UTAH OFFICE OF
ENERGY DEVELOPMENT

Thermal Energy Conversion Using Peltier Power

Grade/Subject: Physics

Strand/Standard PHYS.2.4 Design a solution by constructing a device that converts one form of energy into another form of energy to solve a complex real-life problem. *Define the problem, identify criteria and constraints, develop possible solutions using models, analyze data to make improvements from iteratively testing solutions, and optimize a solution.* Examples of energy transformation could include electrical energy to mechanical energy, mechanical energy to electrical energy, or electromagnetic radiation to thermal energy. (PS3.A, PS3.B, ETS1.A, ETS1.B, ETS1.C) (PS4.A, PS4.B, PS4.C).

Lesson Performance Expectations: Students will build and map the energy flow through a circuit. Students will observe energy transformed from heat into electrical energy with a thermoelectric device (Peltier Plate).

Materials:

A group of 4-6 needs

- 8 Peltier plates
- 1 mini LED bulb (Lowest voltage possible - 1.8 V here)
- 1 multimeter
- 2 aluminum trays that can stack (8” x 5”)
- 10 alligator clips without wires (minimize the amount of wire or you lose voltage)
- Ice cubes or ice packs (small ziplock bags with water frozen flat)
- Source of hot water (suggested to have 1-2 electric kettles or lots of boiling water)
- Hot pads for transporting hot water

Phenomena - Class needs

- 2-3 battery holders with batteries (D)
- 2-3 Peltier plates

Time: 70 minutes/ 1-period

Teacher Background Information:

- Although slightly different from what your students will do, these videos explain the concept of a Peltier plate.
  - YouTube, how does TEC work?
  - YouTube Peltier Modules
  - YouTube Peltier DIY
- After the first videos, show these that explain how Peltier Plates works.
  - YouTube Thermoelectric Technology
  - How to Use a Multimeter Article
- Places the Peltier Plates are used

Student Background Knowledge:

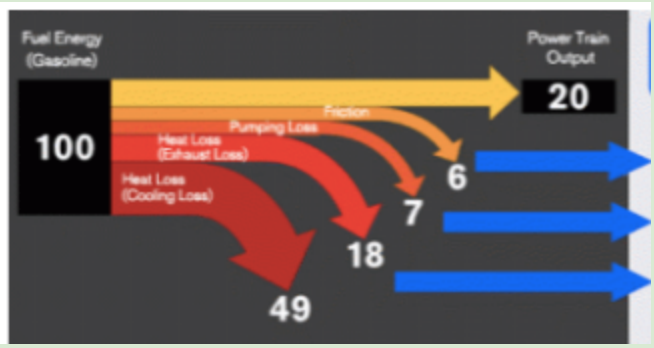
- Students should understand the Law of Conservation of Energy.
- Students should know what a circuit is.
- Students need to know how to use a multimeter.

- It is beneficial for students to understand that a generator and a motor are reverse devices. Other examples will also give them clues that a Peltier plate can be used in both directions- with a battery or using heat as an energy source. If they are unfamiliar with this concept, the diagram below will help explain it.

Teacher Step by Step: A 3-d lesson should insist students do the thinking. Provide time and space for the students to experience the phenomenon and ask questions. The student sheet provided below provides guidance but is only an example of how students might respond.

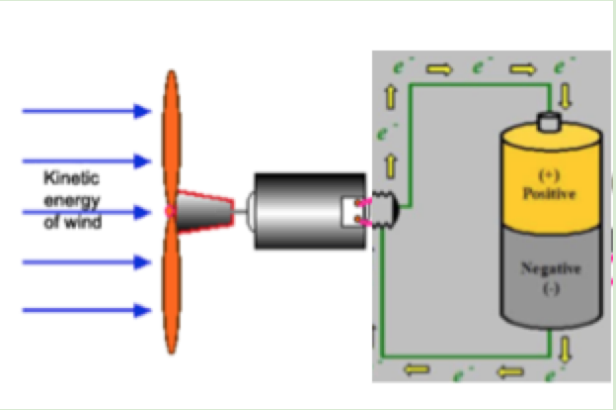
1. **Phenomenon***: Show students a thermoelectric device (Peltier plate), connect it to a battery, and have students pass it around the room. This works best if only 10-13 students handle each plate; their hands will heat up with the cool side, making the effect less apparent. Students should feel one side hot and the other cold. Have students predict what the device might be used for.*
2. Introduce the problem that a great deal of heat is lost in all energetic systems.

   Example of car engine efficiency:



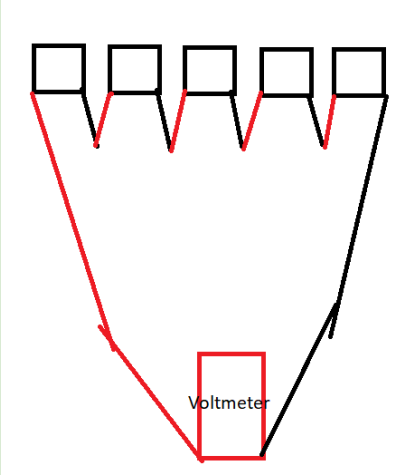
From: http://www.sankey-diagrams.com/tag/engine/

Also, introduce (unless this is a lesson already presented) the concept of circuits moving in opposite directions. A motor run by a battery which also works as a generator charging a battery, is an example of this lesson plan. The following diagram may be discussed:



(the diagram is incorrect with the flow of electrons, still, the point is that the wind can generate electricity, or the battery-operated motor can create wind.

3. Question: Can a Peltier Plate help save energy lost as heat in machines or other heat sources?
4. Give groups of students a set of materials (one Peltier plate, hot and cold source, lightbulb, voltmeter) and ask them to put together an electric circuit using these devices and hot and cold sources. The goal is to create the highest possible voltage and to illuminate a light bulb.

5. Let students know the minimum voltage for the light bulbs they have. (1.8 V is recommended)
6. Set out ice packs and keep HOT water available. Keep the hot water source filled because students will need refills. Make sure students have a safe way to transport the hot water to their lab stations- small beakers work well.
7. As students work, they should discover that they need hot on one side of the plate and cold on the other. Students often want to jump to connect their lightbulb and feel frustrated that 'nothing is happening. Encourage them to use their multimeter and measure the voltage of one plate before they add more. Let students work and struggle and think through their circuits for a good time, 20-30 minutes or so.
8. Ask students to stop and draw their circuits. Remind them to write down the voltage they have measured.
9. Take a break to have a class discussion, have groups share what voltages they have measured, have a couple of groups (especially those with relatively high voltages) draw or explain what they have done.
10. Show this video clip to explain a bit of the science behind the plates.
11. After watching the video, discuss how to connect the plates in series- You may wish to draw a diagram on the board and then give them a little more time in the lab to try to light up the bulb once more.
12. 

13. After 10-15 minutes, have students draw the circuit they created.
14. Discuss the uses of the plates. Ask, where is energy lost as heat in a car? This video explains the uses of Peltier plates (5:30).

    Charge your cell phone with a Peltier plate (thermoelectric generator) click here.

Students should finish with the questions on the student sheet. If you haven't discussed criteria and constraints in engineering, now would be a good time.

Answers to questions:

1. *Answers will vary*
2. *The plates could be used for a device that generates lost heat.*
3. *Yes, a Peltier plate attached to the hot tailpipe could generate electricity.*
4. *The plate would have to generate enough energy to make the extra weight and engineering worth the cost.*
5. *The costs associated with engineering design and materials availability would be constraints.*

Assessment of Student Learning.

1. How is a Peltier Plate similar to an electric motor/generator? *The plate can work forward to create a current if hot and cold temps are available, or it can create hot and cold if it is attached to a battery.*

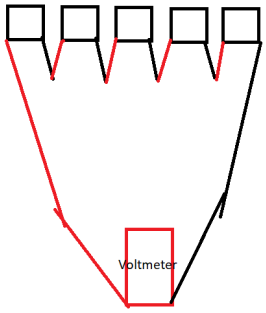
2. What arrangement of Peltier Plates created the greatest voltage? *The greatest number of plates are arranged in a series circuit.*
3. A shallow dish designed to keep food warm has a Peltier Plate on the bottom. What is needed to make it work? *A battery or electric current.*
4. How could the same dish be used to keep food cool? *The plate should be flipped.*

Thermal Energy Conversion Using Peltier Power

1. What is the unique property of a Peltier Plate?
    a. When heated on one side, the other side gets cold.
    b. When placed next to a heat source, the plate becomes hot.
    c. When two plates are placed together, they generate electricity.
    d. When placed in an electric circuit, one side gets hot and the other cold.*

2. How much heat is lost in most energy conversions using fossil fuels, such as a car?
    a. 10-20%
    b. 30-40%
    c. 50-70%*
    d. 90-100

Peltier Plates in a Series Circuit



Voltmeter

3. The voltmeter in the circuit pictured above showed a current of 1.8 v. What is missing from the diagram?
    a. The clips show connections.
    b. The battery that made the circuit work.
    c. The light bulbs lit up when the voltage was decreased.
    d. The energy source-hot and cold substances above and below the plates.*

4. An electric motor will spin when placed in an electric circuit. When is the motor similar to the Peltier Plates pictured above?
    1. When a battery attached to the motor is connected.
    2. When a gasoline line is attached to the motor for energy.
    3. When the motor is attached to another motor in a circuit.
    4. When an energy source spins the motor to generate a current.*

Extension of lesson: Talk about heat loss in car engines, light bulbs, etc., and how this is related to the Peltier plates. Current research is trying to use things like Peltier plates to reduce energy waste. How Does Thermoelectrics Work?

Career Connections: Jobs in Geothermal Energy HVAC Engineer

Thermal Energy Conversion Using Peltier Power

Name_____

Phenomenon: Describe what you notice about the Peltier Plate?

Problem: Energy is lost as heat in virtually all energy transfers. Can a Peltier Plate help save energy lost as heat in machines or electronic devices?

Materials: 6 Peltier plates, hot water, ice, beakers, wire leads, multimeter, aluminum pans, LED light bulb.

Design a Circuit

1. Use the materials to create the largest amount of voltage possible.
2. Make sure you can create a voltage with one plate before adding additional plates.
3. Draw the first circuit you can get to work and label the voltage produced.
4. Create another circuit to maximize your voltage. Draw it and label the voltage. See if it will light the LED bulb.

Data:

Circuit #1
Voltage _____

Circuit #2
Voltage _____

Analysis:

1. What conditions produced voltage? Why?

2. What conditions produced the most voltage? Why?

3. In general, what could the Peltier Plates be used for?

4. Could the tailpipe of a car generate electricity? How?

5. What are the criteria for remodeling the car? In other words, how could a Peltier plate be included in the design of a car?

6. What are the limitations to remodeling the car?