Double-Reflector Hybrid Concentrated Solar Energy System

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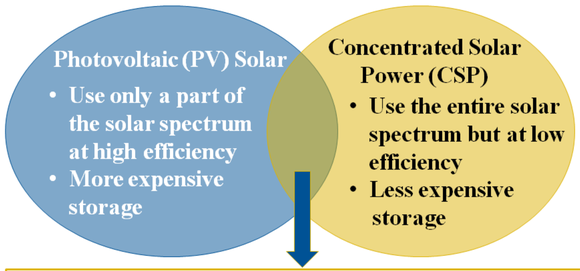
Abstract

The project team of University of California at Merced (UC-M), Gas Technology Institute, and Dr. Eli Yablonovitch of University of California at Berkeley developed a novel double stage hybrid concentrated solar photovoltaic thermal (PV/T) collector using nonimaging optics (NIO) and world record single-junction gallium arsenide (GaAs) PV components integrated with particle laden gas as thermal transfer and storage media, to simultaneously generate electricity, high temperature (up to 500°C) dispatchable heat, and low temperature (200°C) thermal.

Current State of Art & Research Objective

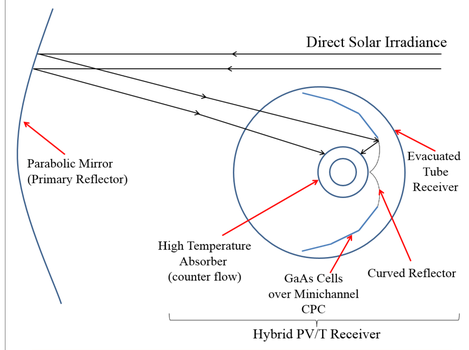
Challenges of the two primary methods for capturing and using sunlight today:



The objective is to develop a hybrid solar energy system that combines the best elements of these two technologies

System Design & Principal of Operation

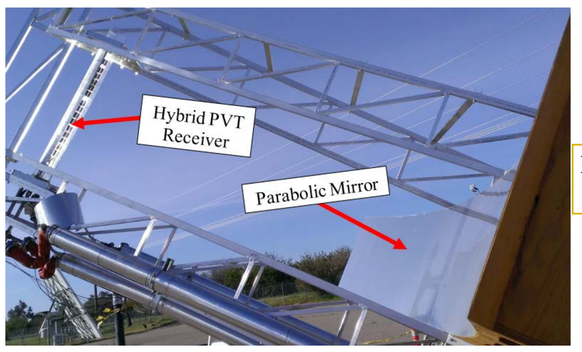
- Using compound parabolic concentrator (CPC), the design transforms a parabolic trough collector into a spectrum-sensitive topping element (GaAs solar cells) on PV/T receiver.
- Light that strikes the GaAs cells is spectrally split based on the 870 nm bandgap cutoff, with about 90% of wavelengths below the bandgap being absorbed and converted to electricity or heat, and about 92% of the wavelengths above the bandgap being reflected towards the high temperature absorber.
- Produces electricity directly and low grade heat is generated by actively cooling the cells via the minichannel substrate.
- The particles are used to store the heat for use immediately or at a later time to drive a turbine and produce electricity.



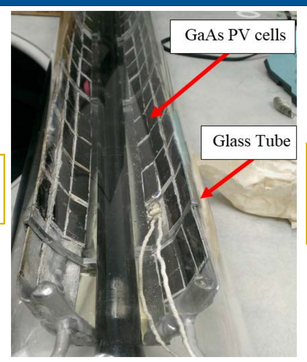
Hybrid PV/T Collector Schematic

Prototype

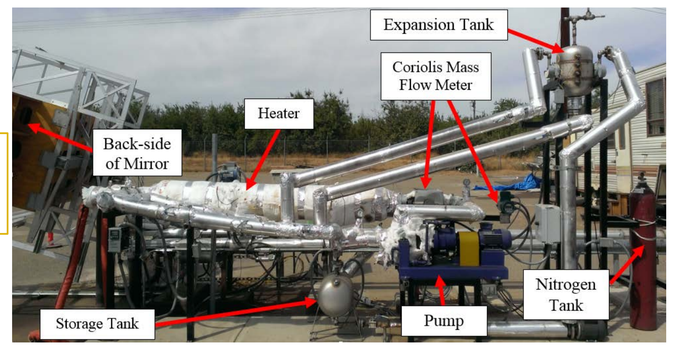
Main Components

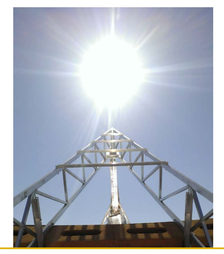


Hybrid PV/T Receiver



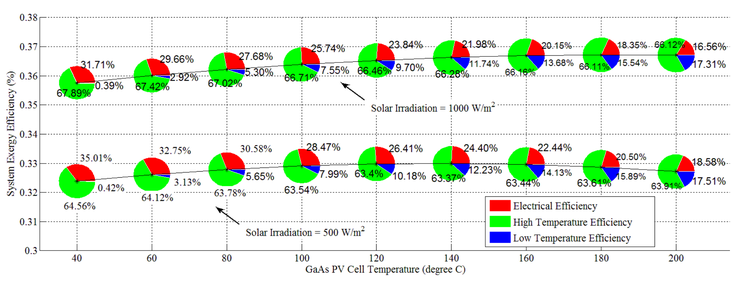
High Temperature Loop



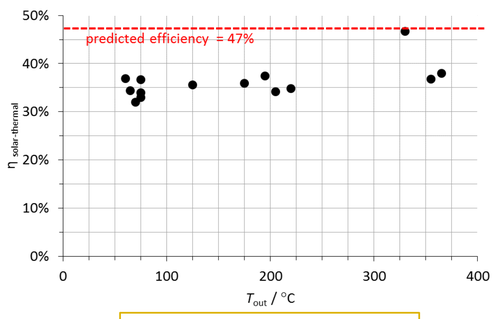


System in Operation at University of California Merced's Castle Research Center

Results



System Exergy Efficiency Breakdown by Components



Solar Thermal Efficiency

Conclusions

The new hybrid solar collector is capable of producing electricity directly at a competitive cost together with high temperature thermal to be stored for evening electricity production and has the potential to significantly upgrade the exergy value of the parabolic troughs plants.

Acknowledgements

The development of this project was supported under grant ARPA-E DE-AR0000464 awarded by the US Department of Energy. Many UC Merced students and staff helped with this project. Contact Information: Prof. Roland Winston (rwinston@ucmerced.edu)