Validation of a Novel Square Receiver with Low-Cost Reflector

Wout Gubbels[1], Dennis Kok[1], Stan Uijttewaal[1], Henk Arntz[1], Margarita Rodriguez Garcia[2], David Argüelles Arizcun[2]

[1] Suncom Energy. Address: Atoomweg 9 (ESI), 3542 AA, Utrecht, The Netherlands

[2] Plataforma Solar de Almería, Tabernas, Spain

Summary

- Suncom is a startup which focusses on developing micro-CSP (<5 MWe) plants for Small and Medium Enterprises (SME's) as well as the Commercial & Industrial market.
- Suncom has developed a novel square receiver (patent granted) to increase the efficiency of a small reflector/receiver combination.
- The focus is on minimizing the LCOE/LCOH of parabolic through collectors.
- This concept has been successfully tested at the Suncom headquarters as well as the Plataforma Solar de Almería (PSA) in the summer of 2022 and have shown very promising results on both heat losses as well as optical efficiency.

Introduction

- Cost savings in Concentrated Solar Power (CSP) have focused on increasing economies of scale.
- These larger installations have the downside of very high CAPEX, long I&C and high project complexity.
- In addition, electricity grids are having congestion problems, increasing the need for decentralized solutions.
- Both problems can be tackled by downscaling instead of upscaling plant size.
- When downscaling the Solar Field (SF), and with it the reflectors and receivers, challenges arise
- Suncom Energy is developing a small-scale (<5 MWe) and low cost CSP concept to tackle these challenges.
- The biggest challenge when downscaling the SF is the reduced hydraulic diameter of the Heat Collector Elements (HCE), increasing the pressure drop over the HCE.
- Suncom Energy has tackled this challenge by switching from a round receiver to a square receiver (patent granted), decoupling the hydraulic diameter from the focal spot of the reflector.
- In addition, this also increases the concentration ratio of the reflector, reducing the focal spot size and thus also the required coated area of the receiver. [1]
- At high temperatures radiation is the dominant heat loss in the HCE, meaning reducing the coated area greatly reduces heat losses.
- Suncom Energy has focused the developments on Levelized Cost of Electricity/Heat (LCOE/H), rather than SF efficiency.
- This concept is tested and validated at the Plataforma Solar de Almería (PSA) at the Molten Salt (MOSA) facility under a SFERA3 project in the Summer of 2022.

Experimental setup

Heat losses

- To validate the reduced heat losses of Suncom's HCE, an electrical test setup has been built, which can be seen in Figure 1.
- In this setup, a PID controller sets the temperature, and the electrical energy needed to maintain this temperature is measured.
- Various configurations of the HCE have been tested in the range of 0 – 550 °C.
- Conduction losses have been minimized by insulation of the connection points of the HCE.
- The HCE was under vacuum for all measurements.

Figure 1: Electrical heat loss test bench

Optical efficiency

- Current parabolic through collectors easily reach collector efficiencies of over 75% but are complex structures that are time-consuming and expensive to produce and install [2].
- The relatively small collector of Suncom Energy has been optimized for LCOE/LCOH rather than system efficiency.
- The efficiency of the third iteration of this collector has been verified at Technology Readiness Level (TRL) 6 at the PSA, as can be seen in figure 2
- Experiments were performed using water at ambient temperature as a Heat Transfer Fluid (HTF).

Figure 2: Two modules being tested at the PSA

- By integrating accurate weather data of the PSA into the data analysis, a high accuracy measurement of the optical efficiency has been achieved.

Results

Heat losses

- Figure 3 shows the heat losses of the Suncom receiver in [W/m] compared to the large receivers ±3 times the size in aperture.
- The heat losses per meter are significantly lower but stand against a smaller aperture.
- The lower bill of material cost along with a lower I&C cost due to the smaller scale improve the LCOE greatly.

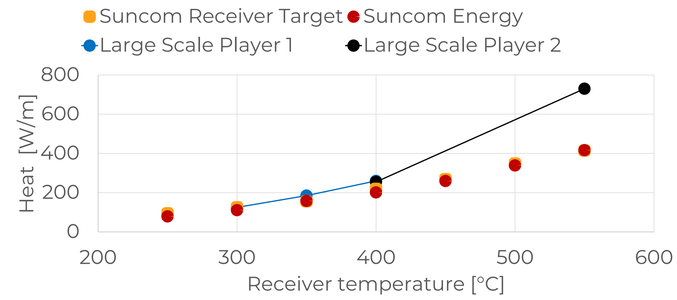

Figure 3: Suncom heat losses versus competition

Optical efficiency

- The testing of the prototype at PSA has revealed the peak optical efficiency during solar noon.
- The optical efficiency is defined as: clean mirror reflectance * annulus glass transmissivity * receiver absorptivity * mechanical efficiency
  82% * 87.42% * 94.5% * 78% = **53%**
- In the fall of 2022, a few easy to implement improvements will be done, such as: using glass mirrors instead of aluminum mirrors and improving the collector frame stiffness
- Using glass instead of aluminum increases the mirror reflectance from 82% to 94.5% whilst reducing negative thermal expansion effects causing mirror deformation, thus increasing the mechanical efficiency.
- Improvements the collector frame is estimated to increase the mechanical efficiency from 78% to 90%.
- This results in the following estimated optical efficiency calculation:
- 94.5% * 87.42% * 94.5% * 90% = **70%**

Net heat output

- Figure 4 shows the net heat output of the Suncom receiver reflector combination in [W/m] at 850 DNI.
- Currently the net heat output is not high enough.
- After the improvements stated in the previous section, the Suncom target for 2023 can be reached.
- This net heat output is sufficient to provide a competitive LCOE/LCOH in many cases, even in Europe.

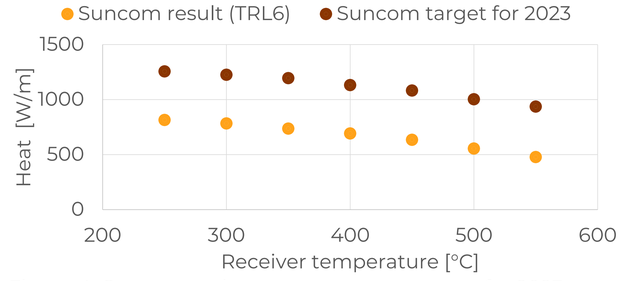

Figure 4: Current net heat output versus target for 2023

Acknowledgements

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Wout Gubbels
Technical Director, Suncom Energy
w.gubbels@suncom-energy.com