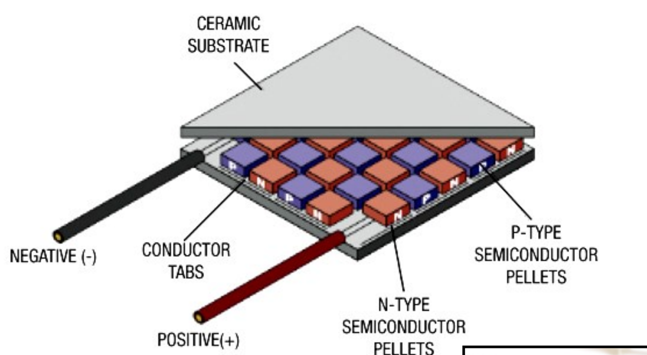
Thermoelectric Generator Ventilation Hood

Introduction

Our project seeks to find a viable way for people in developing communities without access to electric power to reduce health risks caused by inhaling smoke from indoor cooking. We are working to achieve this by pairing a traditional ventilation system with a thermo-electric generator unit. This solves both the air quality concern and as well as the lack of local energy sources.

A thermo-electric generator (TEG) works by converting a temperature difference into electricity utilizing the Seebeck effect. We create this temperature difference by attaching the hot side of the thermo-electric generator to a point on the cook stove, and the cold side to a heat sink.



Cross-section of a standard thermo-electric generator showing internal elements.

Ventilation hood and duct.

Clients

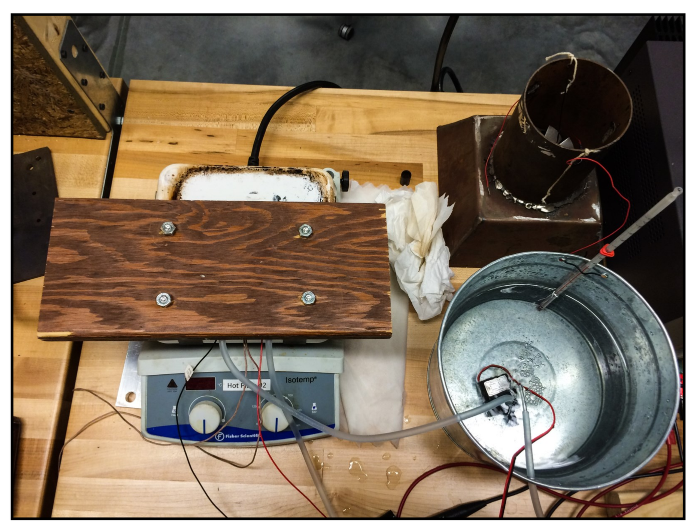
The first application of our design will assist the population of Oaxaca, Mexico. We are partnered with Forward Edge International and their Oaxaca team, including Tom and Wendy Hogan.

TEG Feasibility Testing

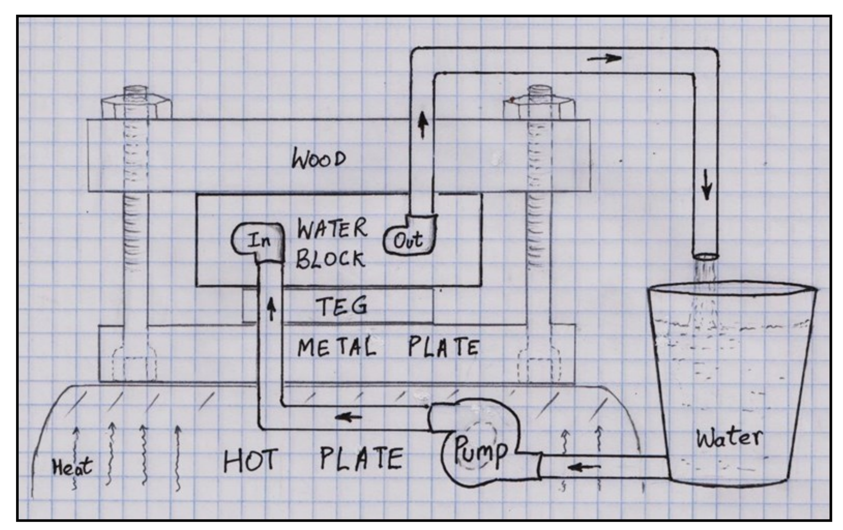
This year our main goal was to verify that we had a viable source of power for the fan in our ventilation system. This included replicating the performance claimed by the TEG manufacturer and exploring solar power as an alternative. In the fall of 2014, TEG tests in our actual prototype system did not generate sufficient power for our fan. This spring we modified our test set-up to more closely follow the manufacturer's configuration and have been able to achieve promising results. These changes are described in the Water Block TEG Setup. Work to reduce the power required is described under Motor testing. Finally, work with on our solar power alternative is described under Solar Testing.

Water Block TEG Setup

To help identify the issues in the fall 2014 testing of the TEG's power output, we contacted the manufacturer for their testing setup. Our goal was to match their setup as much as our limited resources allowed. We created a test fixture which sandwiched the TEG between a hot side metal plate and a cold side water cooled heat sink. A wooden base with four bolts were used to adjust the applied torques to an ideal pressure for the TEG. The water cooled heat sink consisted of a block of metal with a serpentine channel. Water was circulated through this channel using a pump submerged in a bucket. Water has a higher specific heat capacity than air. This allowed us to develop a significantly higher temperature difference across the TEG compared to our air cooled testing this fall resulting in promising power generation.



Test setup



Drawn diagram (Not to scale)

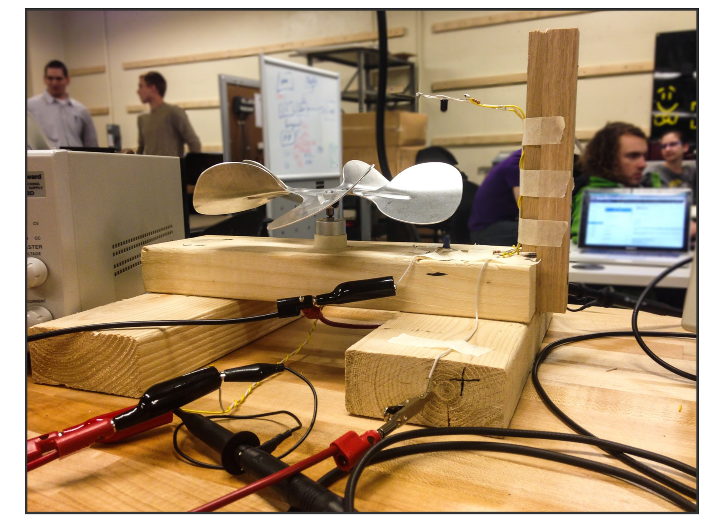
Further Information

For more information, visit www.messiah.edu/info/21317/collaboratory_new and find the TEG project under the Energy tab.

Acknowledgements

We'd like to acknowledge Dr. Fish for his invaluable help in advising our project, our contacts Tom and Wendy Hogan in Oaxaca, and Abhishek Jacob as well as Lee Drummond for their previous work on the project.

Motor testing

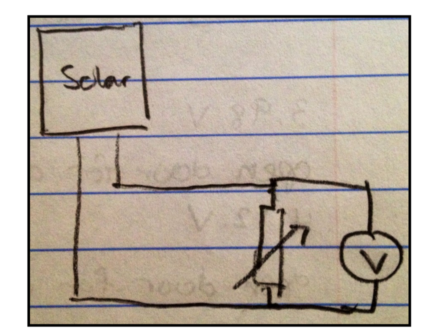


In an effort to reduce the amount of power needed by our fan, we investigated pulsing the power to the fan motor. The momentum of the blade allows it to continue spinning even if we remove power for a fraction of a second. To evaluate this hypothesis, we needed a test rig which allowed us to accurately control the amount of time the power was applied and removed (duty cycle) as well as measure the fan RPM. As seen in the picture to the left, we used a phototransistor and photo-LED to measure the fan RPM. A relay controlled by a function generator was used to adjust the duty cycle of the power. We were able to demonstrate that a reduction in power of approximately 30% was possible using this approach. However, this comes at the cost of additional circuitry and a slightly more complicated design.

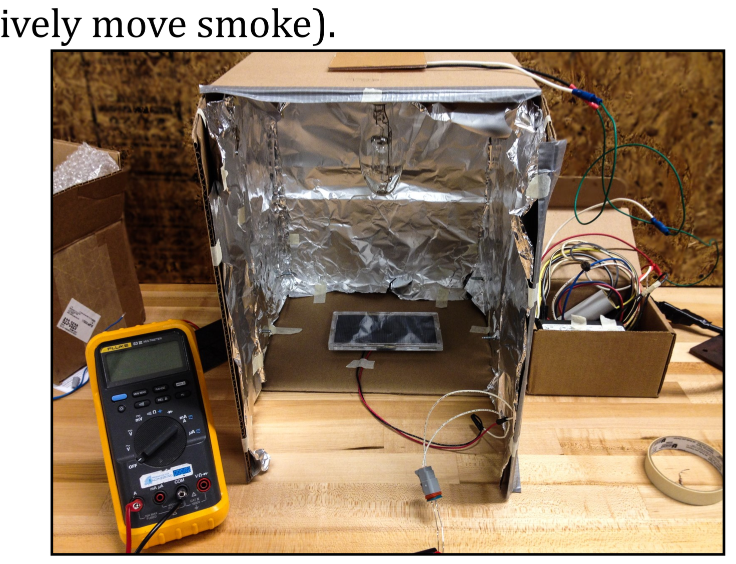
Solar Testing

We designed and built an indoor solar testing rig to conduct tests inside with consistent lighting conditions, unlike weather conditions which change every day. The goal of the solar research was to find out the conditions and setup in which a small (6" x 4") solar panel is able to produce 1 watt of power (an estimate of power needed by the fan to effectively move smoke).

After numerous trials and errors, we found the right circuit setup which maximized the solar panel power output—which, thankfully, was 1 watt! We concluded that solar energy is a viable backup plan if the TEG turns out to be an unreliable energy source.



Final circuit setup



Indoor solar testing box

Conclusion

We made considerable progress on our project this year. We developed a TEG test setup able to replicate the manufacturer's performance claims. We verified the amount of power needed to effectively remove smoke for our clients. We confirmed that solar energy is a viable failsafe if the TEG approach requiring water cooled heat sink is not ultimately feasible. Our next step will be to use what we learned this year to modify our prototype and create a system which can be fielded and tested with our client.

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