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



Final design of SPECTRUM's PV sub-system

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Public Executive Summary

The SPECTRUM project aims to develop two prototype polygenerating solar collectors that splits the solar spectrum and converts it into heat, electricity, and hydrogen while providing wastewater remediation. This report covers task 2.3: the design of the photovoltaic component for the two prototypes, SPECTRUM-LT and SPECTRUM-HT. The two systems operate in different temperature ranges and impose very different boundary conditions on the PV module, so each was designed separately.

The design work rested on two simulation levels. At cell level, Quokka3 was used to study how the uneven irradiation inside the collectors affects silicon solar cells. At module level, SmartCalc.CTM was used to estimate cell-to-module losses and predict output power for two competing interconnection schemes: conventional ribbon interconnection and shingling with electrically conductive adhesive.

The cell-level study yielded valuable insights for the project. In the LT absorber, where inhomogeneous irradiation is anticipated, the series resistance of a PERC cell increases from 253 to 444 mΩ·cm², but the output power density falls only from 26.26 to 26.19 mW/cm². Lateral diffusion of charge carriers evens out most of the local variation. The effect is second order and does not drive the design.

For the LT collector, the available width of roughly 160 mm forces a single series string along the 2.3 m length. A monofacial p-type PERC cell was chosen mainly for its low cost and manufacturing maturity, rather than maximum efficiency. When comparing the two interconnection methods on this footprint, the ribbon design produces 59 W at 25 °C and 47 W at 100 °C. In contrast, the shingled design with 73 strips measuring 150 mm by 32 mm achieves 74 W at 25 °C and 59 W at 100 °C. The approximately 25% increase in power is primarily due to the removal of the 3 mm inter-cell gap required by the ribbon interconnection.

For the HT collector, the PV layer is decoupled from the other energy vectors and can receive light on both sides, about 1000 W/m² at the front and 100 W/m² at the rear. A bifacial silicon heterojunction cell was chosen for its high bifaciality and low temperature coefficient. On a 350 mm by 2000 mm area, a matrix-shingled layout with alternating 210 mm × 26 mm and 105 mm × 26 mm cells across 76 rows provides 166 W at 25 °C and 132 W at 100 °C, compared to 153 W and 122 W for the half-cell ribbon alternative.

Shingled interconnection is advantageous in both configurations, primarily because it transforms interconnection gaps into photoactive areas. The electrical layouts and performance data presented here serve as the basis for the mechanical and thermal integration detailed in D2.4 report.

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