Engineering Problem

- There is no effective and/or efficient product for mobile consumers to generate electrical energy to power mobile electronic systems

Engineering Goals

- To develop an accessory which can capture thermal energy and convert and store it as electricity, for later charging use.
- This product will optimally provide mobile consumers with emergency power
    - If used conservatively, it could act as a full-fledged power bank.

Purpose

- Harnessing thermal energy could be a major step forward to ultimately reducing electricity demands from generation plants and making consumer devices even more convenient.
- Danger in emergency situations could be alleviated, with users being able to have access to their communications devices to call for help
- Although a permanent solution to the energy crisis is far ahead in the future, modern improvements to renewable energy technology must occur.

Background

- **Thermoelectric Generation**
  - Peltier Effect: an effect whereby heat is emitted or absorbed when an electric current passes across a junction between two materials. [4]
  - Seebeck Effect: a phenomenon in which a temperature difference between two dissimilar electrical conductors or semiconductors produces a voltage difference between the two substances. [4]
  - Peltier Tile: is the common system or apparatus used for Thermoelectrical Generation (TEG) and Thermoelectrical Cooling (TEC) [6]
    - Applications include refrigeration, climate control in enclosed areas, as well as deep-space travel missions
      - Useful as components of a Peltier Tile are damage resistant, resulting in less issues

Seebeck vs Peltier

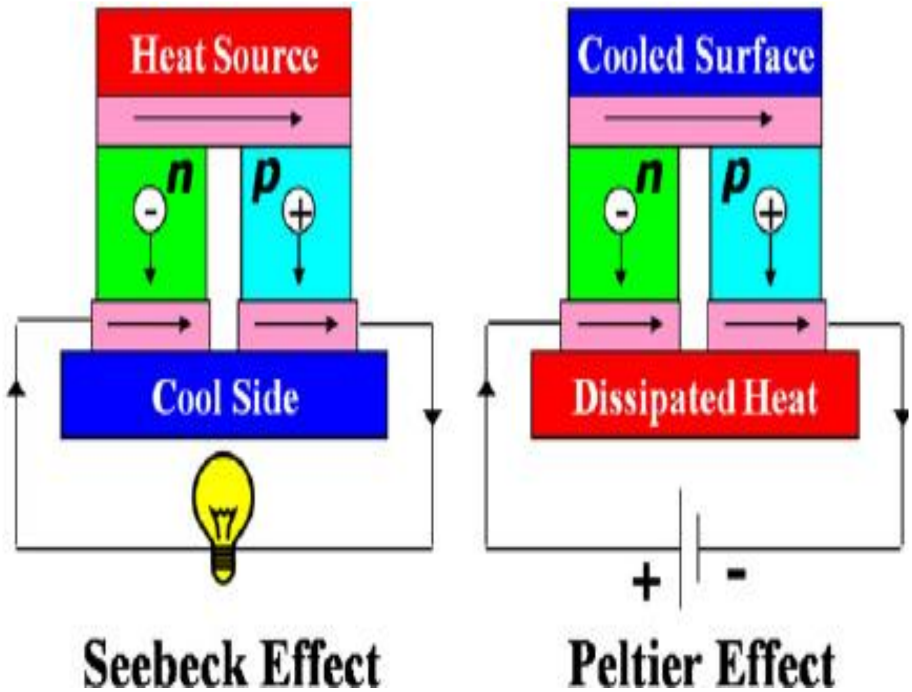

Figure 1. Lee, S. (2012, July). Ferroelectric-Thermoelectricity and Mott Transition of Ferroelectric Oxides With High Electronic Conductivit [Digital image]. Retrieved from https://www.researchgate.net/publication/233971442_Ferroelectric-Thermoelectricity_and_Mott_Transition_of_Ferroelectric_Oxides_With_High_Electronic_Conductivity

Components of a Peltier Tile

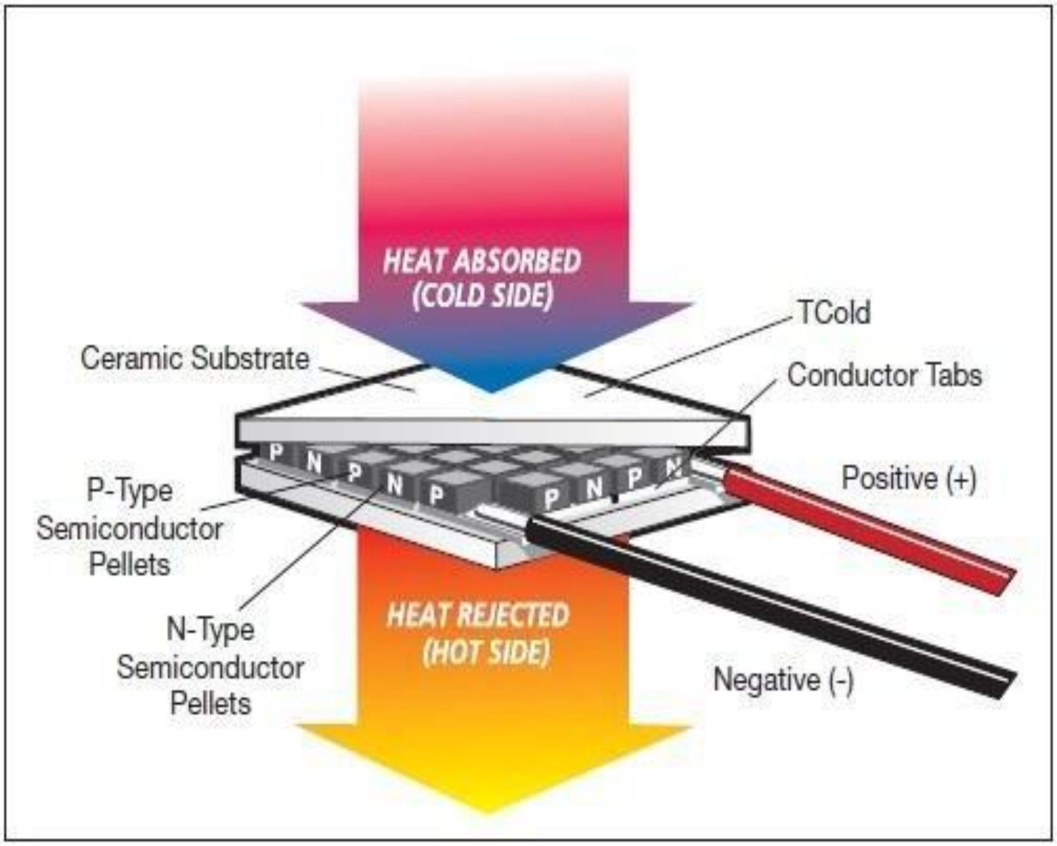

Figure 2. Moustafa Mohamed Ahmed, JEHAD MOSTAFA SUBHI AL-BAYOUK, Nivan Mahmoud Fikry, Moustafa Moustafa Mohamed, Thanaa Ibrahim Shalaby & Mohamed Ibrahim Ibrahim. (2014). Design and construction of cryosurgical and hyperthermia device using thermoelectric effect. Retrieved from http://www.dx.doi.org/10.13140/RG.2.2.16905.85606

Series vs. Parallel

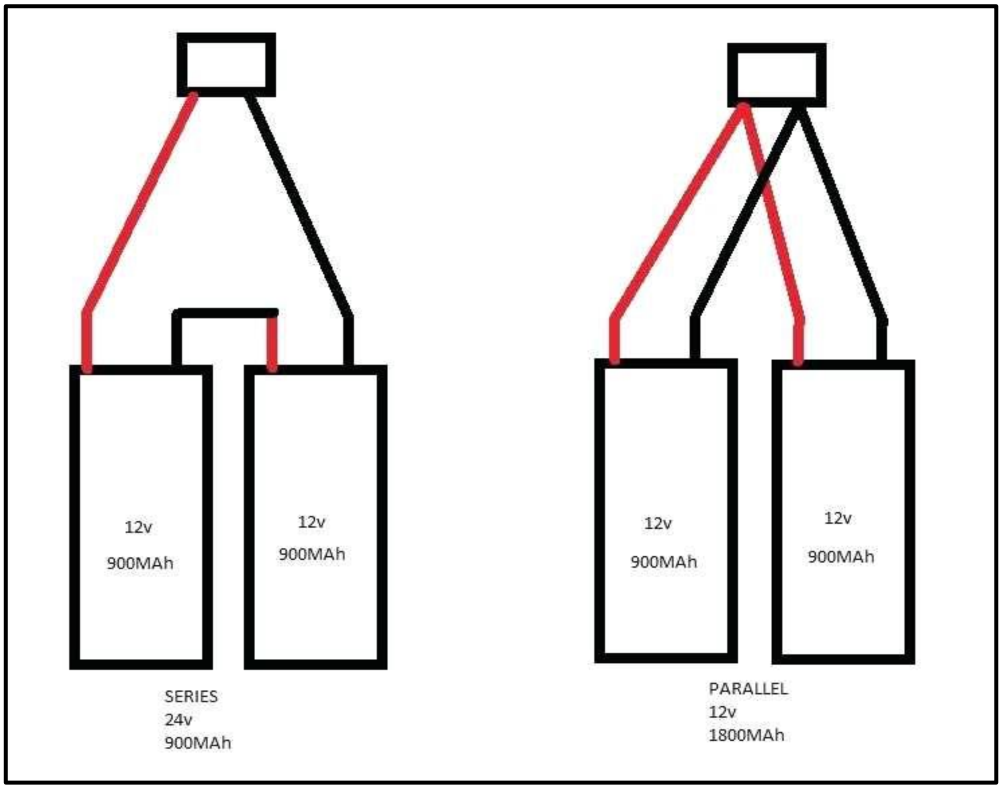

Figure 3. Wiring in Series Vs Parallel [Digital image]. (2018, March 8). Retrieved from https://www.google.com/url?sa=i&source=images&cd=&cad=rja&uact=8&ved=2ahUKEwiQ1br00IzfAhUhTd8KHdT6BCMQjRx6BAgBEAU&url=http://eromania.pro/wiring-in-series-vs-parallel/&psig=AOvVaw21p0i4LO6K1Y0t3rzMJ9uC&ust=1544234287803617

Materials

- Electrical Components and Related Materials
    - Peltier Tiles, electrical wires (alligator clips), electrical soldering set, thermal management materials (ex. heat sink, thermal paste), heat sources (candle, etc), heat containment apparatus, cooling agents (ice gel packs, cold water)
- Safety
    - Non-flammable workspace, rubber gloves, protective clothing, protective glasses

Procedure

1. First, identify an optimal and abundant source of untapped energy, that can be found with ease in various human environments
    a. Has been decided that thermal energy is the most optimal and abundant form of energy for the device to utilize
2. Second, utilize the Peltier Tiles to construct an apparatus that meets the design criteria
3. Test the electrical output and data (voltage and amperage) before applying the device to charge anything
4. Construct a containment unit or case that will protect the device, allow it to be efficient, and make it more convenient to use
5. Test charging rate of device and potentially develop a battery system to not require constant charging of devices

Experiment One

- Setup:
  - Used a tealight candle as the heat source inside a candle holder, covered by a steel plate with a Peltier Tile on top. The Peltier Tile is cooled on the topside with multiple cooling agents (ice packs and ice cubes)
  - The output of the Peltier Tile is measured directly using a multimeter and alligator clips
- Results and Observations
  - Max voltage was 1 full DC volt, trending between .600 - .800 volts
  - Largest fluctuations of voltage occurred after each cooling agent was added or removed

Experiment Two

- Setup:
    - Used three tealight candles as the heat source inside a candle holder, covered by a steel plate with three Peltier Tiles on top. The Peltier Tiles were cooled on the topside with multiple cooling agents (ice packs and ice cubes)
    - The output of the Peltier Tiles is measured directly using a multimeter and alligator clips
- Results and Observations
    - Max voltage came out to be 3 volts at its peak, dropped to about a consistent 2 – 2.5 volts
    - Confirms the observation from experiment one that each Peltier Tile outputs roughly .800 volts in this apparatus

Experiment Three

- Setup:
  - Used five tealight candles as the heat source inside a candle holder, covered by a steel plate with five Peltier Tiles on top. The Peltier Tiles are cooled on the topside with multiple cooling agents (ice packs and ice cubes)
  - The output of the Peltier Tiles is measured directly using a multimeter and alligator clips
- Results and Observations
  - Max voltage was roughly 7 volts, dropping to a constant 4-5 volts
  - Constant amperage was reaching only 200 mA
  - The 5 Peltier Tiles were puling 1+ volts without additional cooling

Data Analysis

- With each new iteration of the prototype, voltage is rising to appropriate levels and remaining consistent
- Amperage is still not at the most optimal level for consistent and efficient charging
- A potential cause of this, is due to the lack of accounting for resistance, as voltage = resistance * current
    - The resistance could be acclimated to the setup of the wiring, which has been tested in both series and parallel

Decision Matrix

		Options/Devices	
Criteria	**Weight**	**On-Device Apparatus**	**Stand-Alone Device**
Cheap	4	1	0
Portable	4	1	1
Efficient	3	-1	1
Functional	3	0	1
		5	**10**

Figure 4. Decision Matrix

Design Criteria

- The product should comply with the following design criteria:
  - Inexpensive
  - Portable
  - Usable

Future Work

At this point, there yet some procedures to be completed. First, a wiring system (series vs parallel) would need to be decided upon to ensure maximum efficiency. Along with this decision, a final completed Peltier Tile apparatus will be decided upon, after further testing through experimentation. Lastly, some form of enclosure or case will be developed and assimilated into the Peltier Tile apparatus.

Timeline

- December Fair to the start of Winter Break:
    - Determination of an appropriate wiring system
- Winter Break:
    - Completion of Peltier Tile apparatus
    - Potential addition of a battery
- January:
    - Addition of an enclosure
    - Charging tests and analysis
    - Adjustment period