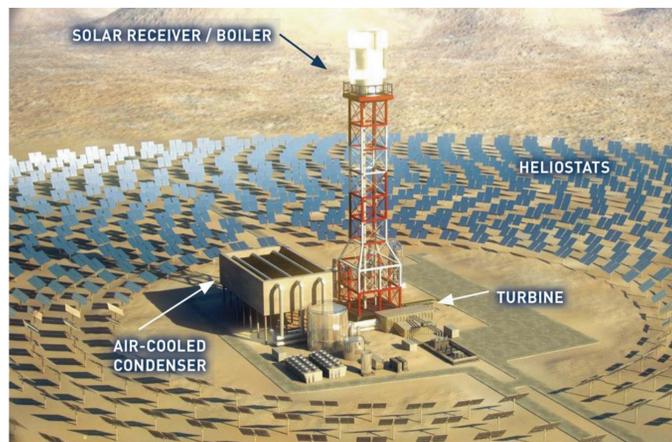


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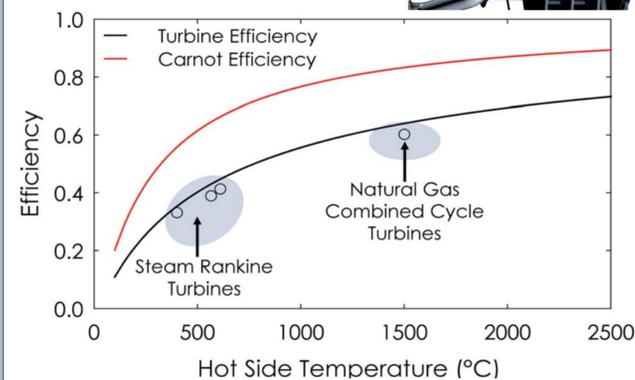
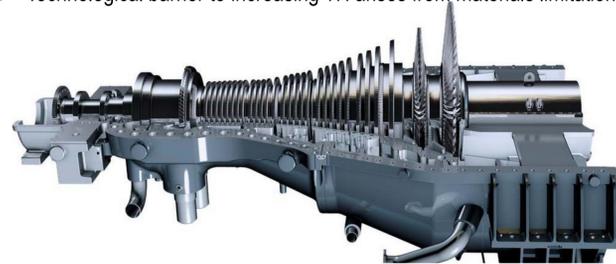
Concentrated Solar Power (CSP)

- Concentrated Solar Power (CSP) is an important solar technology that can provide dispatchable electricity 24/7 via built-in heat storage.
- The primary issue with CSP is its high Levelized Cost of Electricity (LCOE).
- Around 20-25% of LCOE is associated to cost of power cycle.
- One of the pathways to decrease LCOE is to reduce the cost to power ratio of power block.



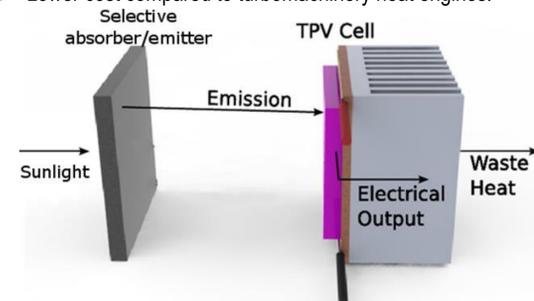
Turbomachinery Heat Engines

- Well-established industry with well-established cost.
- High cost → \$1/W-e (20-25% total cost of CSP).
- Moving part → high O&M cost.
- Improving the efficiency has limited prospects other than increasing the temperature.
- Technological barrier to increasing TH arises from materials limitations.

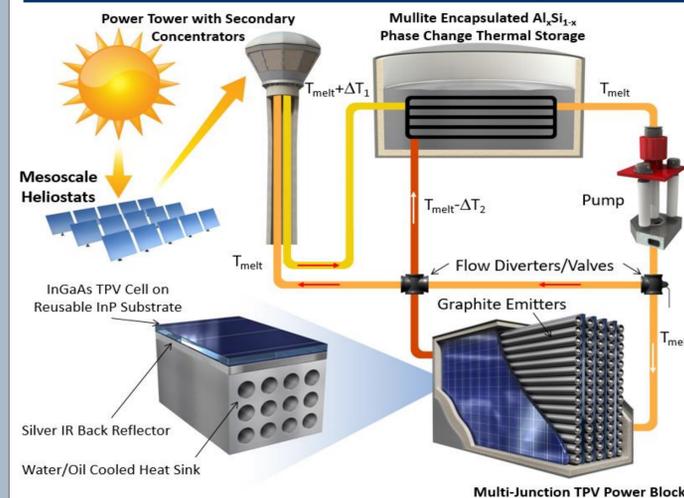


Concept of Thermophotovoltaic (TPV)

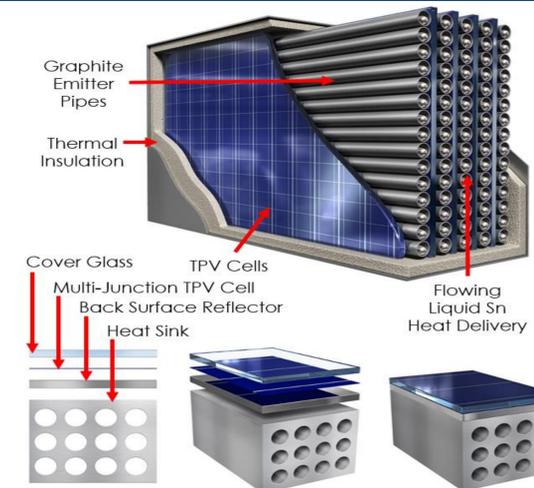
- Solid state energy conversion technology.
- Photon recycling of low energy photons.
- Constant temperature heat input → $\eta_{TPV} = \eta_{Carnot}$.
- Longer life time → lower maintenance cost.
- Lower cost compared to turbomachinery heat engines.



Concentrated Solar TPV with Thermal Energy Storage

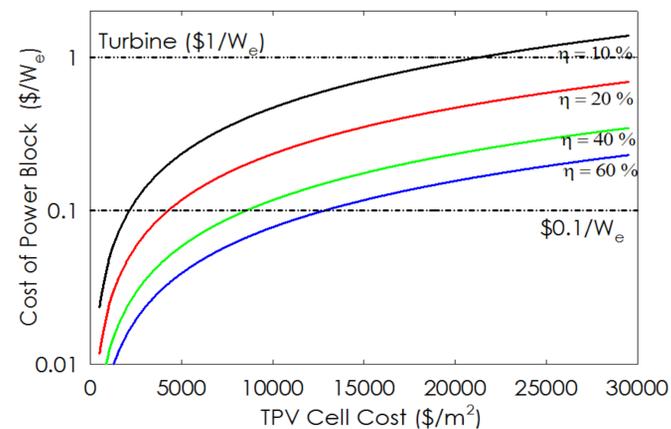


Multi-Junction TPV Power Block

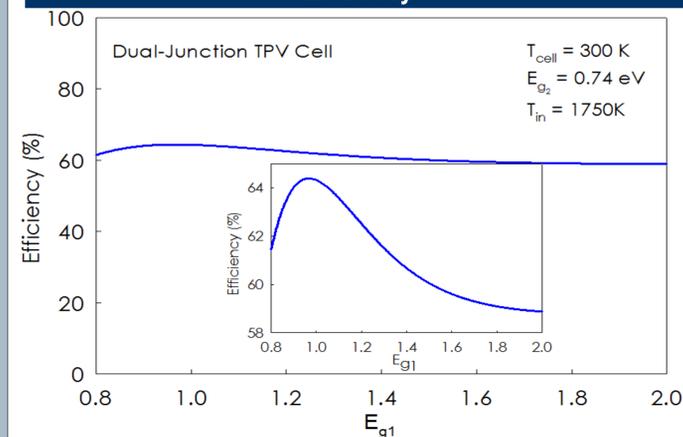


Cost Estimation

- Cost of graphite tubes, heat sink, and insulation is low compared to cost of cell.
- Cost of InGaAs cell on InP substrate is the major cost driver.
- If reusable substrate is used, the cost can potentially decrease significantly.
- To compete with Turbine, TPV must be > 50% efficient and cell cost reduced to < \$10000/m²



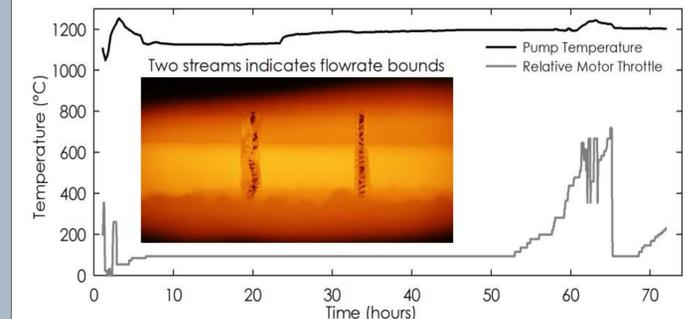
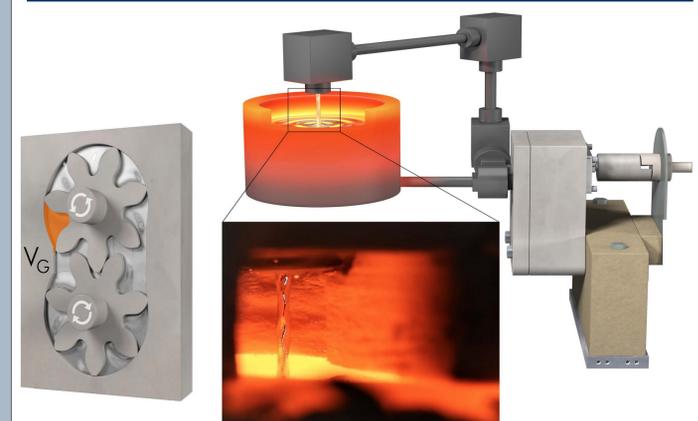
Efficiency



Fabrication of High Temperature Components



Pump Operation at high Temperature



Conclusions

- TPV has the potential to exceed the efficiency of the most efficient heat engine on the earth that has ever been achieved commercially, i.e., tandem/combined (Brayton + Rankine) turbine based cycle.
- Cost of turbines are well-established and unlikely to see significant decreases in the future, and their performance is limited by thermodynamics – which is fundamental.
- It is remarkable to consider TPV as an alternative power cycle for CSP or grid scale storage applications, particularly given its potential to cost 2-10X less than a turbine.

Publications

H.R.Seyf and A. Henry, (2016), "Thermophotovoltaics: a potential pathway to high efficiency concentrated solar power", *Energy and Environmental Science*, 9, 2654-2665.

Acknowledgment

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