Solar Polygeneration Collector for Combined Heat, Power, Hydrogen Fuel and Wastewater Treatment

SPECTRUM

Final design of SPECTRUM's thermal absorber

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Public Executive Summary

The SPECTRUM project aims to develop innovative solar concentrating collectors that simultaneously generate heat, electricity, and hydrogen while performing industrial wastewater (IWW) remediation. Conceptually aiming to use ultraviolet (UV) light for photocatalytic H_2 production with pollutant degradation, infrared (IR) for thermal energy generation, and visible and near infrared (VIS-NIR) light for photovoltaic (PV) production of electricity, these collectors aim to achieve higher overall solar conversion efficiency.

This report focuses on the development of the design of the thermal sub-system of the collectors, summarizing the modelling and simulation activities carried out within Task 2.2 – Thermal design and optimization, and presenting their main conclusions.

The methodologies for thermal analysis of both configurations are discussed in detail, and key results including thermal efficiency, temperature profiles, estimations of electric efficiency are presented. Modelling approach for both systems is multi-layer, ranging from simplified models to full high-fidelity conjugate simulations.

For the low temperature collector, the chosen design balances between different requirements, including thermal and electrical efficiency, operating temperature, and significant irradiation of the photoreactor layer. It achieves a thermal efficiency of >27% for the thermal absorber, and >16% for the spectral filter (photoreactor layer), with outlet temperatures above 100ºC and 60ºC, respectively.

The selected thermal receiver for the high temperature collector corresponds to a conventional evacuated receiver tube used for parabolic trough collectors with a 34 mm diameter thermal absorber. The relative position of the primary concentrator / thermal receiver / spectral splitter and the shape of the spectral splitter was studied using ray-tracing simulation and 1D thermal simulation and a solution that maximizes thermal efficiency while keeping the irradiance at the photoreactor within acceptable thresholds was selected. This solution achieves a thermal efficiency of 40% for a thermal output of 1 400 W at 200 ºC.

It should be noted that these might not be the final designs for the thermal sub-system of SPECTRUM-LT and SPECTRUM-HT collectors, as modifications may be required due to the results of the activities being carried out related with the optimization of the optical design (Task 2.1) and the integration of remaining sub-systems, namely the photoreactor, within the collector (Task 2.4).

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