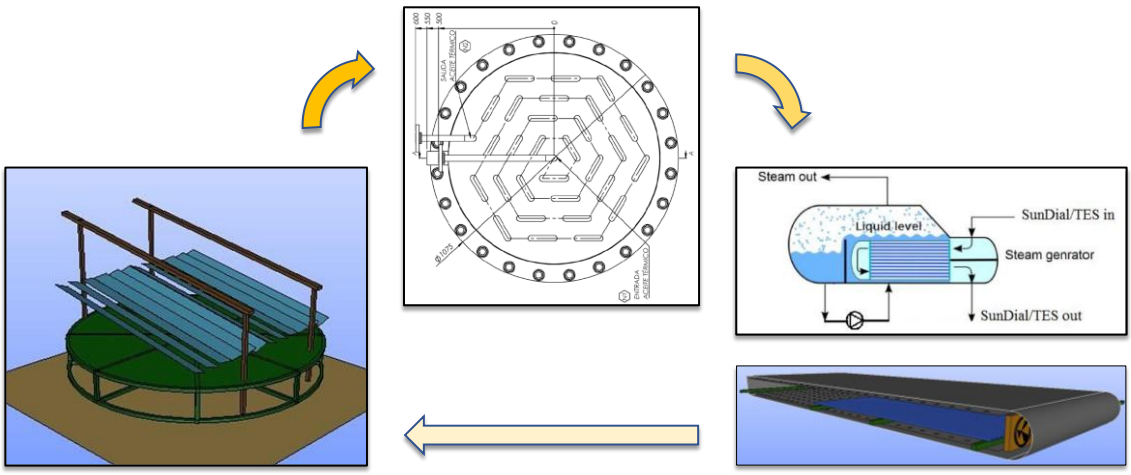
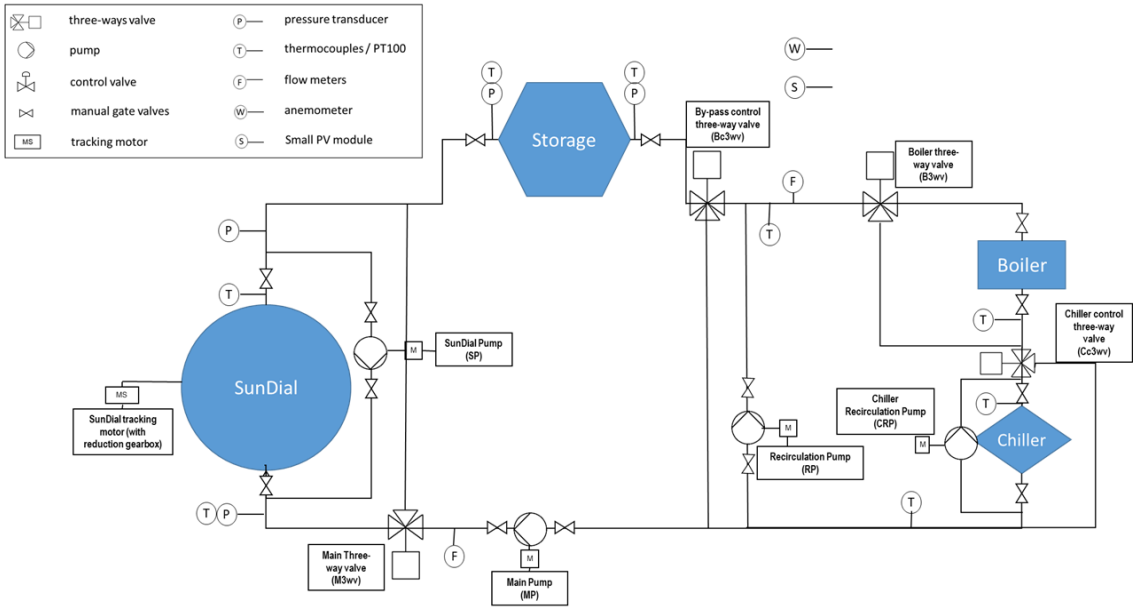
**Integrated ASTEP system: operation, control, and performance.**

ASTEP project creates a new innovative SHIP concept, the ASTEP system. The solution is based on modular and flexible integration of two innovative designs for the solar collector (SunDial), conceived by UPM and UNED, and the Thermal Energy Storage, based on Phase Change Materials. These technologies are integrated via a control system which will allow flexible operation to maintain continuous service.

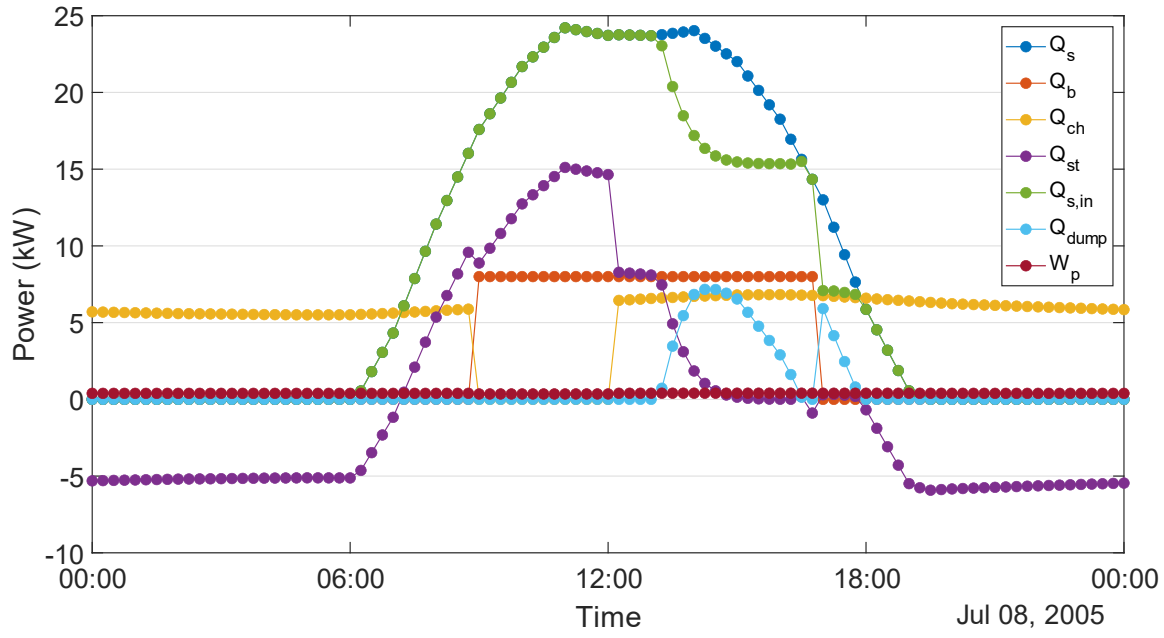


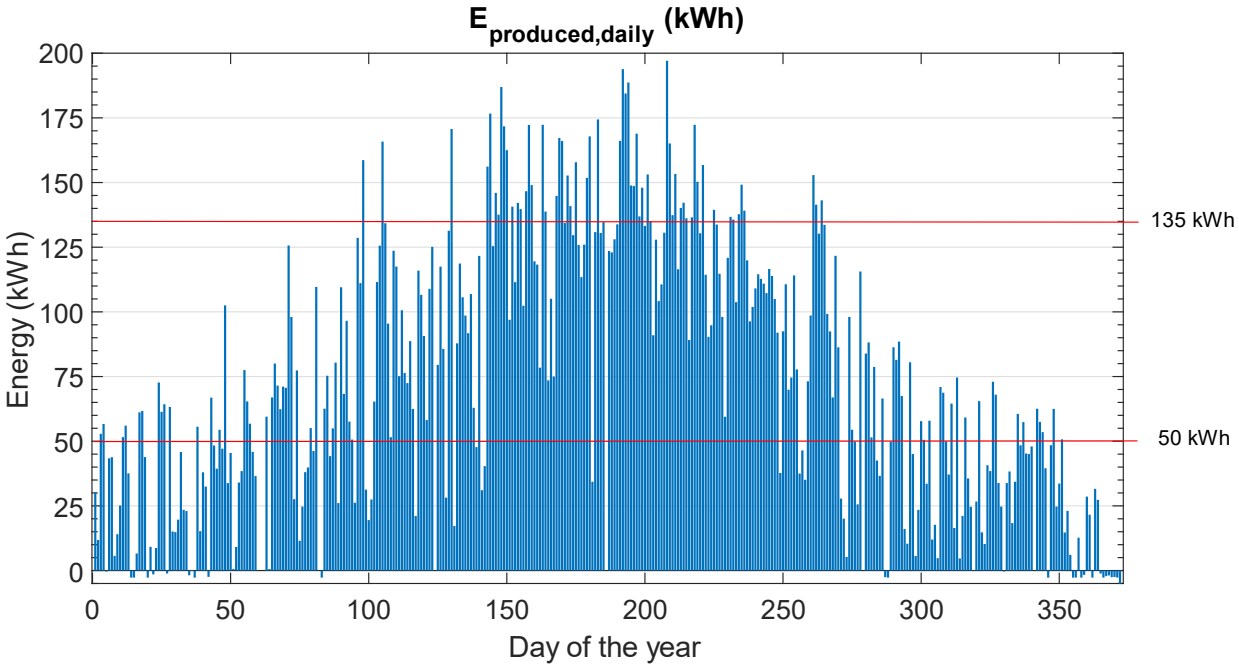

In a first stage, two different layouts were proposed for the concept definition, one with the Sundial and the thermal energy storage system in series and the other with the Sundial and the thermal energy storage in parallel, selecting the first one as the most appropriate. Then, according to the information related to the thermal energy demand at the end-users, the involved temperatures, and the schedule of operation of the industry, a control strategy was outlined with the objective of maximising the solar energy integration into the processes and minimising the hysteresis in the thermal energy storage system. The different operation modes of the system and the sensors and actuators were selected for that.



For the sizing and the assessment of the system, two simulation models were developed, namely a steady-state one and a dynamic one. With this aim, several sub-models for simulating the different components of the system were also developed and integrated.

The steady-state simulation model was used to assess the whole system. First, the daily and yearly behaviour of the two proposed designs (ArcelorMittal and Mandrekas industries) were analysed. As conclusion, the design is able to reach the yearly energy KPI in both case studies as well as the daily energy KPI more than 30 days per year.

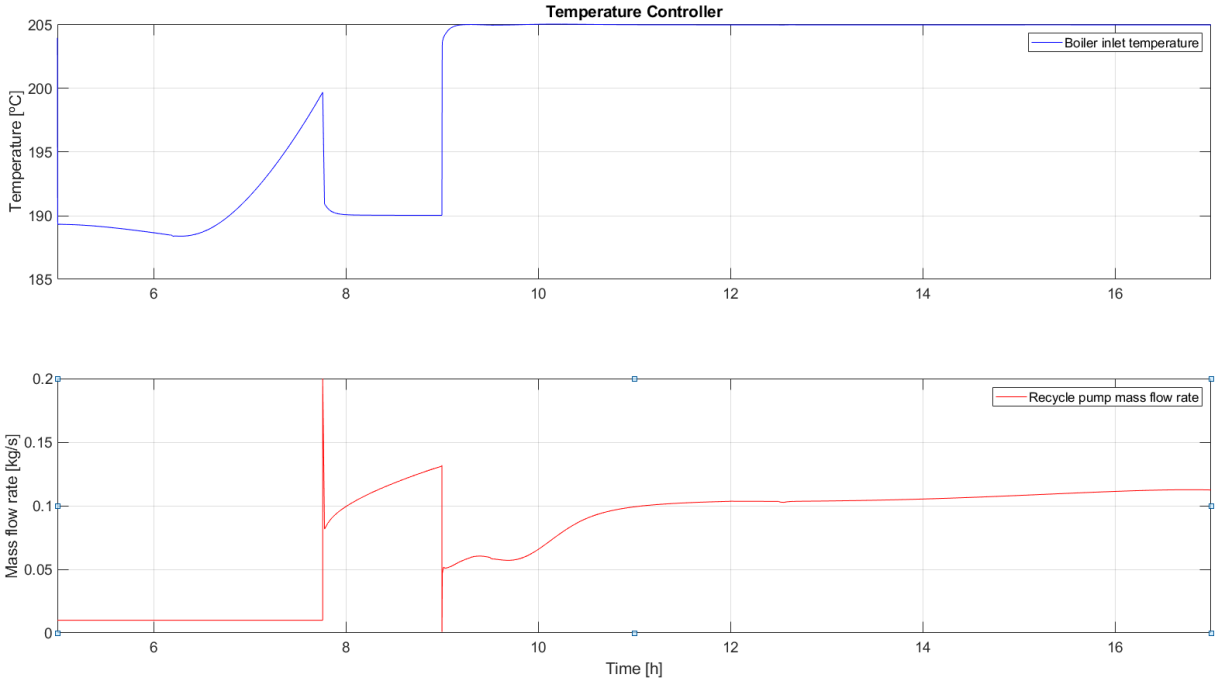



To complete these reference cases, some sensitivity analyses are performed, considering different thermal loads at the industry side, both for the heating and cooling demands, and varying the number of accumulators inside the thermal energy storage system.

Finally, the steady-state simulator also allowed the analysis of the ASTEP concept at different working temperatures and at different sites to provide information about its possible performance within industries different from the end-user cases.

Besides, the dynamic model was used to analyse the response of the control system in the different transient conditions during some representative days, and to assess the defined operation modes. The results show that the control system is able to guarantee a correct operation of the system, particularly ensuring the established set points for the temperatures and mass flow rates in the different operation modes.




The model shows the success of the serial configuration since it allows a simple control of the system with a simplified layout and without performance decrease.

***Contributors:***

UPM and UNED teams.