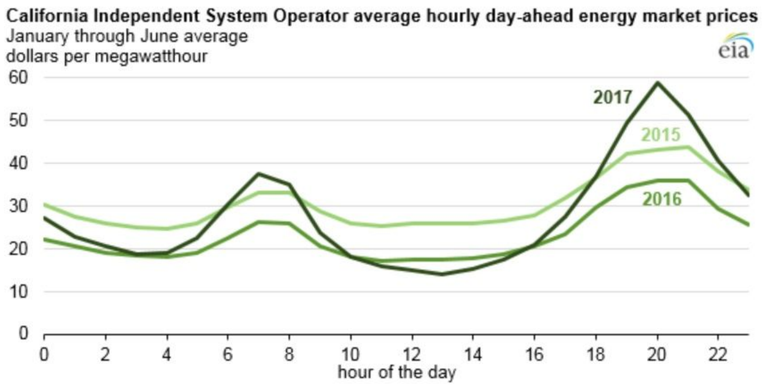
# Two-Stage High Concentration Hybrid SBS CPV/CSP Collector

Widyolar, Bennett K., et al. "Design, simulation and experimental characterization of a novel parabolic trough hybrid solar photovoltaic/thermal (PV/T) collector." *Renewable Energy* (2017)

## 1. Motivation

- Increased penetration of *variable* renewables (PV, wind) without an economic means of storage has a destabilizing effect on the grid (curtailment of power, "Duck Curve") and reduces the value of additional future variable generation.

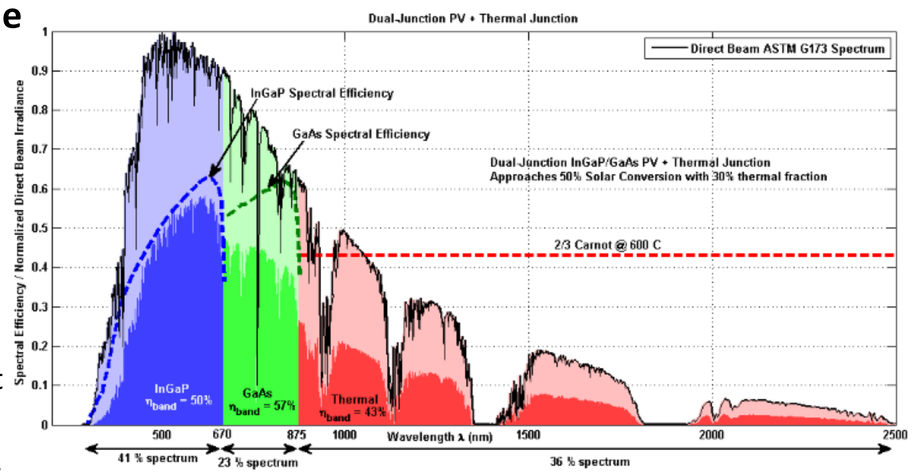



Thermal Energy Storage (**TES**) provides a cheap storage solution for *dispatchable* power when combined with a Concentrating Solar Power (**CSP**) system, but the cost of current CSP systems is a barrier to deployment.

- By combining cheap, high efficiency PV with lower efficiency and more expensive CSP in hybrid systems, a middle ground can be reached where CSP subsystems with TES can be deployed for less than standalone systems today.

## 2. Operating Principle

- PV semiconductor materials are highly efficient at converting incoming photons within a certain spectral band (near the bandgap) into electricity, but convert photons outside this band mostly into heat.

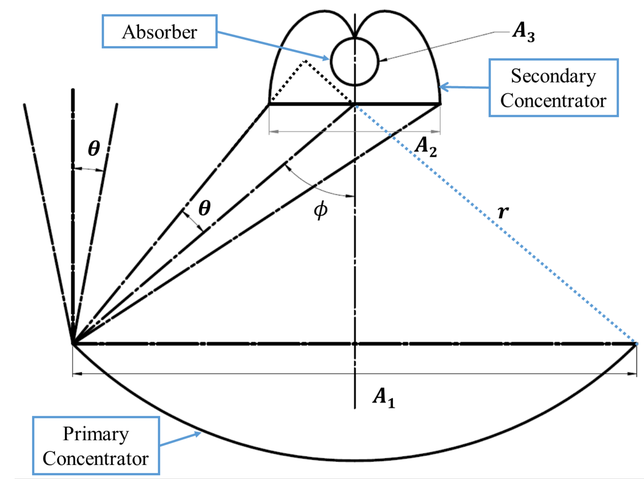


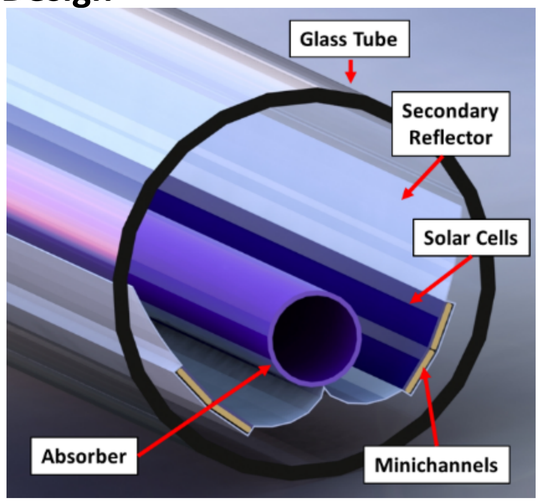

- CSP systems are wavelength independent but require high temperatures to generate useful Carnot conversion efficiencies.

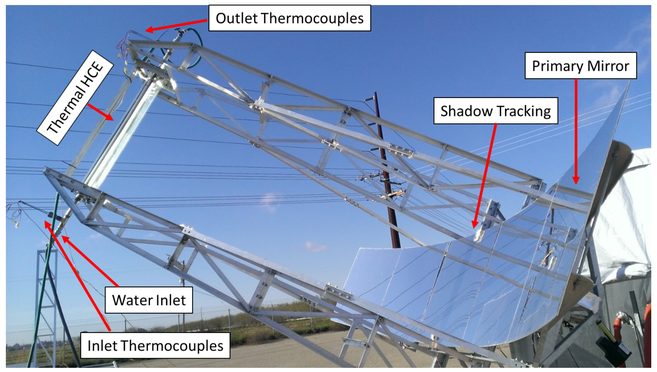
$$\eta_{Carnot} = 1 - T_C / T_H$$

- By directing UV/VIS toward a CPV system and the remainder towards a CSP subsystem using a technique known as *Spectral Beam Splitting* (**SBS**), the CPV and CSP subcomponents can be thermally isolated and operated independently at their respective temperatures for maximum conversion. The plot above approaches 50% conversion of the solar spectrum!

## 3. Two-Stage Parabolic Trough Collector Design

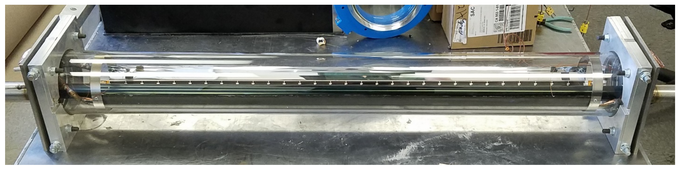


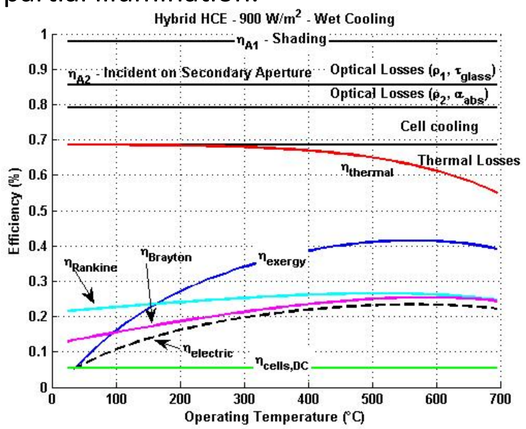




Light from primary reaches secondary aperture at 45X concentration. Dual Junction InGaP/GaAs back-reflecting beam splitter generates electricity and provides additional 1.1X concentration for sub-bandgap photons. Design achieves **50X** concentration (compared to 23X for today's trough) enables high temperature operation (650 °C) under partial illumination.

To date we have tested up to **500 °C** using a particulate-based heat transfer fluid (HTF), with a target final experimental test temperature of **650 °C**. We have also developed and are testing a non-hybrid version of the collector for pure CSP or industrial process heat (**IPH**).







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