Renewable Energy

Introduction

There are many renewable energy sources available for use on our planet. We can derive energy from the sun, wind, water, biomass, and through many forms of conservation. In developing energy resources, we can concentrate on a single source of available energy (i.e., solar energy in the desert), or we can utilize multiple sources of energy by integrating several systems (i.e., solar, wind, and biomass). The renewable energy resources that a country can develop depends on that country's location, the available of various resources, and that country's economic condition.

In order to develop a strong energy base, we need to increase the availability and use of renewable resources. The most valuable and available renewable energy source we have is solar energy. Solar energy reaches the earth in various forms, one of which is heat. In order to use heat energy, however, we must transfer it from one form or place to another. There are three forms of heat transfer; conduction, convection, and radiation.

Water is a good example of a substance capable of transferring heat energy from one source to another. Water can be heated by a number of energy sources, such as a fire, a hot water heater, or, as described in this lab, the sun. Heat energy is transferred from the heat source (i.e., the sun) to the liquid (i.e., the water) by **conduction**, and is then moved through the water by **convection**. We can quantify this transfer of heat energy by defining it in terms of thermal units. For example, one type of thermal unit, the calorie, is defined as the amount of internal energy added to or extracted from one gram of water, which will cause the internal energy to change one degree (+ or -) Celsius.

In this lab, we will use the sun's energy to heat water. We will be able to quantify transfer of heat energy from the sun by measuring the change in water temperature caused by the energy from the sun. If we know the mass of the water and if we measure its change in temperature, we can determine the amount of energy added to the water. The equation below demonstrates the relationship between the energy gained or lost (in calories), the change in water temperature, and the mass of the water (we will assume 1mL water has mass of 1g):

$$E = (t_f - t_i) \times m$$

E = energy gained or loss (cal)
t_i = initial water temperature (°C)
t_f = final water temperature (°C)
m = mass of the water (g)

In the first part of this lab, we will heat several containers of water using the sun as the energy source. We will measure the initial temperature of the water(before exposing it to the sun) and the final temperature (after exposing it to the sun's heat energy). The change in temperature represents the amount of solar energy reaching the water and being absorbed by it. If the container is glass, the solar energy absorbed is the portion of the solar energy that is transmitted through the glass. Changing the container in some way (i.e., such as covering part of the glass surface with aluminum foil, or painting the glass black) affects the solar energy transfer. When we use aluminum foil, we can either block the sun's rays, or concentrate them, depending on how we position the container with respect to the sun. If we use a metal can, the metallic surface absorbs the heat energy, and transfers it by conduction through the metal to the water inside, where convection moves the heat through the water. If the source of energy is removed (i.e., the sun goes down), then the energy will move from the walls of the container to the surroundings until the temperature of the containers and its surroundings is the same.

Energy from the solar heated water can be removed from the water by a heat exchange mechanism. We will use a coiled metallic pipe placed in the water. If cooler water flows through the pipe, the temperature of the water leaving the pipe will be higher than that entering the pipe, because the pipe will absorb heat from the hot water. Thus, the internal energy of the water in the pipe will have been increased. Likewise, the internal energy of the water in the container will have decreased.

Objectives

- To understand the principles of transfer of heat energy
- To examine the storage of heat energy extracted from the sun
- To examine a method of transferring heat energy that has been stored
- To gain an awareness of the use of solar energy by humans

Hypotheses

The temperature of water exposed to the sun will increase.

The temperature of water passing through a coiled pipe placed the solar heated water will increase.

Materials

- glass containers with lids
  - unaltered
  - painted black
  - one side covered in aluminum foil
- thermometers
- metal tubing with 3 coils
- metal tubing with 6 coils
- plastic tubing (to connect coil to water source and to connect coil to receiving container)
- graduated receiving containers (500ml capacity)

Procedure

Week One

1. Work in groups by lab table.
2. Gather one jar as assigned below, place 1000mL of tap water in it, label with section number and group name, determine the temperature (initial temperature (t_i)) and record in Table 1 and on the overhead transparency (or blackboard), and place jar on window sill as indicated by instructor
   a. Lab table 1: jar painted black
   b. Lab table 2: clear jar
   c. Lab table 3: clear jar
   d. Lab table 4: jar with 1/2 covered with foil, place with foil facing <u>away</u> from window
   e. Lab table 5: jar with 1/2 covered with foil, place with foil facing <u>away</u> window
   f. Lab table 6: jar with 1/2 covered with foil, place with foil facing <u>toward</u> window

Week Two

1. Retrieve from the window sill the jar your group prepared last previous week.
2. Measure and record in Table 1 and on the overhead transparency (or blackboard) the final water temperature (t_f) in the container.
3. Attach the plastic tubing (as directed by instructor) to both ends of the metal tubing with 3 coils.
4. Measure and record in Table 2 and on the transparency (or the blackboard) the temperature of the water source (t_i).
5. Attach the plastic tubing from one end of the 3-coil metal tubing to the water source (as directed by instructor) and insert the plastic tubing from the other end of the 3-coil metal tubing into the receiving container.
6. Lower the plastic tubing/3-coil metal tubing into the assigned container.

7. Start the flow of water from the water source through the tubing and adjust the flow so that water trickles very slowly through the metal tubing and into the receiving container. Continue until the receiving container is filled to the 400ml mark.
8. Measure and record in Table 2 and on the transparency (or blackboard) the temperature of the water in the receiving container (t_f).
9. Repeat steps 5 through 9 using the metal tubing with 6 coils, recording the data in Table 3 and on the transparency (or blackboard).
10. Copy the data for all groups from the overhead transparency (or blackboard) onto your data sheet.

Calculations

1. Use Equation 1 (page 2) to calculate the following (assume that 1mL of water has a mass of 1g)
   a. Table 1: solar energy added to the water (cal)
   b. Table 2 & 3: Energy transferred from solar heated water to source water (cal)

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Student Name: ______________________ **Lab Date:** __________

Lab Instructor: ______________________ **Section #:** __________

Results (Data)

Table 1. Initial versus final water temperature in solar (glass) containers and solar energy added (in cal).

	Black jar	Clear		1/2 covered in aluminum foil away from sun		toward sun
Lab table #:	**1**	**2**	**3**	**4**	**5**	**6**
Water volume (mL)	1000mL	1000mL	1000mL	1000mL	1000mL	1000mL
t_i (°C) (glass jar)						
t_f (°C) (glass jar)						
Solar energy added to the water (cal)						

Table 2. Initial versus final water temperature of source water run through 3-coil metal tubing and energy transferred from solar heated water (in cal).

	Black jar	Clear		1/2 covered in aluminum foil away from sun		toward sun
Lab table #:	**1**	**2**	**3**	**4**	**5**	**6**
Water volume (mL)	1000mL	1000mL	1000mL	1000mL	1000mL	1000mL
t_i (°C) (water source)						
t_f (°C) (receiving container)						
Energy transferred from solar heated water to source water (cal)						

$$E(\text{in cal}) = (t_f - t_i) \times \text{mass}$$

Table 3. Initial versus final water temperature of source water run through 6-coil metal tubing and energy transferred from solar heated water (in cal).

	Black jar	Clear		1/2 covered in aluminum foil away from sun		1/2 covered in aluminum foil toward sun
Lab table #:	**1**	**2**	**3**	**4**	**5**	**6**
Water volume (mL)	1000mL	1000mL	1000mL	1000mL	1000mL	1000mL
t_i (°C) (water source)						
t_f (°C) (receiving container)						
Energy transferred from solar heated water to source water (cal)						

Conclusions (Questions): For full credit, questions should be answered thoroughly, in complete sentences, in legible handwriting.

1. Which container (clear, black, 1/2 foil facing sun, 1.2 foil away from sun) absorbed the most heat energy and reached the highest temperature? Which remained at the lowest temperature? Explain the differing temperatures of the containers.

2. Which type of container (clear, black, 1/2 foil facing sun, 1.2 foil away from sun) was the most efficient container in extracting solar energy as determined by the amount of solar energy added to the container in calories? Why?

3. In transferring heat energy from the heating container, through the coils, and into the receiving container, was there any difference in the amount of energy transferred by the different containers?

4. Which combination of container and number of coils allowed for the greatest transfer of energy from the original (solar) container to the receiving container? Explain.

5. Based on what you have learned in this lab, describe the type of solar water heater (the type of collector, the number of coils, and the water speed), that would be most efficient in heating water, and/or transferring the heat energy to another water source.