Exploring the effect of cavity geometry in Thermophotovoltaics

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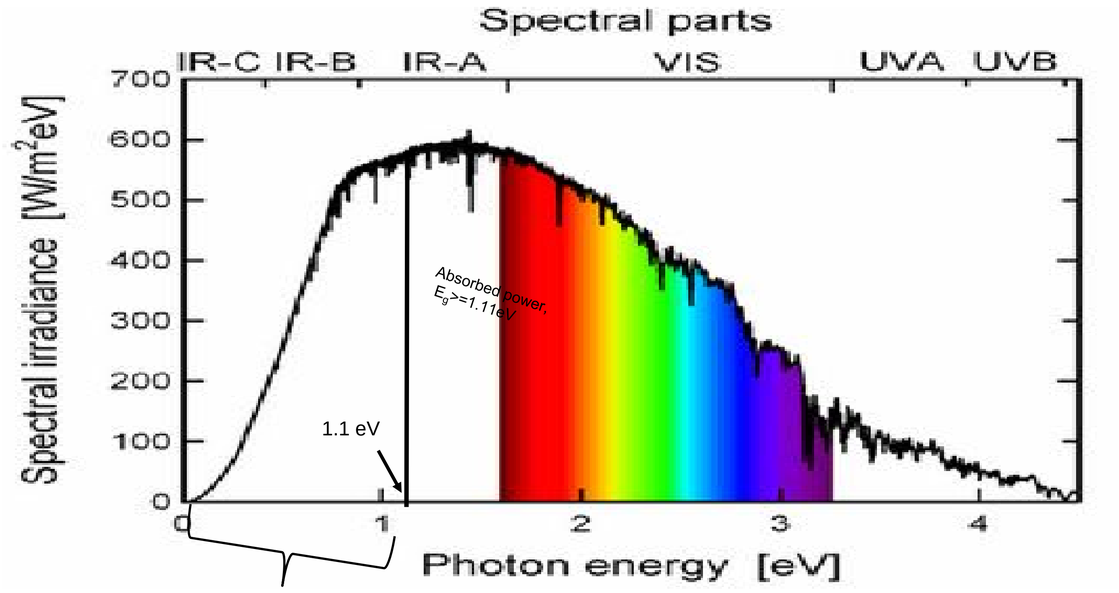
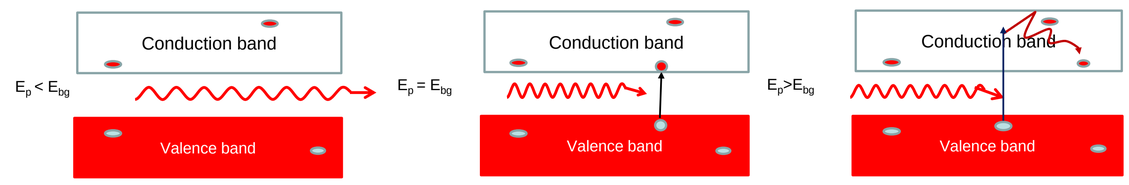
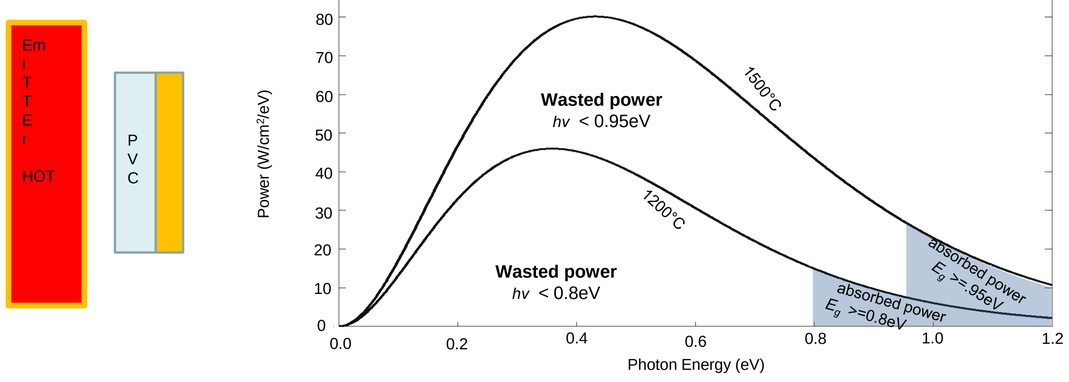
Abstract: The main goal of this work was to investigate the theoretically predicted high efficiencies of thermophotovoltaic (TPV) systems. The geometric arrangement of the emitter, the PV cells, and the rest of the cavity have a significant impact on the efficiency of the system. Ray tracing methods were used to build a computational model of photon flux in a 3D TPV cell cavity. Efficiency of TPV cell depended on the view factor of the cavity and how well the cell can reflect below bandgap radiation to be recycled. Efficiency levels around 50% were observed for uniform emitter at temperature off 1600 ^{0}C for a PV cell with 98% reflectivity. Future work will focus on exploring the expected increase in efficiency with Gaussian temperature distribution of emitter.

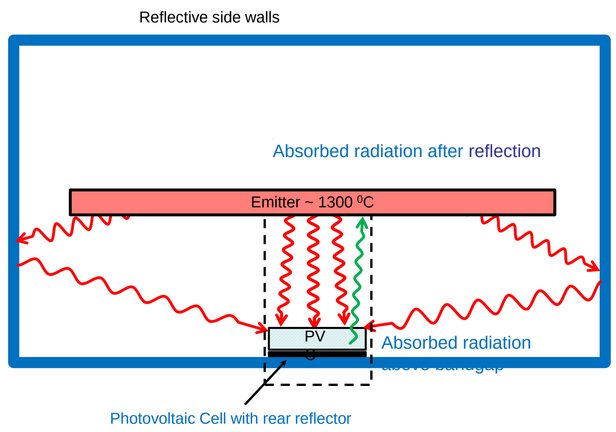
Solar Spectrum and PV Cell

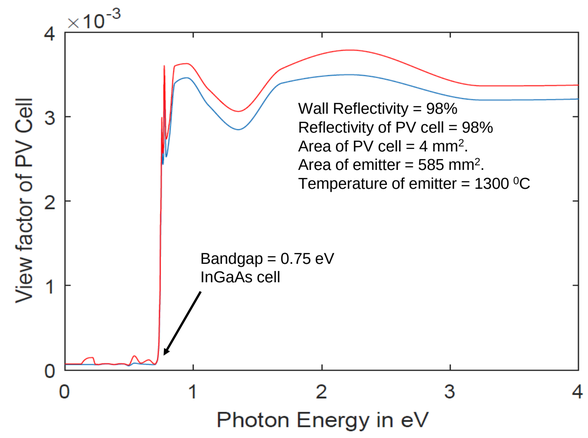




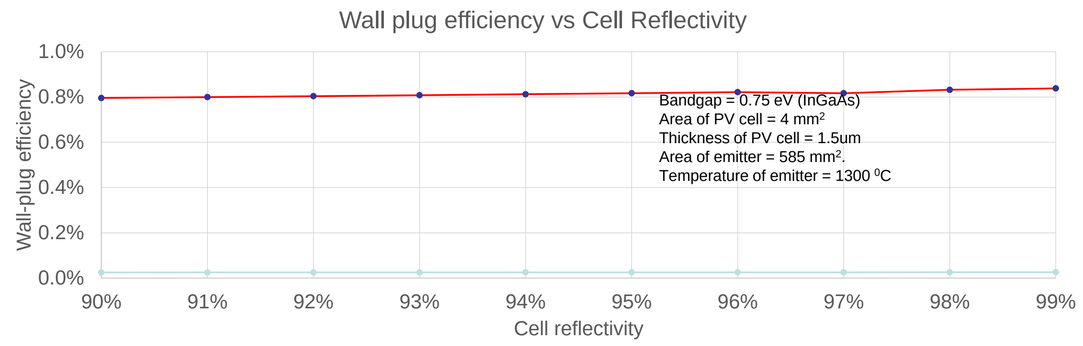
What is Thermophotovoltaics? (TPV)



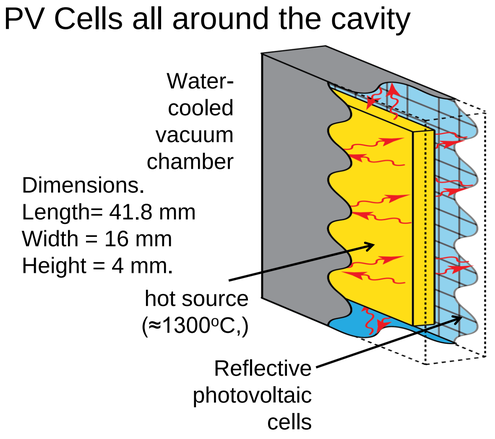


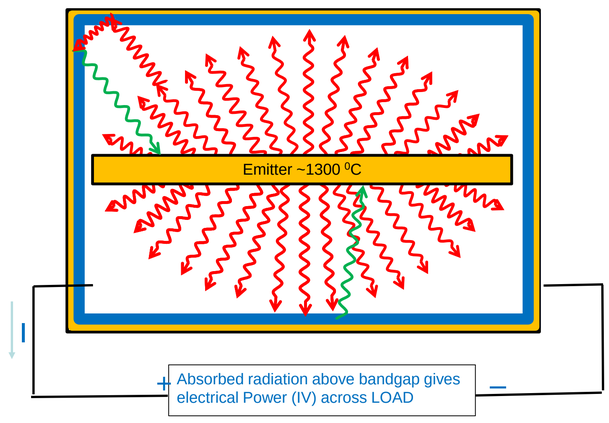


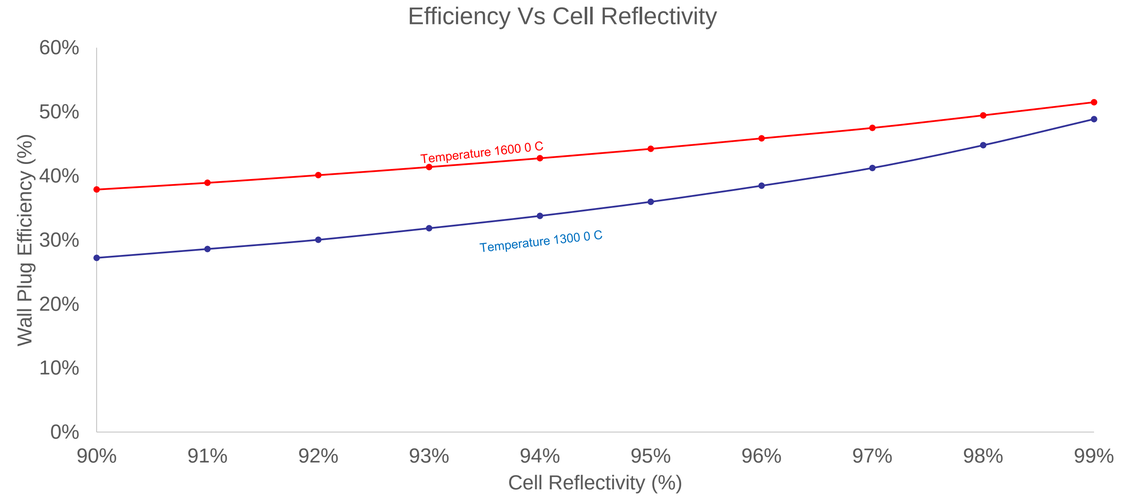
Results…



PV Cells all around the cavity

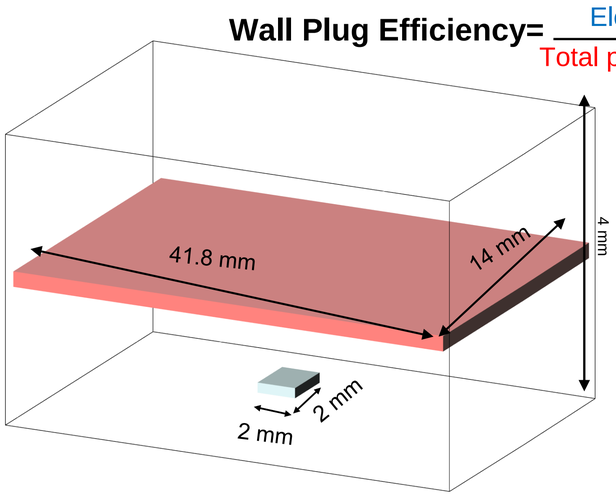


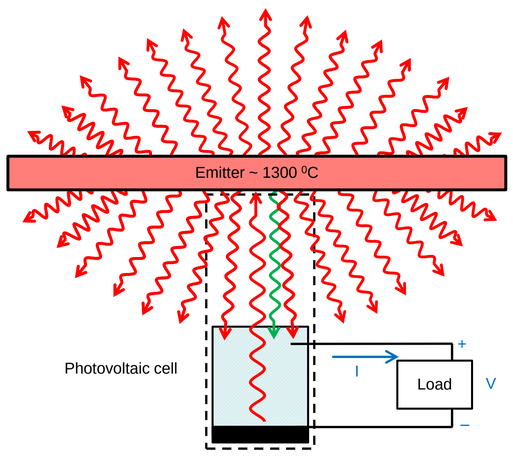




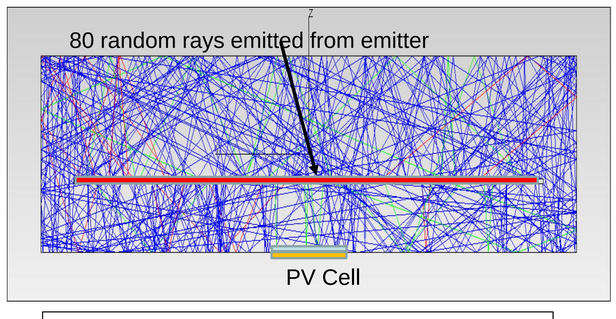
Method of Efficiency Calculation from TPV Cavity Geometry

Wall Plug Efficiency= $\dfrac{\text{Electrical power from PV cell}}{\text{Total power emitted} - \text{Recycled power}}$

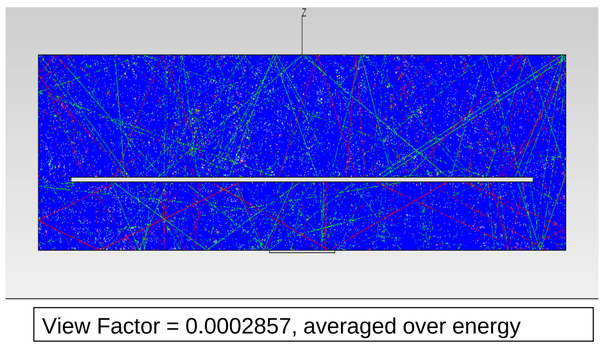




View Factor = $\dfrac{\text{Number of photon hit on the PV Cell}}{\text{Total number of rays emitted}}$



View Factor = 0.0006708, averaged over energy



View Factor = 0.0002857, averaged over energy

Conclusions:

1. **For a very small PV cell, The cavity effect does not significantly affect the wall plug efficiency. It is below 1%, in both cases, with reflective walls or no walls and almost independent of cell reflectivity.**
2. **Three-dimensional cavity analysis with 98% below-bandgap reflecting PV cells enclosing emitter will enable use of recycle power that makes very efficient Thermophotovoltaics (~50%).**

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2. © 2016 Lambda Research Corporation, TracePro Software
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