Thermoelectric Modules: The Future of Rural Communities

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Introduction

Modern energy services are essential to humans well-being and to a country's economic development; and yet, approximately 18% of the global population (1.3 billion people) lack access to electricity despite overall worldwide improvements. Of this initial populace, 84% are located in rural areas that lack monetary funds and/or the resources to produce solar panels, wind turbines, etc. A potential solution to this problem would be to implement thermoelectric devices to everyday applications that are already in use and produce heat (temperature differences). The use of these modules have no limit and are versatile since they can be used in the following two ways due to their physical effects:

- Seebeck effect (thermoelectric generator, *TEG*)
  - temperature difference between two dissimilar semiconductors produces a voltage difference between two substances
  - converts heat that will be lost into electricity through a TEG
- Peltier effect (thermoelectric cooling device, *TEC*)
  - electric current is sent through a pair of semi-conductors that are connected to each other in-between two ceramic substrates; one substrate becomes warm, while the other cools down

Methods

•Data was collected through the thermoelectric module (Fig 1): TEC1-12706
•TEC1-12706: converts electricity into a temperature difference (TEC)

The thermoelectric module was tested through an open circuit system to compare the voltage in respect to the difference in temperature

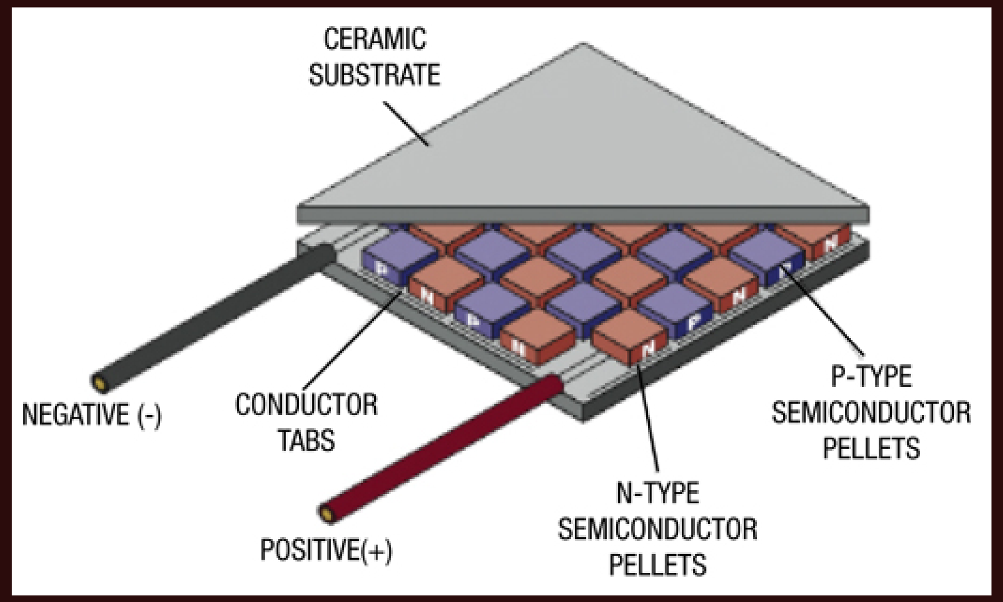

Fig. 1: Thermoelectric module TEC1-12706

Results

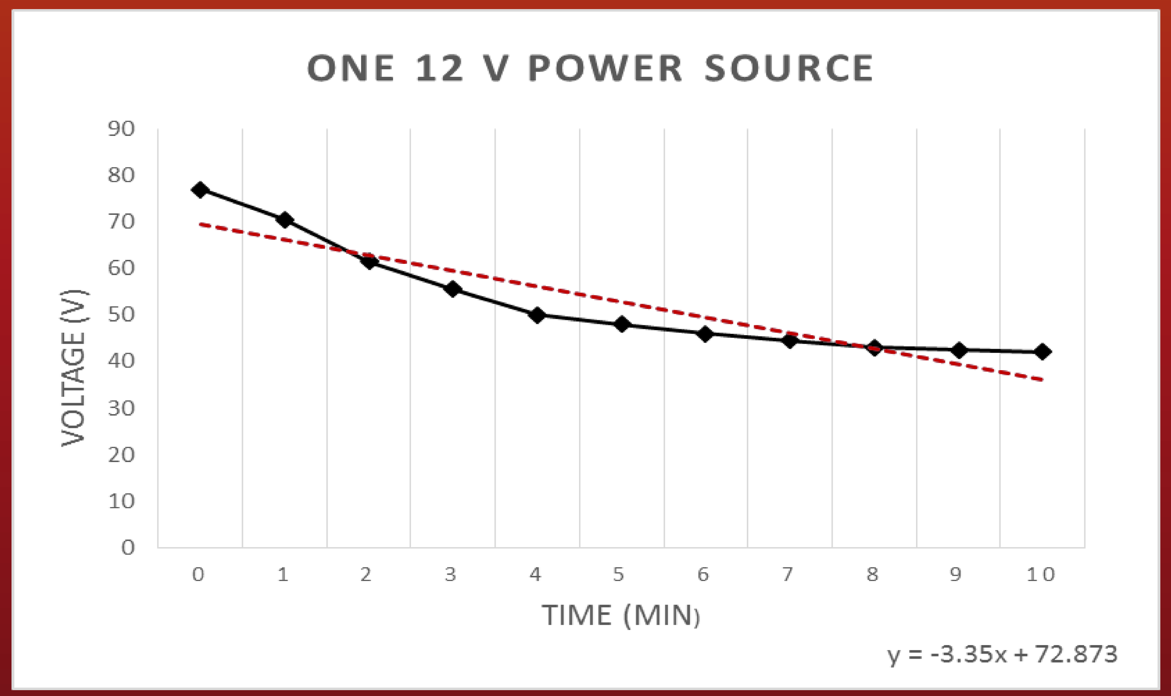

Fig. 2a: Maximum Voltage: 5.10 V, Minimum Temperature: 42 ^{0}F

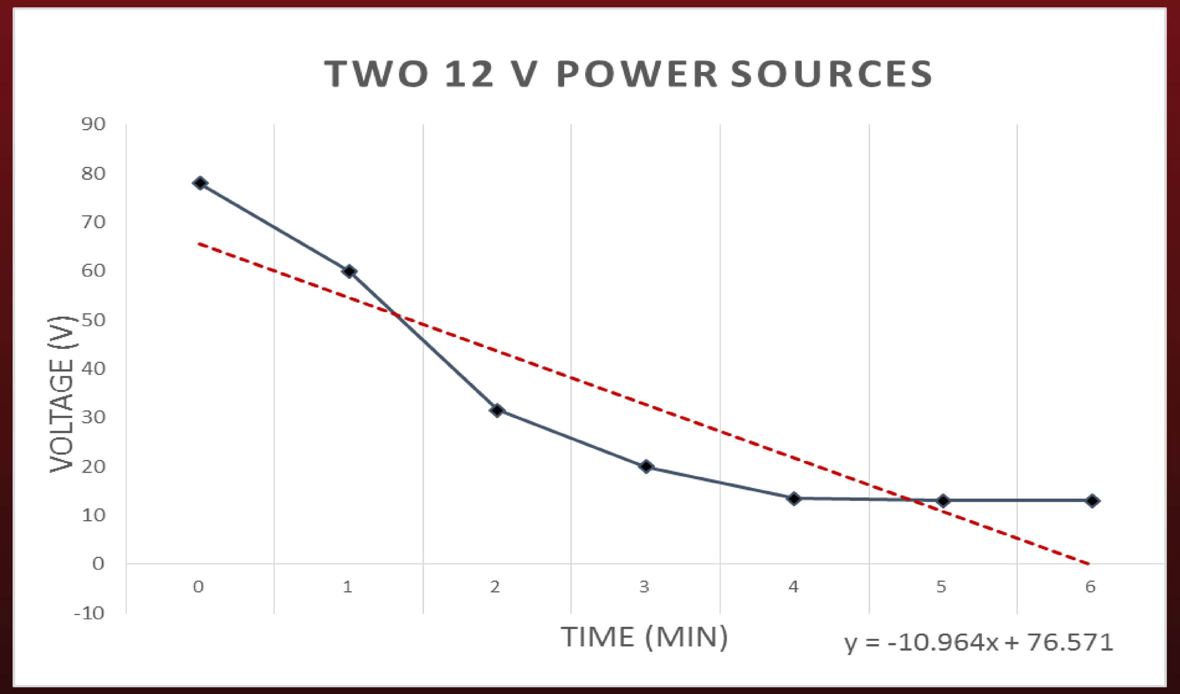

Fig. 2b: Maximum Voltage: 7.31 V, Minimum Temperature: 13 ^{0}F

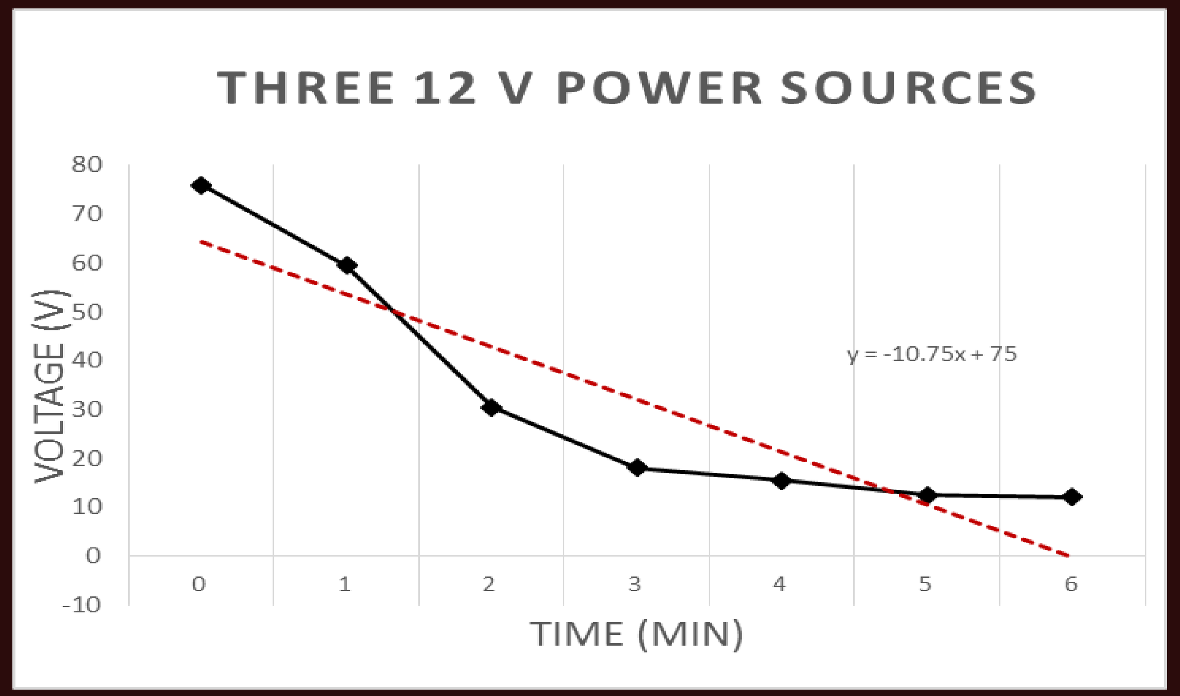

Fig. 2c: Maximum Voltage: 9.11 V, Minimum Temperature: 12 ^{0}F

Fig. 1a, 1b & 1c: A different number of battery sources (N=1,2,3) were connected to a TEC module placed above a heat sink submerged in approximately half a liter of room temperature water for varied amounts of time

Discussion

In our project one of the main objectives was to construct a device that would be able to efficiently dissipate heat to ultimately freeze water. Initially our module was connected to one (1) 12V power source with a submerged heat sink which produced poor results. As can be seen on Fig. 2a. the setup achieved a minimum temperature of 42^{0}F while using 5.10 V.

The spec sheet for module TEC1-12706 states that the module is equipped to deal with loads of up to 10 volts. Additional power sources were connected to the wire terminals in hopes of reaching the maximum voltage to gauge the effect it had on the overall cooling. The addition of one or two modules to our initial setup with one module produced a drastic temperature difference of almost 30^{0}F.

Contrary to our belief the addition of a third module was not efficient since it cooled down at a slower rate and had a similar minimum temperature as our two power source setup.

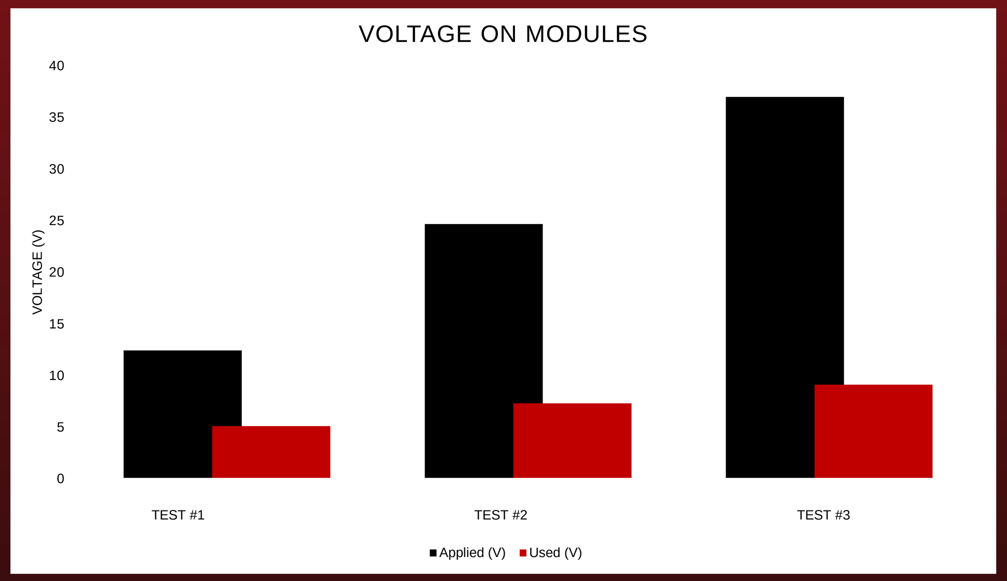

Fig. 3: Relationship between the number voltage applied to the module versus how much it was actually receiving

Conclusion

At the Advanced Energy Lab, we are focused on increasing the efficiency of the modules by creating a nanomaterial that will have high electrical conductivity and low thermal conductivity to achieve a high figure of merit. With a more efficient module on hand the potential applications are infinite. An ultimate goal would be to create thermoelectric generators that have a low price tag, are portable, and produce sufficient electricity.

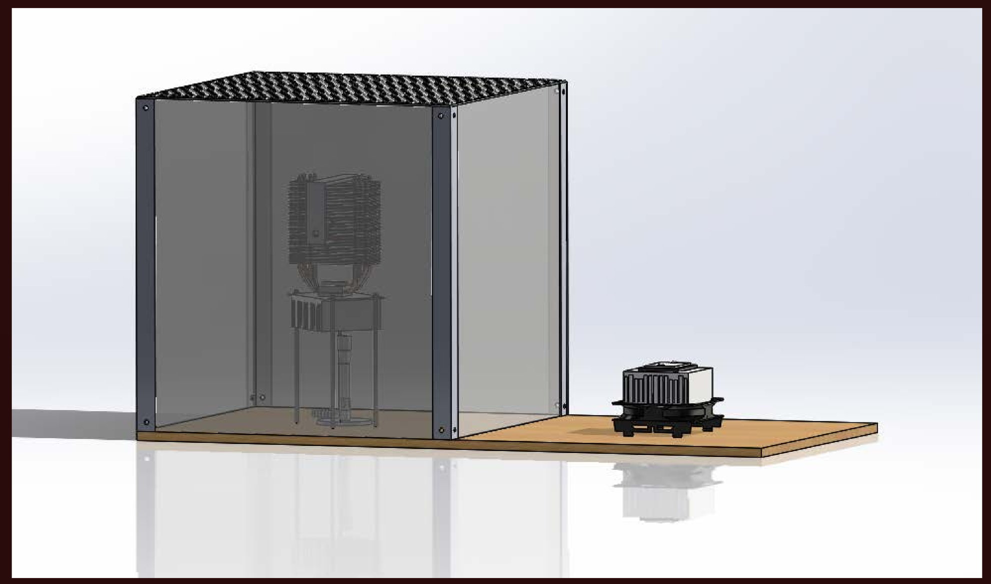

Fig. 4: Thermoelectric demonstration project
Thermoelectric generator (left) Thermoelectric Cooler (right)

Acknowledgements:

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