stratified vertical storage tank providing the temperature distribution throughout the tank and its outlets
Solar Pump	114	Single speed pump	Models a single speed pump, imposing the mass flow rate in the PVT field header pipe and determining the electric power consumption of the pump and the heat transferred to the HTF due to the pump operation

Name	Type	Description	Function
Solar Pump Control	165	Differential controller	Differential controller that yields the control signal for the pump of the PVT field circuit
HEX	5	Counterflow heat exchanger	Models that counterflow heat exchanger that pre-heats the boiler feedwater
PumpHX	110	Variable speed pump	Models a variable speed pump, imposing the mass flow rate in the hot side of the pre-heating heat exchanger and determining the electric power consumption of the pump and the heat transferred to the HTF due to the pump operation
PumpHXControl	Equation	Control algorithm	Models the control algorithm implemented for the variable speed pump combining inputs from the operation calendar, the differential controller and the PID controller
Operation Calendar	41	Calendar	Operation calendar of the industrial facility imposing operation stops during public holidays and vacation periods
Process Control	165	Differential controller	Differential controller that yields an on/off control signal for the variable speed pump of the hot side of the pre-heating heat exchanger
Flow Control	22	PID controller	PID controller that yields a proportional control signal for the variable speed pump of the hot side of the pre-heating heat exchanger
Boiler Needs	Equation	Load data processor	Determines the mass flow rate of the boiler feedwater as a function of the operation calendar and the typical flow rate profile
Feedwater Profile	9	Load data reader	Provides the hourly profiles of the boiler's feedwater mass flow rate and temperature at the outlet of the condensate tank

A variable speed pump is used to modulate the flow of the heat transfer fluid from the thermal energy storage tank that passes through the heat exchanger. This pump is controlled by a signal that integrates three control levels: a on/off control determined by the plant's boiler weekly operation schedule; a differential controller that provides an on signal if the temperature difference between the storage tank top section and the feedwater at the inlet of the heat exchanger is equal or greater than 10 ºC; a PID controller with a set-point of 100 ºC and a minimum operation level of 25% - if the feedwater outlet temperature reaches 100 ºC the pump speed is reduced in order to avoid overheating the feedwater and intermittent operation, particularly when process loads differ from the design point.

Finally, the model uses meteorological data for the plant location provided by a TMY3 file generated with the Meteonorm software (Meteotest, 2023). For this site annual global horizontal irradiation reaches 1659 kWh/m^2, with a maximum monthly value of 211 kWh/m^2 in June and July, and a minimum of 59 kWh/m^2 in December. Dry bulb air temperature oscillates between a maximum value of 35,5 ºC and a minimum of 2,6 ºC, averaging at 16,7 ºC.

5. Performance analysis

5.1. System Thermal performance

Computational simulations were carried out using the TRNSYS model to study the annual performance of the PVT-based boiler feedwater pre-heating system for different configurations. A parametric study was performed to determine the influence of the solar field aperture area and configuration (number of collectors in series and number of collector arrays connected in parallel) and the thermal energy storage tank volume in the electrical and thermal energy production, the solar fraction for the pre-heating process and the degree of utilization of the system. The range of different variables considered in the parametric analysis was the following: solar fields with 60 to 240 arrays of collectors (evaluated in intervals of 20 arrays) and 3 to 7 collectors connected in series per collector array; storage tank specific volumes of 25 l/m^2, 50 l/m^2, 75 l/m^2 and 100 l/m^2.

Figure 9 presents the energy delivered by the PVT field (electricity to the facility grid, heat to the thermal energy storage tank and total energy) during a typical year of operation for all combinations of solar field sizes/configurations and storage tank specific volumes considered in the parametric analysis.

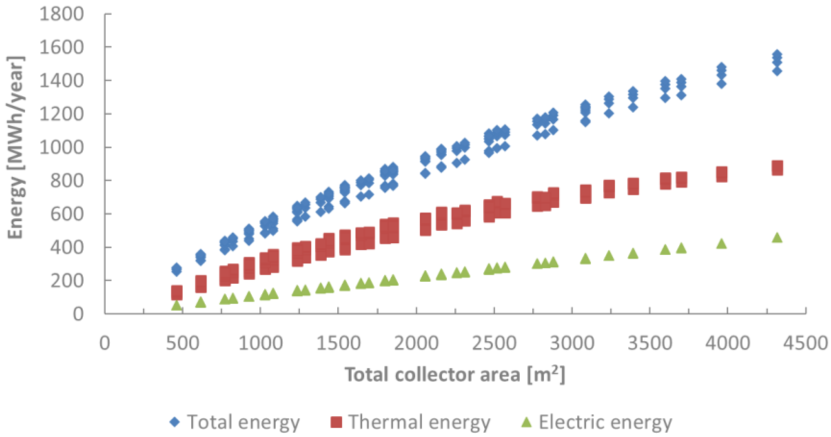

Figure 9: Energy delivered by the PVT field for all configurations analysed in the parametric study.

The electric energy delivered by the PVT field, after the inverter, in a typical year, ranges from 53 MWh for a system with a total PVT collector area of 462,6 m^2 up to 462 MWh for a system with 4317,6 m^2 of total area. The results show the electric energy produced by the PVT field most relevant dependence is to the total collector area (as expected), being this relation well approached by a linear relation (R^2=0,99975). On the other hand, storage tank specific volume has a small impact on the electric energy production: for a similar solar field, tripling the thermal energy storage specific volume (from 25 l/m^2 to 100 l/m^2) results in an increase of electric energy production always equal or less to 3%. The effect of increasing the storage volume decreases for larger solar fields, being less than 1,5% when tripling the storage specific volume from 25 l/m^2 to 100 l/m^2 for similar solar fields with total collector areas greater than 2775,6 m^2. For equal total collector areas, the configuration of the solar field (i.e., the different arrangements of the collectors in series and parallel arrays) also yields a small impact on the electric energy production of the PVT field, being negligible for all practical purposes as it was always less than 0,4% for all configurations analysed in this parametric study.

The thermal energy delivered by the PVT field to the storage tank, in a typical year, ranges from 200 MWh for a system with a total PVT collector area of 462,6 m^2 - approximately 3% of the energy required to pre-heat the feedwater up to the saturation temperature (170 ºC) - up to 1096 MWh for a system with 4317,6 m^2 of total area - approximately 22% of the energy required to pre-heat the feedwater up to 170 ºC. The results show the electric energy produced by the PVT field most relevant dependence is to the total collector area (as expected). The storage specific volume and configuration of the PVT field have a greater impact in the thermal energy production than in the electric energy production: there is more dispersion for the values of thermal energy production at the same total collector area (red squares in Figure 9) than for the electric energy production. The storage specific volume impacts the thermal energy yield of the PVT field: for the analysed systems with a similar solar field, tripling the storage tank specific volume from 25 l/m^2 to 100 l/m^2 results in an increase of thermal energy production always greater than 9,6% (can reach values of 18,6%), while doubling it from 25 l/m^2 to 100 l/m^2 increases the thermal energy production by a minimum of 3,7% and a maximum of 6,6%. The increase of thermal energy production due to the storage tank specific volume increase is smaller for smaller and larger total collector areas. For equal total collector areas, the configuration of the solar field (i.e., the different arrangements of the collectors in series and parallel arrays) also yields a small impact on the thermal energy production of the PVT field, being the variation of energy production always less than 1,5% for all configurations analysed in this parametric study.

Figure 10 presents the useful total energy (electric plus thermal) provided by the PVT field for system configurations with 3 and 7 collectors connected in series and storage tank specific volumes of 25 l/m^2 and 100 l/m^2 (the extreme cases considered in this parametric analysis).

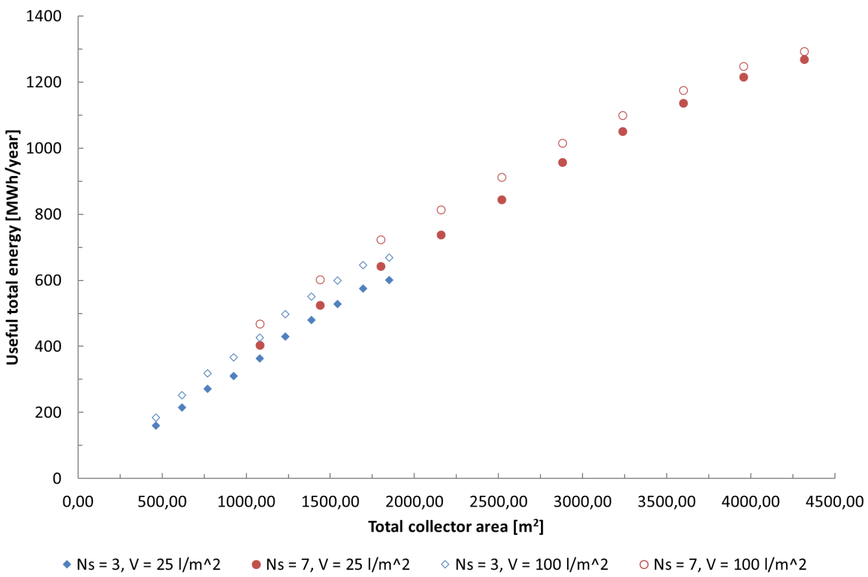

Figure 10: Useful total energy delivered by the PVT system for configurations with 3 and 7 collectors connected in series and specific storage volumes of 25 l/m^2 and 100 l/m^2.

From the analysis of the figure, it is possible to conclude that increasing the storage tank specific volume increases the system yield. This increase is smaller both for systems with smaller total collector areas and systems with larger collector areas. In the former, the solar field is too small in relation to the demand, being unable to fully charge the storage tank even with the low specific volume tank, therefore, increasing the volume of the storage tank does not lead to an increase of the stored energy. However, the average operating temperature of the PVT field and storage tank is lower for the larger storage tank specific volume, resulting in an increase of the overall efficiency of the system (lower losses in the collector field and the storage tank) and thus a greater useful total energy. In the latter, the solar field size is too large for the available storage tank, saturating the tanks during the high irradiation periods for all storage specific volumes explored in this assessment. Nevertheless, systems with larger storage tank specific volume are able to store more energy during the periods of lower irradiance than the ones with lower storage specific volumes, resulting in a slightly higher delivery of useful energy. The final design of the system will have to ensure there is a proper sizing of the solar field and storage tank in order to avoid falling on these two situations, which result in sub-optimal systems. Additionally, it is visible that systems with 7 collectors connected in series yield more energy than systems with 3 collectors in series. However, the overlap of systems of similar area is limited, therefore this conclusion should not be generalized and requires a more detailed study.

Finally, Figure 11 presents, for all the analysed configurations, the solar fraction, as a percentage of the thermal energy required for the feedwater pre-heating up to the saturation temperature (170 ºC), and the PVT system degree of utilization (in this case considering the total useful energy generated by the system).

For all storage tank specific volumes analysed in this study, the system degree of utilization has a maximum value for PVT systems with total collector areas around 1000 m^2, reaching a maximum of 23,9% for a collector area of 925 m^2 in a PVT system with specific storage volume of 100 l/m^2. Systems with storage specific volume of 25 l/m^2 achieve a maximum of 20,6% for a collector area of 1079 m^2.

The feedwater pre-heating solar fraction is higher in the simulated systems with higher specific storage volumes and larger PVT fields, ranging from 2,9% (system with specific volume of 25 l/m^2 and 463 m^2) up to 22,1% (system with storage volume of 100 l/m^2 and 4318 m^2). The figure also shows lower increases of solar fraction (i.e. useful thermal energy) for higher solar field areas. This means that for the same load the system presents diminishing marginal productivity, which is a well-known behaviour of solar thermal systems (see, for example, Castro (2018)).

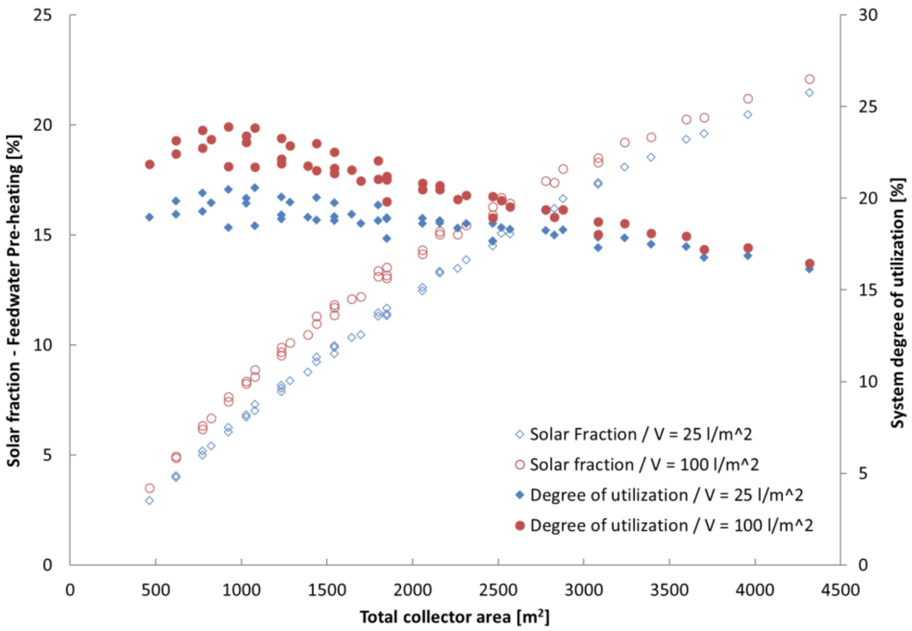

Figure 11: Feedwater pre-heating solar fraction and system degree of utilization for PVT systems with specific storage volumes of 25 l/m² and 100 l/m².

5.2. System economic performance

Assuming the investment costs are concentrated on the initial period, as well as constant operation and maintenance costs and useful energy production, the Levelized Cost of Energy (LCOE) can be computed as (Castro, 2012):

$$LCOE = \frac{I_t(i + d_{om})}{E_{annual}} \quad (1)$$

where I_t represents the total investment costs, i the discount rate factor, d_{om} the operation and maintenance costs as a fraction of the total investment costs and E_{annual} the energy (thermal and electric) provided by the PVT system during one year of operation. For the purposes of this study, the discount rate factor was valued at 7,72% for a lifetime of the system of 25 years.

The investment associated to the PVT systems was estimated taking into consideration the actual costs of the different components. Pump, propylene glycol and insulation costs were obtained from direct contact with pump, glycol and insulation vendors, respectively. Apart from the PVT field, the other equipment costs were estimated using available data from specialized chemical engineering design databases, namely the Matches online database (Matches, 2014). Installation costs and annual operation and maintenance costs were estimated a share of the total investment costs (20% and 2%, respectively). Considering the targeted collector is still at an early prototyping stage, and that this work aimed to support its development by informing on its performance in boiler feedwater pre-heating solar systems, different values for the PVT field specific cost were considered. The LCOE results for a given set of PVT field area and storage specific volume were analysed as a relative LCOE, i.e., as the ratio between the LCOE for a given field area and the maximum LCOE obtained for the given storage specific volume. Figure 12 presents the relative LCOE obtained for all the field area / storage volume combinations analysed in the parametric study.

The LCOE is significantly affected by the thermal energy storage specific volume and the solar field size. The configuration of the PVT field can also impact the LCOE, with relative LCOE differences reaching up to 2,5 p.p. for the same field area and storage volume. This difference is due to the investment costs and energy consumption associated with the circulation pump system of the PVT field: for the same area, a system with less collectors in series but more arrays of collectors will require a higher mass flowrate (to maintain the same flow rate in each collector array) increasing the pump requirements and the electricity self-consumption for HTF pumping.

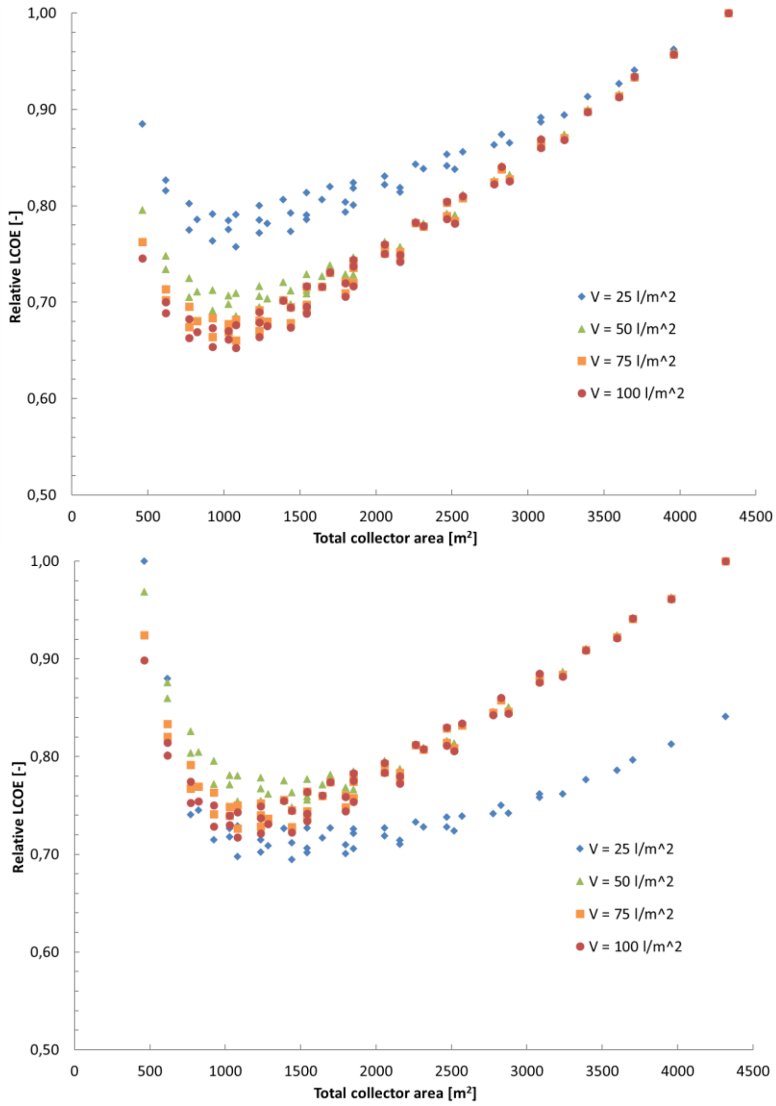

Figure 12: Relative LCOE as a function of the total collector area and thermal energy storage specific volume: top) high and average PVT costs; bottom) low PVT costs.

As was the case for the system degree of utilisation, the lowest LCOEs are found, independently of the storage tank specific volume, for PVT systems with total collector areas around 1000 m^2, reaching a relative LCOE minimum of 63,8% for a collector area of 925 m^2 in a PVT system with specific storage volume of 100 l/m^2. Systems with storage specific volume of 25 l/m^2 achieve a minimum relative LCOE of 74,6% for a collector area of 1079 m^2. The system with the overall lowest relative LCOE has a solar fraction of 7,4% and a system degree of utilization of 21,7%, achieving an annual productivity, at system level, of 396 kWh/m^2 (545 kWh/m^2 at collector level). A system with the same storage tank specific volume (100 l/m^2) and similar relative LCOE (63,9%) yield even better energetic results, with a solar fraction of 8,9% and a system degree of utilization of 23,9%, achieving an annual productivity, at system level, of 434 kWh/m^2 (539 kWh/m^2 at collector level). Showing the need to check for better solutions, from an energy point of view, in the region close to minimum LCOE.

Systems with high thermal energy storage specific volume have lower relative LCOEs. However, the difference between two systems of equal area but different specific volume is highly dependent on the cost of the PVT field. Moreover, there is a cost for the PVT field below which the effects of the cost of the remaining equipment are more significant and the relation of the relative LCOE with the storage tank specific volume is inverted. In this case, the optimum system requires a larger PVT field.

6. Conclusions

The design, modelling and simulation of a PVT system, using prototype based PVT-MG collectors under development in the PVT4EU project, to be used as a boiler feedwater pre-heating stage of the steam generation unit of an canned food production plant was performed, enabling the study of the technical feasibility and potential of integrating solar electricity and process heat at the steam supply system of a canned food production plant located in Portugal.

A parametric study was carried out to analyse different configurations of the PVT system. The system with the overall lowest relative LCOE has a solar fraction of 7,4% and a system degree of utilization of 21,7%, achieving an annual productivity, at system level, of 396 kWh/m^2 (545 kWh/m^2 at collector level).

A second version of the PVT-MG collector prototype is being developed in the PVT4EU project. Future works should carry out a detailed cost assessment of the novel collector and assess the impact of an improved performance of the PVT collector in the PVT system energetic and economic performance.

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