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Photocell Optimization through Thermoelectric Generation

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MULTIDISCIPLINARY

Photocell Optimization

through Thermoelectric Generation

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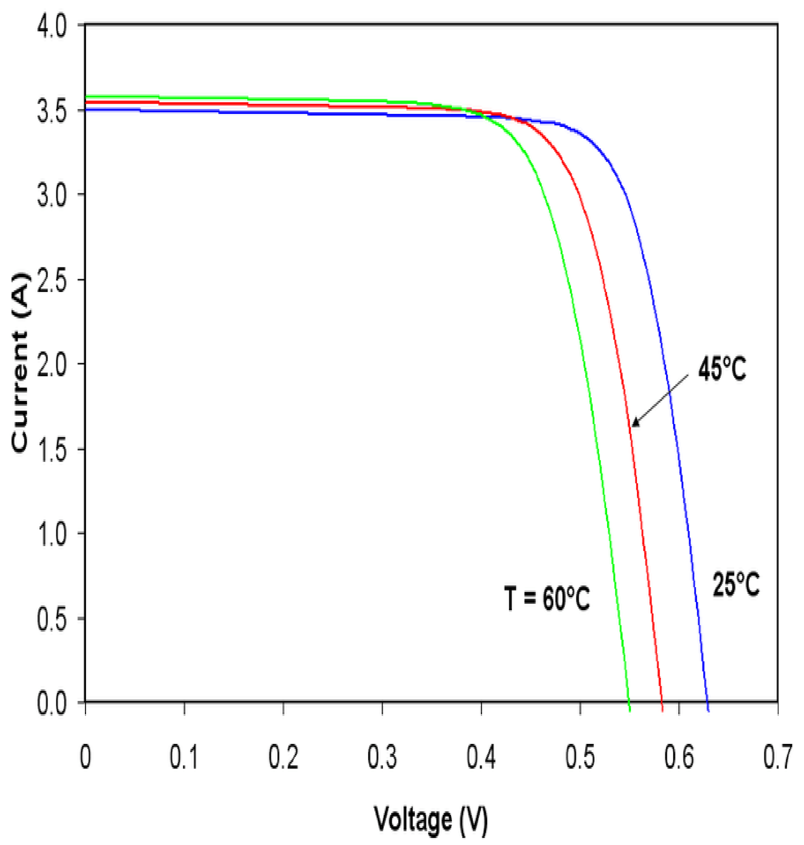
Problem

Solar cells have an ideal operating temperature of about 25˚C or 77˚F.



For each degree Celsius above the optimal operating temperature, we can expect the efficiency of the unit to drop 0.5%.

On any given summer day, it is not uncommon for solar cell temperatures to reach upwards of 70˚C which is about 158˚F, this results in a drop of 25% off the overall power conversion efficiency.

During a sunny day in Virginia, the power provided from the sun is equal to 800 W/m^{2}.

Given the area of the solar panel, we can determine that the expected efficiency (E_{ff}), is 19.5% when the panel is operating at its ideal temperature of 25ºC.

$$E_{ff} = \frac{power\ produced}{Sun\ energy * Surface\ area\ of\ solar\ panel} = \frac{6}{800 * 0.0385} = 19.5\%$$

However the actual temperature of the panel on a sunny day with an ambient temperature of 25ºC is 47ºC resulting in a 2.1% efficiency decrease to 17.4%.

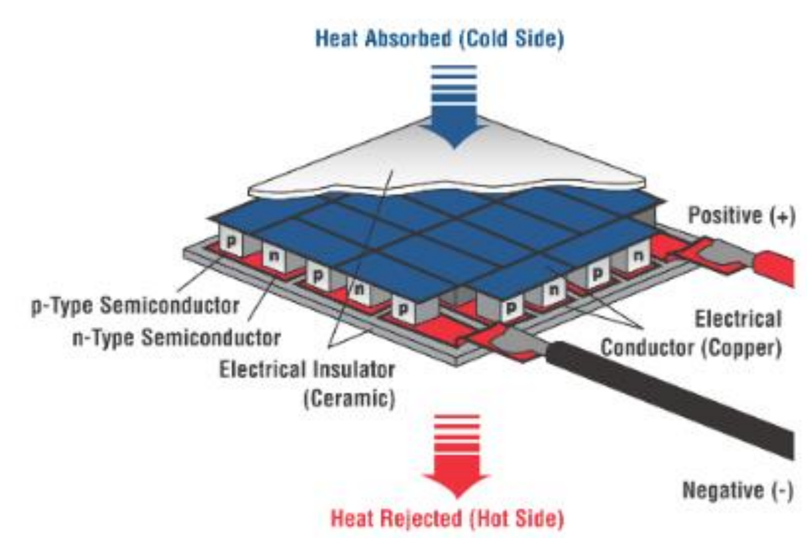
With a 2.1% efficiency drop the power production would drop from 6 Watts to 5.4 Watts .

Objective

To recuperate a tangible portion of the power loss energy through thermoelectric generation (TEG) using the wasted heat from the solar cells to create a current that we can add back into the total power produced.

Design process

A TEG is a semiconducting device used to create a current through a process know as the Seebeck effect.



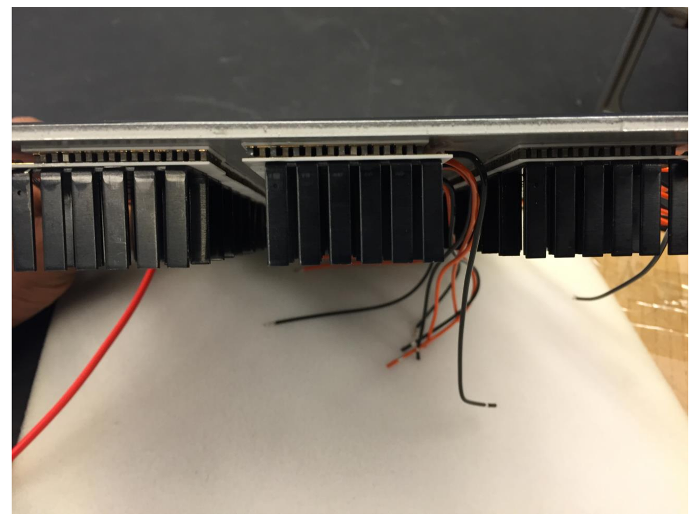
Heat is absorbed through the cold side, and is dissipated through the hot side, the difference in temperature creates the voltage between the two semiconductors

Using TEG's required the consideration on how to cool the hot side

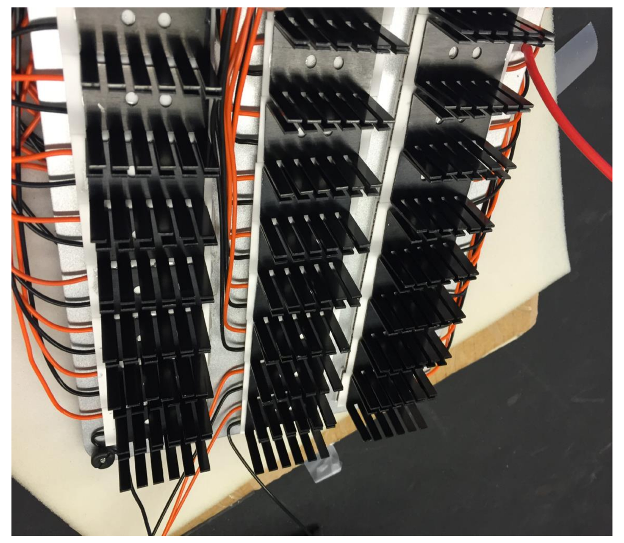
Geographical location would not only effect potential cooling method but also how much energy we can get from the sun

Assuming optimal sunlight we can cool the hot side using a form of geo thermal cooling, deep water cooling, or using standard heat fins forced and non forced.

	Advantages	Disadvantages
Geo thermal:	renewable and efficient	initial cost and need to dig deep
Deep water:	renewable and efficient	large and deep water quantity and cost
Fins (forced):	reasonable application	would require energy to cool
Fins (non forced):	no additional cost	relying on ambient temperature and wind to cool it



Our approach



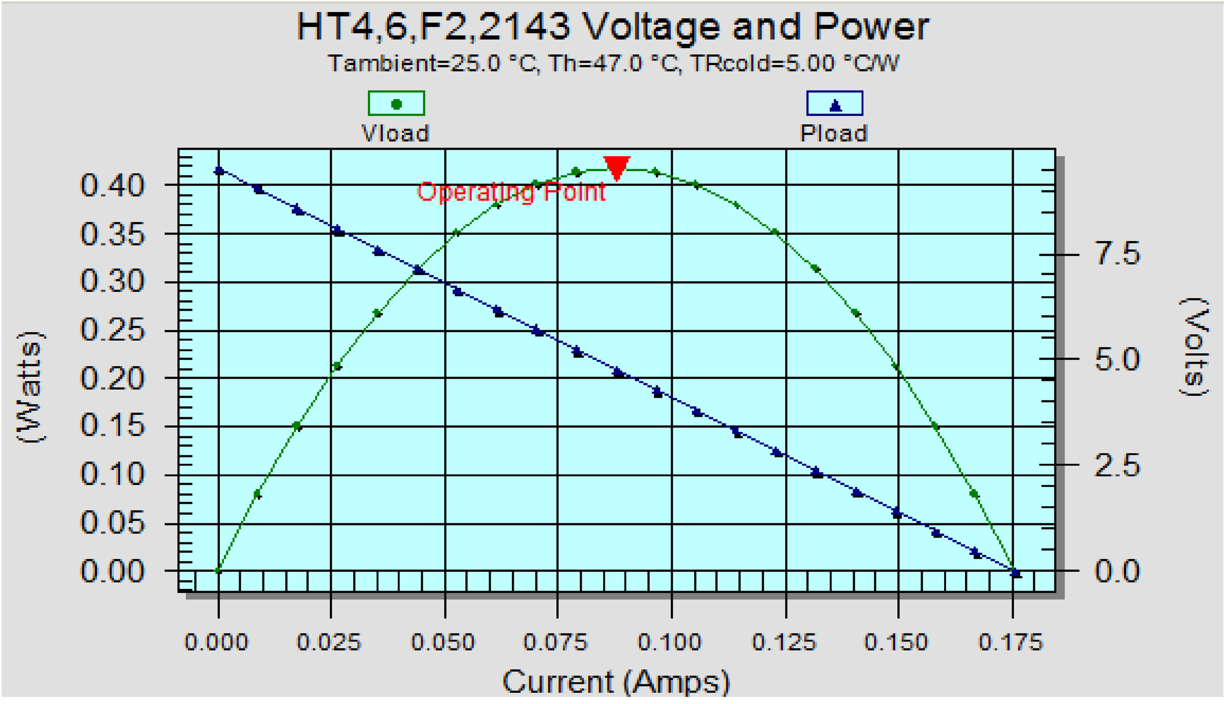
We chose to use fins with natural convection as our cooling method.

Model the power output

Compare experimented results with the theoretical results

Our goal will be to create the largest possible difference in temperature between the plates of the thermoelectric devices

The overall system should produce the expected wattage as shown in the figure below if we can achieve the temperature difference, resulting in the appearance that the solar panel is operating at its optimal efficiency.



TEG power and voltage output from Laird Tech AZTEC software

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