Two-Stage High Concentration Hybrid SBS CPV/CSP Collector

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, the “Duck” curve) and reduces the value of additional future variable generation.

Thermal Energy Storage (TES) provides a cost effective 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 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.
- 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 the primary mirror reaches the secondary aperture at 45X concentration. Dual Junction InGaP/GaAs back-reflecting solar cells generate electricity and provide an additional 1.1X concentration for sub-bandgap photons. The design achieves 50X concentration (compared to 23X for a conventional trough) which enables high temperature operation (650 °C), even under partial (spectral split) illumination.

4. Prototype Development

5. Experimental Performance

6. Project Outcomes
- A two-stage linear parabolic trough system demonstrated 50X geometric concentration, enabling high temperature operation of the CSP system.
- Back-reflecting solar cells implemented as spectrum splitting devices, thermally decoupling the CSP and CPV systems and maximizing exergy production.
- Solid particle heat transfer media operated through > 50 meters of pipe and flex hose, enabling high temperature operation of the CSP system.

Surpassed 400 °C oils, 580 °C molten salts, in the realm of tower temperatures with a linear system.

Exciting opportunity for high temperature IPH and CSP!

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