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A Flexible Solar Thermal Platform for Deployable Thermal Energy Generation

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INTRODUCTION & AIM

Solar thermal technologies provide one of the most direct pathways for converting solar energy into usable heat. Despite significant progress, many existing systems remain constrained by structural complexity, deployment limitations, and the challenge of simultaneously achieving high absorption, thermal effectiveness, and operational robustness. These limitations restrict broader adoption across distributed thermal energy applications where scalable and deployable heat generation is required.

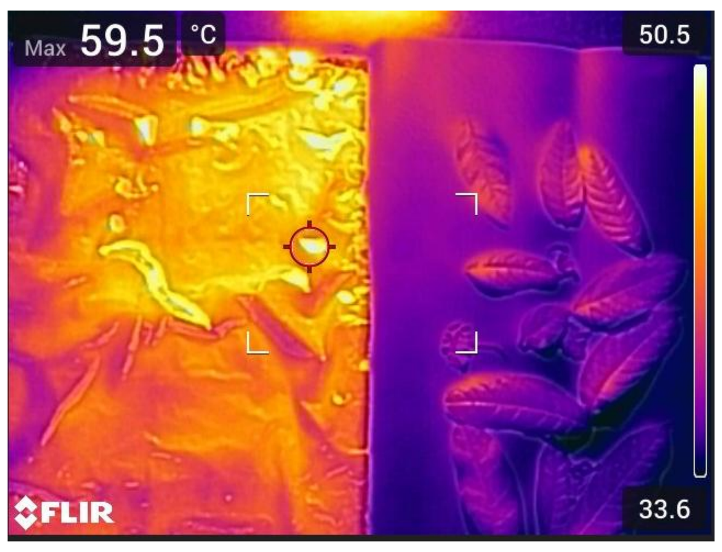
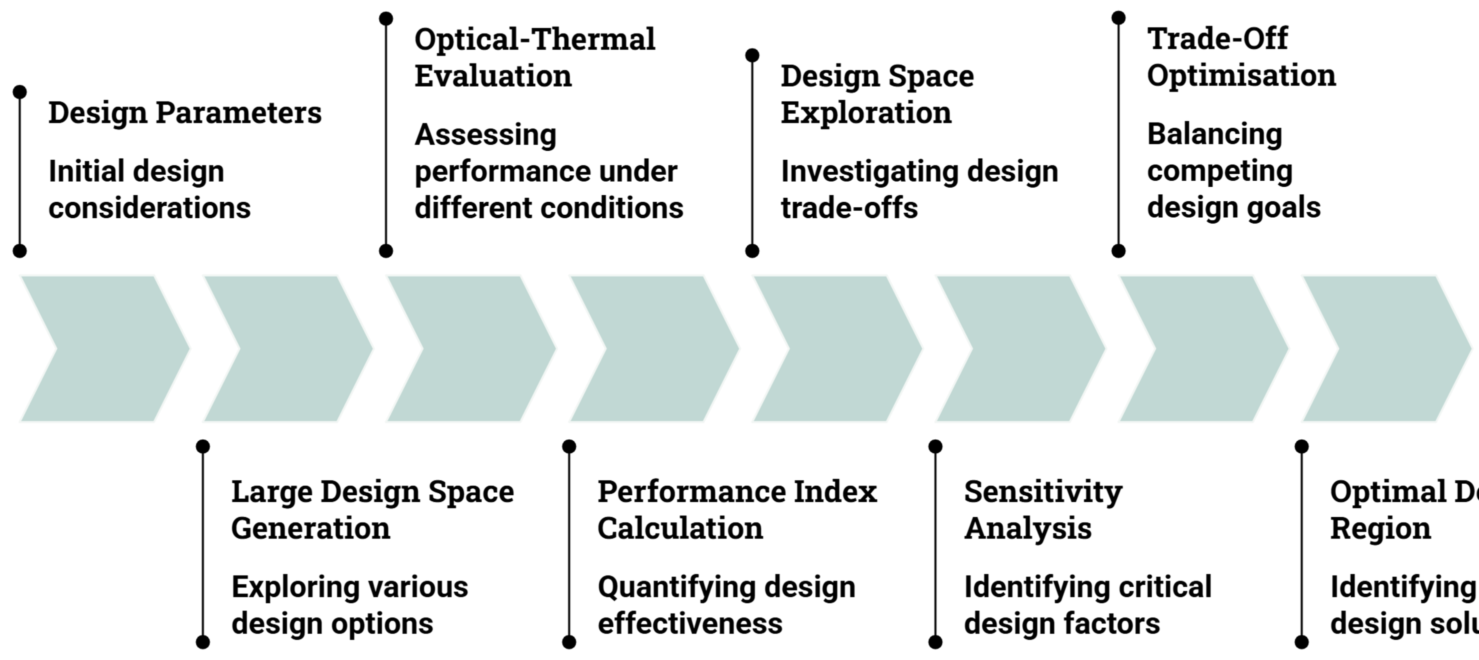


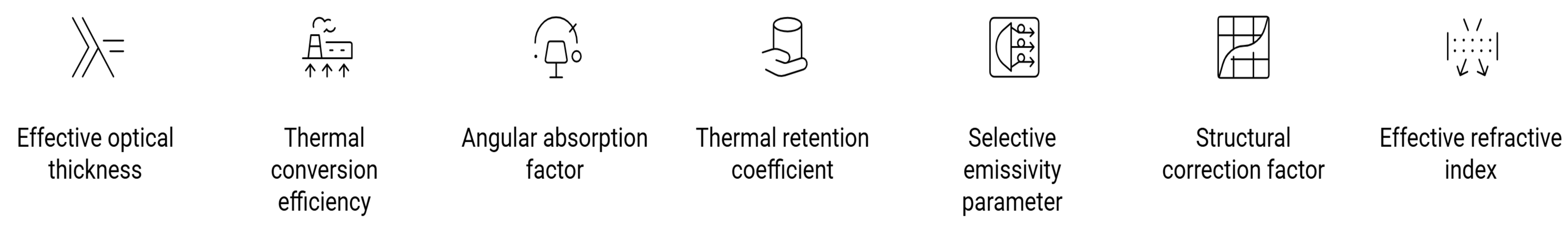
Figure 1. Experimental Thermal Validation

This work presents a flexible solar thermal platform for deployable thermal energy generation. The aim is to investigate the governing parameters influencing thermal performance, identify high-performance operating regimes, and establish a physics-guided pathway for the development of next-generation solar thermal technologies. Experimental thermal characterization is further performed to evaluate practical heat generation capability.

METHOD



Design Variables



RESULTS & DISCUSSION

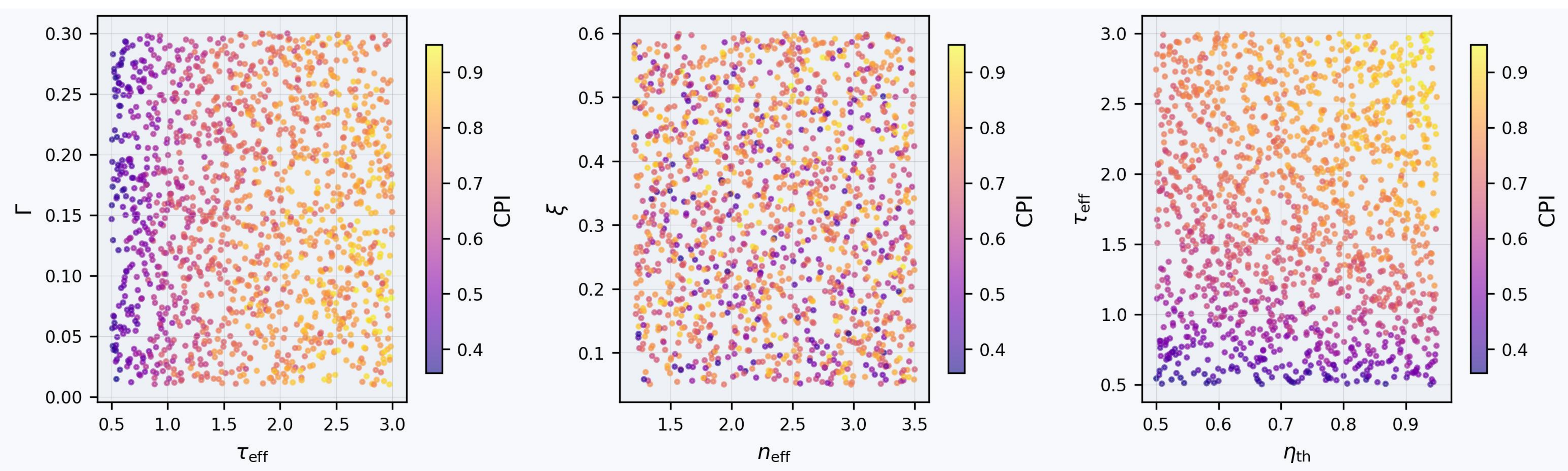


Figure 2 .Electromagnetic Design Space Exploration

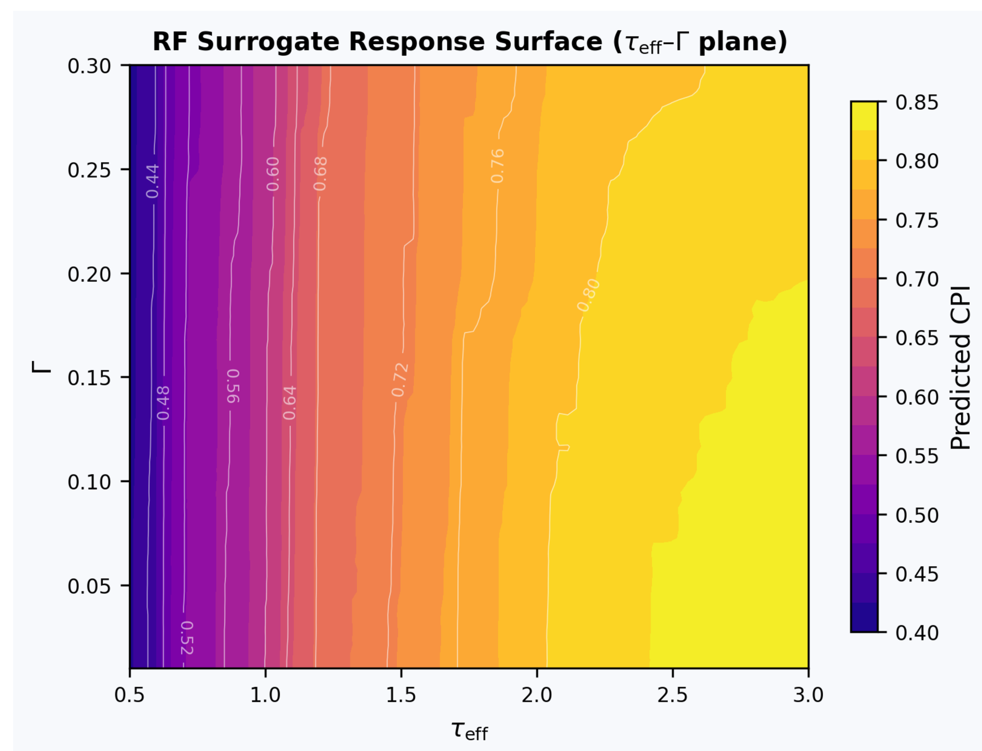


Figure 4 Thermal Performance Landscape

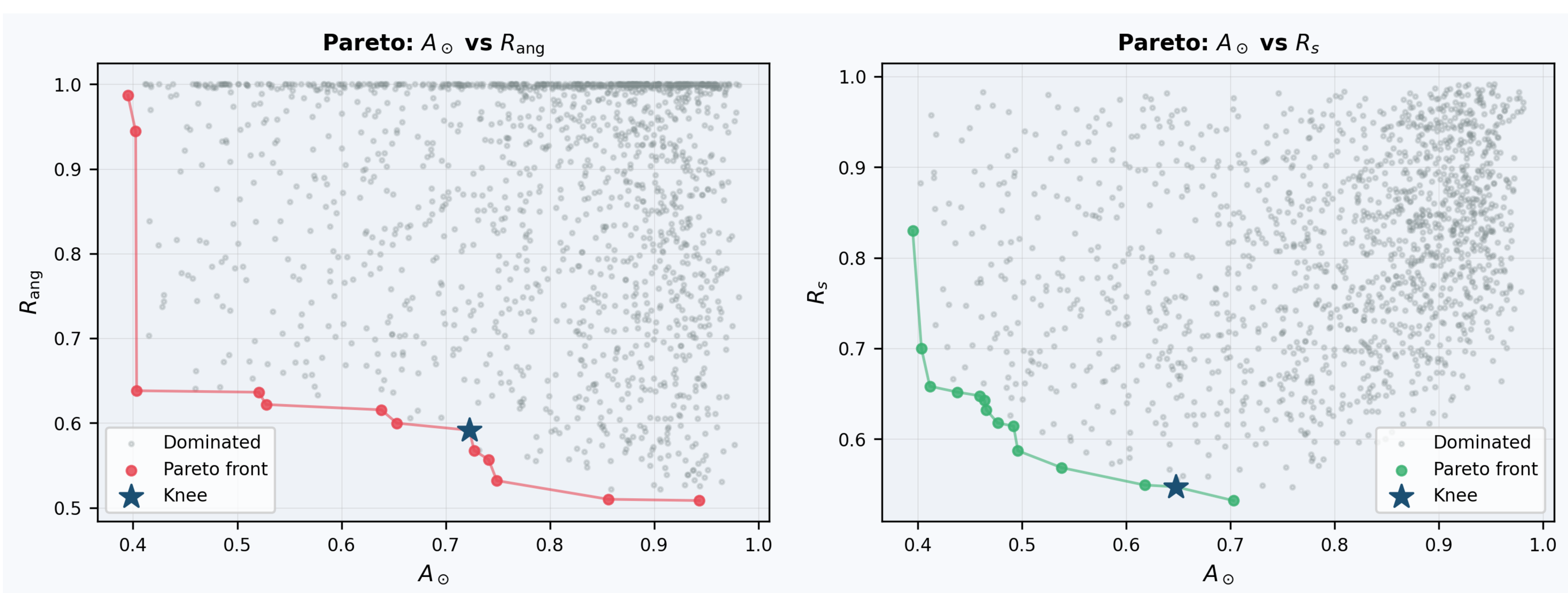


Figure 3. Optimal Operating Regions for Deployable Thermal Generation

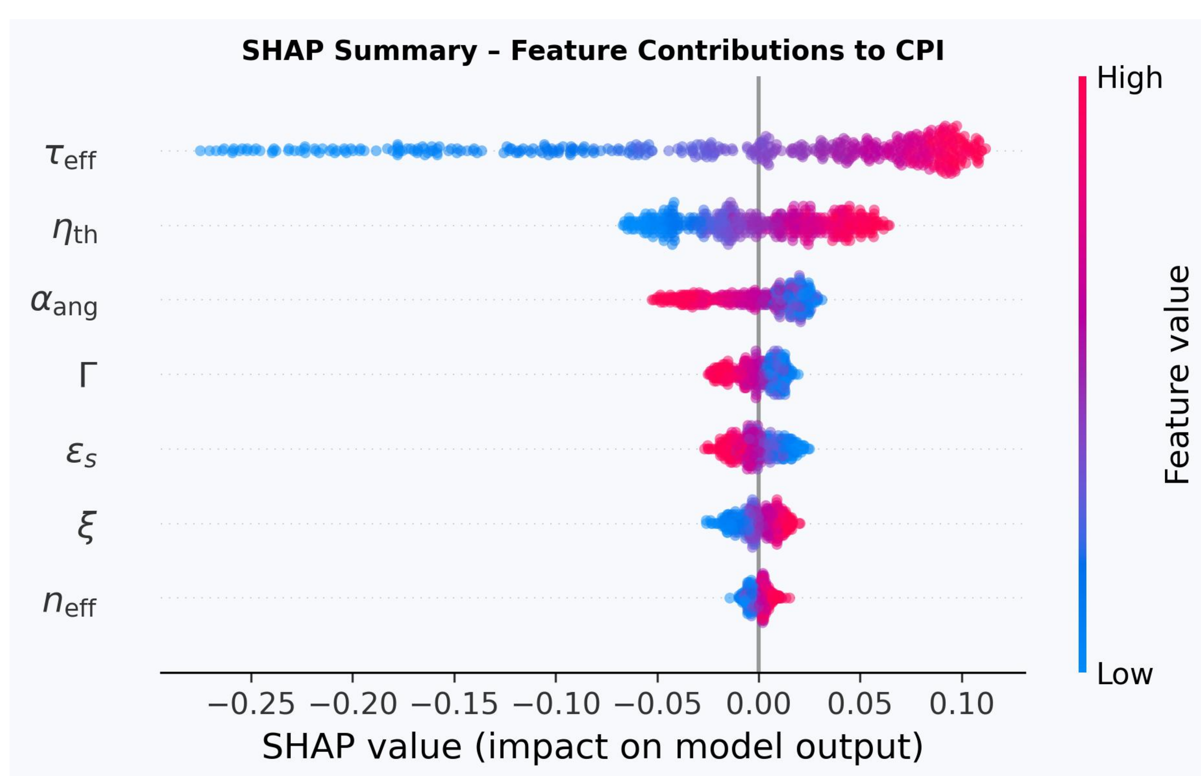
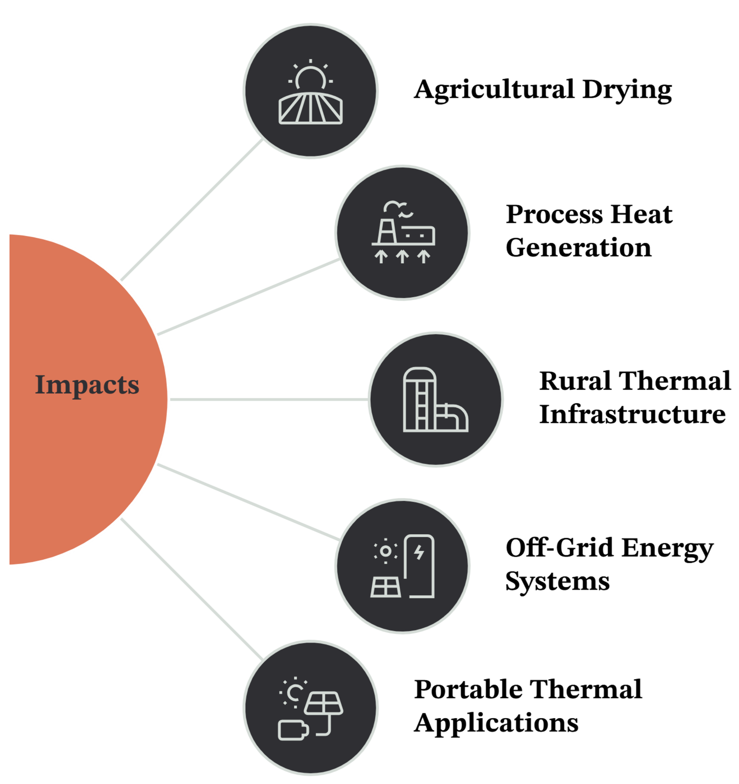


Figure 5. Global Parameter Contribution Analysis

Design-space exploration revealed multiple high-performance operating regions capable of sustaining enhanced thermal performance (Figure 1). The thermal performance landscape demonstrated that favorable operation is concentrated within specific regions of the design space, highlighting the importance of coordinated parameter selection (Figure 2).
Multi-objective optimisation identified balanced operating regions capable of simultaneously maintaining performance and robustness, providing practical targets for deployment (Figure 3). Analysis of governing design variables revealed effective optical thickness as the dominant parameter influencing collector performance, followed by thermal conversion efficiency and angular response characteristics (Figure 4).
Experimental infrared thermography confirmed localized heat generation and elevated operating temperatures under solar exposure (Figure 5), validating the computationally identified high-performance operating regions and demonstrating effective solar-to-thermal energy conversion.

CONCLUSIONS

The proposed solar thermal platform demonstrated effective thermal energy generation through a combination of design-space exploration, performance optimisation, and experimental validation. High-performance operating regions were identified, key governing parameters were established, and infrared thermography confirmed practical solar-to-thermal conversion. The results highlight the potential of deployable solar thermal technologies for future distributed heat applications.



FUTURE WORK/ REFERENCES/ACKNOWLEDGMENT

Future work will focus on prototype scale-up, outdoor performance validation, and application-specific deployment studies to further evaluate the platform under practical operating conditions.
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