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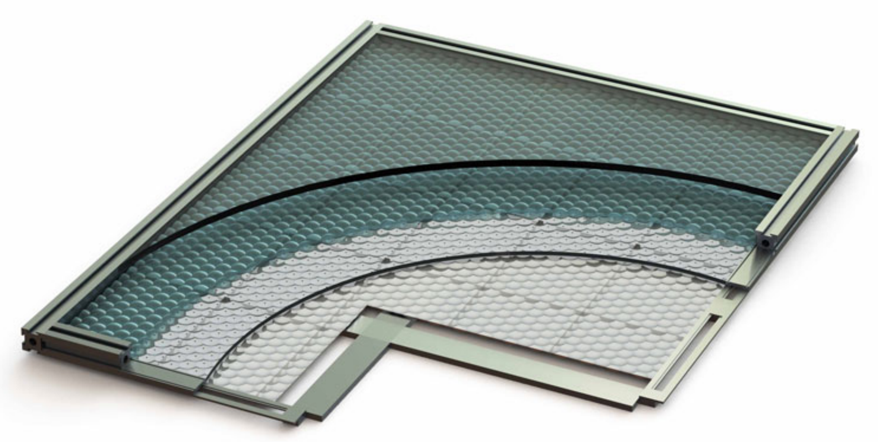
Modeling The Energy Yield Of Microtracking CPV Technology



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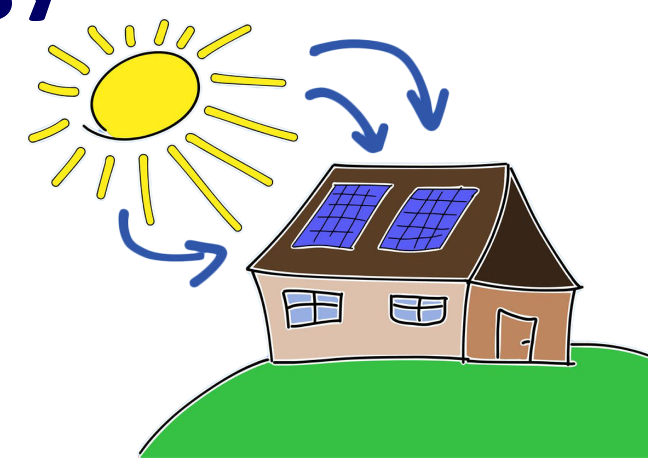

1. Problem Statement:

- Solar photovoltaic (PV) performance models are used to predict annual and lifetime energy yields of a given PV system for any location. Current models are based on commercially available silicon solar panels.
- New models must be developed for emerging PV cell technologies as they become commercially viable over the next decade.
- This project aims to develop a usable model for microtracking multijunction concentrating photovoltaics (μCPV) which use a lens and mirror to focus sunlight onto a small PV cell, as shown on the right.

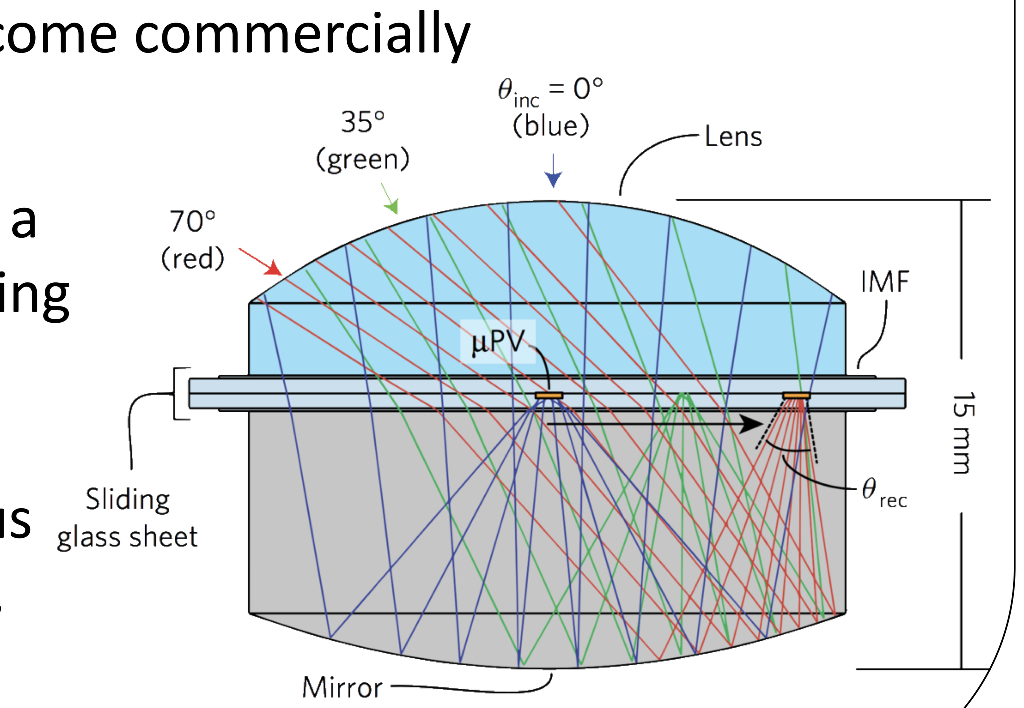

Figure 1. μCPV Cell and Ray Diagram.

2. CPV Model Design:

- Based on Sandia National Laboratory's PV performance modeling approach and uses functions from their PV_LIB toolbox for MATLAB.
  - **Weather Data:** Irradiance(direct & diffuse sunlight per unit area), air temperature, and other weather properties for the given location.
    - **PV Cell Temperature:** Affects the output potential.
      - **Power Conversion Efficiency(PCE):** Used with irradiance and cell temperature data to determine power output.

3. Results:

- CPV system(30% cell efficiency) modeled and compared with a standard silicon PV system(20% efficiency) of the same size and orientation.
- PVWatts Calculator, by National Renewable Energy Laboratory(NREL), was used to calculate standard system outputs.
- 4 cities were chosen as site locations - Redding, CA; Phoenix, AR; Pittsburg, PA; and Anchorage, AK – for their differences in solar availability.

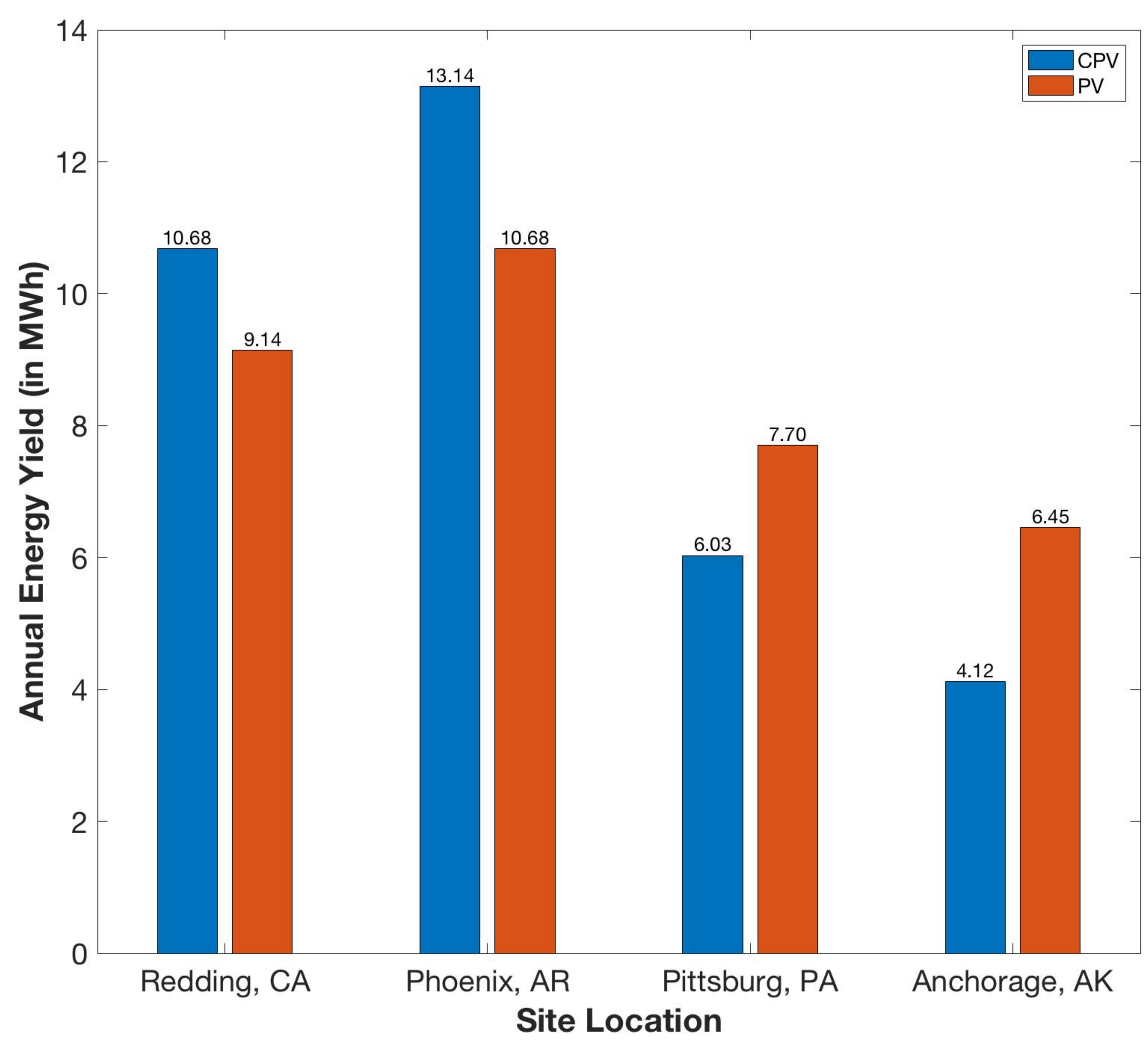

Figure 2. Annual energy yield(in MWh) for a CPV and standard silicon PV system in the chosen site locations.

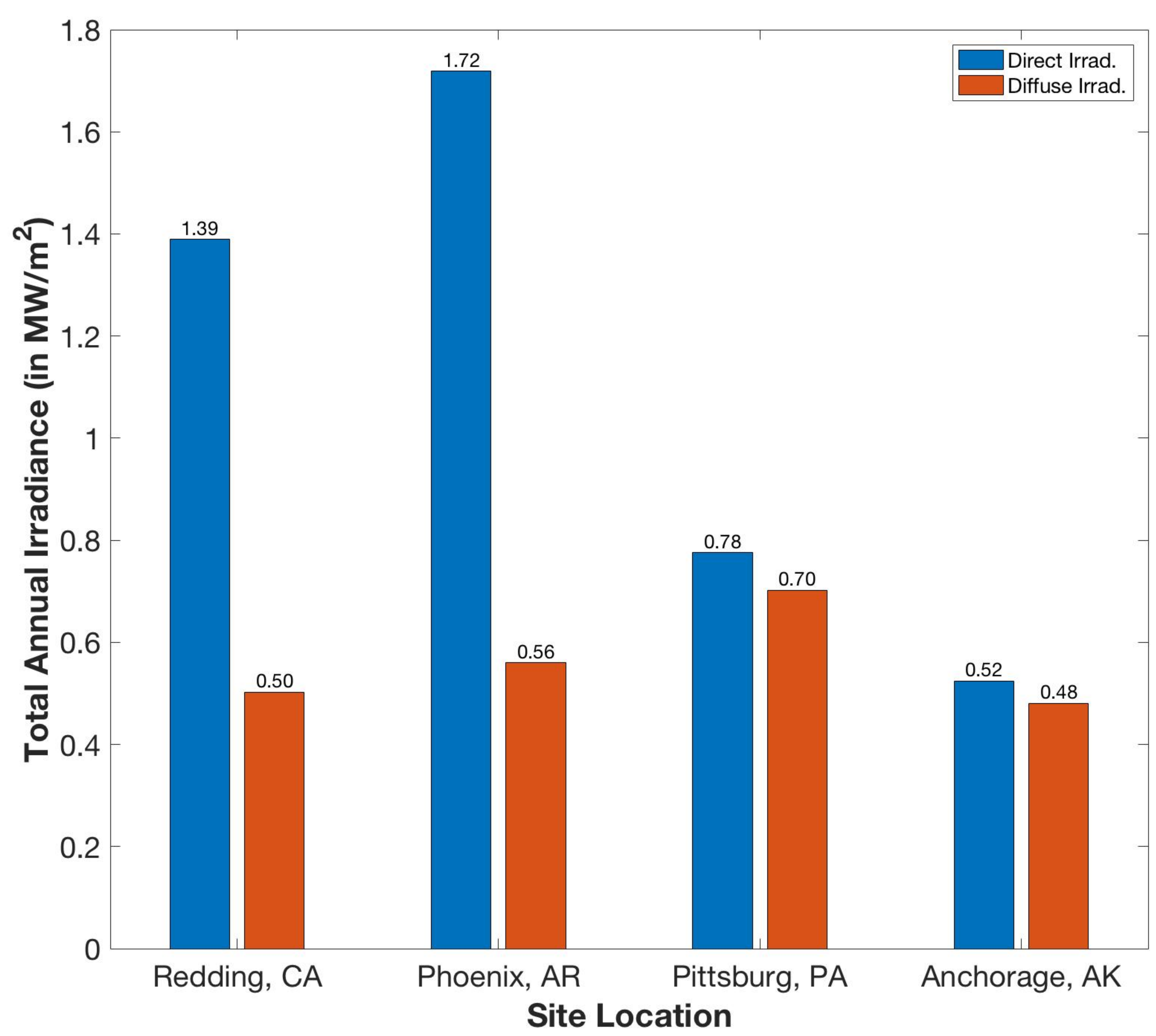

Figure 3. Annual direct and diffuse irradiance(in MW/m^2) data for the 4 chosen sites.

4. Discussion:

- The CPV system performed better than a standard system in locations that received significantly more direct sunlight (Redding, CA & Phoenix, AR) than diffuse.
- A standard PV system performed better compared to CPV on sites that received equal amount of direct and diffuse sunlight(cloudy weather; Pittsburg, PA & Anchorage, AK), but in general performed well in all sites.
- Significant reduction in CPV performance in locations with cloudy weather. This difference is likely due to the amount of direct irradiance available for the CPV to collect.

Acknowledgments

I would like to thank Dr. Chris Giebink for his guidance throughout this research project.

5. Conclusion and Future Work:

- Developed useable performance model for CPV technology.
- CPVs are most useful in locations that receive plenty of direct sunlight(sunny weather) but its advantages might not be enough to incentivize its adoption in the PV market.
- Future work could involve increasing the accuracy of the model by accounting for other output losses(e.g. due to mismatch, wiring, shading, degradation, etc.) and incorporating IV-curves, as well as further studying its commercial viability.

References:

Price, J. S. *et al.* High-concentration planar microtracking photovoltaic system exceeding 30% efficiency. *Nat. Energy* 2, 17113 (2017)

"Modeling Steps." *PV Performance Modeling Collaborative*, National Technology and Engineering Solutions of Sandia, LLC, pvpmc.sandia.gov/modeling-steps/.

"PVWatts." *PVWatts Calculator*, Alliance for Sustainable Energy, LLC, pvwatts.nrel.gov/index.php.