Hybrid PV-TEG System

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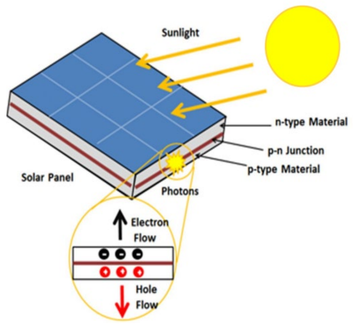
Abstract

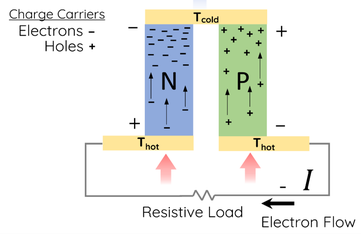
This research is focused on an innovative approach to improving the efficiency of a well-established renewable energy source. Solar cells are becoming more prominent as the power industry is shifting towards using more clean energy sources. Photovoltaic (PV) solar cells can only absorb a portion of the irradiance spectrum. The portion that is not absorbed raises the temperature of the system. The efficiency of PV cells drastically decreases as the temperature of the module rises and more energy is lost in the form of heat waste. Thermoelectric generator (TEG), when combined with PV cell, thrives off of the PV cell's drawbacks in output efficiency. By attaching an array of TEG to the back of a PV cell, the heat waste will be converted into energy. As the heat waste is repurposed, the solar cell will be cooled, and the efficiency boosted. With the hybrid system having a higher efficiency than a standalone PV cell, there will be an increase in motivation to use this renewable energy source.

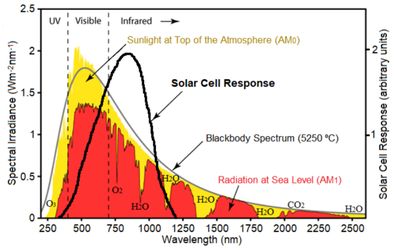
Introduction

- PV power generation is appealing and the most promising renewable resource because of the lack of mechanical parts, the clean energy output, and the copious amount of solar energy that is available.
- PV cells directly convert solar energy to electricity via the photovoltaic effect.
- The incident photons slam into the loose electrons within the cell, exciting them enough to jump from their atom, generating a current.
- Thermoelectric generators (TEGs) uses the Seebeck effect.
- TEGs produce a voltage proportional to the temperature differential of the hot and cold sides.



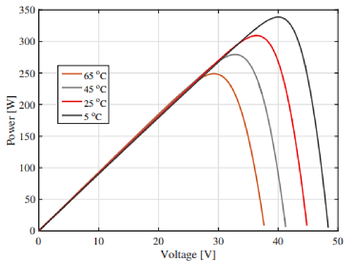
Thermoelectric Generator (TEG) [Seebeck Effect]





Research Purpose

- The solar irradiance not absorbed by the panels results in excess heat.
- Due to heat waste, the panel's temperature rises, which decreases the efficiency and lifespan of the cells.
- A hybrid PV-TEG was proposed to combat these problems.
- TEGs utilize the heat waste of the PV cells and cool the module without using system power.
- Allow the panels to stay within the optimal operating temperature for maximum power output



Excess heat waste generated in PV cell and increases its temperature → **Power generation efficiency drops as temperature rises** → **Add TEGs to convert heat waste to energy as well as lower the operating temperature of PV cell**

Objectives

- Develop a more efficient PV system by implementing an array of TEGs on the back of the PV module
- Compare the effect of two different cooling systems, one being a standard aluminum heat sink and the other being a PCM heat sink
- Use the experimental data that is gathered to compare the power output of the hybrid PV-TEG to a standalone PV system

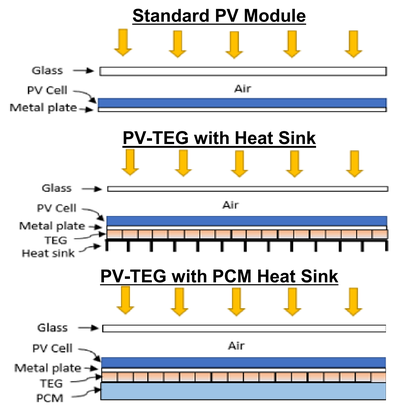
Create a more efficient PV system

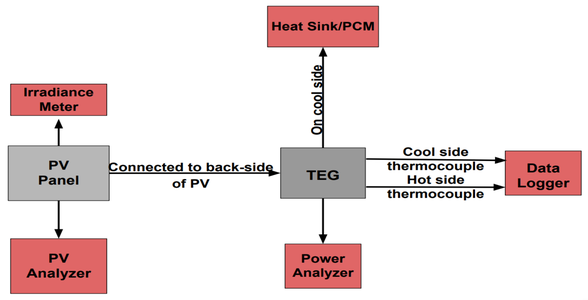
Compare two different passive cooling systems

Compare results of hybrid PV-TEG system to standard PV system

Design of Experiments

- Three different panel configurations
- Two different types of heat sink
- A pyranometer will collect sun irradiance data
- Thermocouples will be attached to the system to log the temperature differentials
- All temperature data will be recorded using a data logger
- Input solar irradiance and output power of the PV cell will be measured using the PV analyzer kit
- A power analyzer will be used to measure the power output from the TEGs

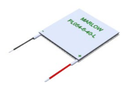




Component	Purpose
PV Module	• Generates power from the solar energy absorbed
TEG Module	• Generates power from temperature differential
Data Logger (DAQ970A)	• Measures and records the temperature
PV Analyzer (Fluke SMFT-1000/KIT)	• Measures solar irradiance • Measure the generated output power of the PV module
Power Analyzer	• Measures the power output of the TEG

PV Module

PV Analyzer Kit



TEG Module

Power Analyzer

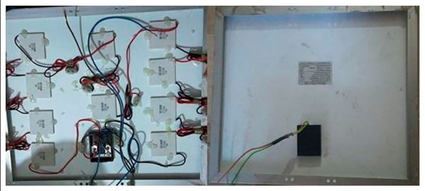
Data logger (DAQM901A)

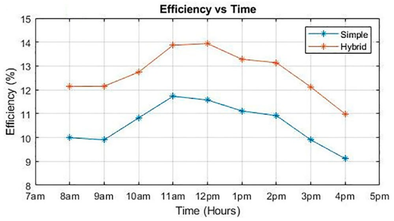
Next Steps

Physical Build
- The three different module builds, all with identical PV panels. Ensuring all power variations are solely due to cooling system.
- Three identical stands, ensuring consistent incident light angles from sun.

Conduct Experiments
- Experiments conducted over 10-day period, measuring the following parameters:
  - Solar irradiance
  - Voltage
  - Current
  - Temperature

Analyze & Compare Results
- Power output and efficiency of PV-TEG compared against standard PV module
- Values will also be compared to simulation results, ensuring experiment accuracy.
- Experiments will be repeated if necessary





Conclusion

Energy consumption has increased dramatically in recent years, leading to greater consumption of environmentally harmful energy sources. This increase has caused renewable energy sources to become more necessary. Therefore, these energy sources must be consistent and efficient. Photovoltaic power generation continues to be one of the most favorable avenues because of the abundance of solar irradiance. However, PV cells lose efficiency as the temperature of the module increases. A hybrid PV-TEG module provides a solution to this issue. We expect the efficiency of this hybrid model to be greater than the efficiency of a standalone PV. This result can be seen in multiple other studies. Improving the efficiency of a well-established renewable energy source will increase the incentive to utilize green energy and shift the industry away from environmentally harmful sources.

References

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