Lesson 14: Earth Energy

Adopted/Revised From
N/A

Grade Level
6-12

Objectives
- Predict the factors that produce the greatest geothermal temperature change
- Design a geoexchange system to implement their predictions
- Collect temperature data
- List common factors that contribute to the greatest geothermal temperature change
- Determine the effectiveness of geoexchange system for both heating and cooling

Overview
Students design a simple geoexchange system in order to both extract heat from and disperse heat into sand.

Materials (per group)
- Two (2) three to six-foot length of ½" poly drip irrigation tubing (the two lengths of tubing for a given group should be the same, but each group can have different sets of lengths)
- Two (2) ½" end caps/plugs for poly drip irrigation tubing
- Two jars, bowls, measuring cups, or similar (4-6 cup capacity each)
- One thermometer
- One trowel (optional)
- One Sterilite tub, 5 gallon bucket, or similar
- Enough sand to fill the tub or bucket 2/3^{rds} full

Estimated Cost of Materials
$15 per group

Computer Required?
No

Duration
1 class period

Primer References
1.1 Forms of Energy
3.3 Geothermal Energy

Related Articles
- "Ikea's cool new digs in Colorado to feature geothermal system" – Denver Post, September 17, 2010

Engagement

1. What do the terms “geo” and “thermal” refer to?
2. How do we usually provide heating and cooling to a home or school?
3. Why would we want to use the earth’s energy to heat and cool our homes or schools instead?

Investigation

Now we’re going to see experimentally how a geothermal system – also called geoexchange or ground-source heat pump - works:

1. Divide the students into small groups (no more than 5 per group recommended) and provide them with the materials listed.
2. Students should fill the tub 2/3 full of sand. The sand represents the ground.
3. Design a geoexchange system to maximize heat exchange between the earth and the tubing, and sketch to record the design.
4. Using the trowel, dig the trench for the tubing if necessary to follow the design.
5. Plug both lengths of the 1/2” drip tubing at 1 end with the end caps.
6. Fill a jar (or similar) with hot water or cold water, and measure the water temperature. Some groups can use hot water and others can use cold, or groups can each conduct the experiment once with hot and once with cold.
7. Temperature should be recorded in the activity sheet.
8. Quickly (to avoid temperature fluctuations from measured temperatures as much as possible) pour the water into the tubing lengths and plug the other ends. One length is to be buried and the other is to be a “control” just laid out in the classroom.
9. Quickly arrange one of their tubing lengths in a 5 gallon bucket or similar to be filled with sand. Arrangements might be circular, loops, linear, etc. Students should arrange their tubing with maximizing heat transfer between the tubing and the sand in mind.
10. Leave no tubing exposed.
11. Once the tubing is completely buried, students should start the 10 minute wait period.
12. Measure and record the temperature of both the sand and the room (air).
13. After exactly 10 minutes, pull tubing out of the sand, remove the end cap from one end of the tubing, pour the water back into the jar, and measure the temperatures of the water. Students should simultaneously pour water out of the control tubing into the other jar and measure the temperature of its water.
14. They can continue to fill out their activity sheets and draw conclusions

Class Review

1. Ask the groups to share the results of their experiments by reviewing each of the questions on the activity sheets as a class.

Elaboration

Now we have to figure out how this concept can be applied to heating and cooling a building:

1. Have students read or otherwise explain the information from the Forms of Energy and Geothermal Energy chapters of the Primer.
2. How do ground source heat pumps work?

3. Is geoexchange a practical option for your school? Why or why not? Where might the loop field be located?

Instructor Notes

1. Different groups may have different results based on the layout of their tubing in the buckets, the lengths of their tubing, starting temperatures, etc.
2. The groups using cold water should use cold enough water so that there is a significant difference between the water temperature and the sand temperature. Ice may need to be added to the cold water.
3. Greater temperature differences may be experienced by groups who start with hot water simply because the initial difference in temperature between the hot water and the sand is likely greater than the initial difference in temperature between the cold water and the sand.
4. If tubs/buckets used by groups are different, this should be noted when comparing temperature fluctuations.

Extensions and Variations

- You may want to start students with all the same lengths of tubing and then have them repeat their experiment with different lengths of tubing, different layouts, and using different buckets (i.e. shallow vs. deep), changing just one variable at a time to compare the effects of different variables on temperature fluctuations.
- If sand is available and accessible at your school's playground, students can replicate this experiment outside using longer runs of tubing. They can experiment with horizontal loops and vertical loops if a decent garden shovel is provided.

References/For More Information

U.S. Department of Energy:
http://www.energysavers.gov/your_home/space_heating_cooling/index.cfm/mytopic=12640

Colorado Geothermal Working Group:
http://coloradogeothermal.groupsite.com/main/summary

Earth Energy

Experiment Number	Length of Tubing (ft.)	Type of Container	Temperature of Water - Start (F)	How is Buried Tubing Arranged (i.e. loop, linear, etc.)?	Temperature of Sand (F)	Temperature of Air (F)	Buried Tubing: Temperature of Water - End (F)	Control Tubing: Temperature of Water - End (F)	Temperature Change of Buried Water (F)	Temperature Change of ControlWater (F)	Percent Temperature Change of Buried Water	Percent Temperature Change of Control Water

Questions

1. Which experiment (one of yours or a classmates) resulted in the greatest water temperature change?

2. What factor - length of tubing, type of container, starting temperature of the water, temperature of the sand/air, the absorption capacity of sand/air, or layout of the tubing - do you believe had the greatest impact on temperature change? Why?

3. Where did thermal energy move from and to in your experiments?

4. Could geoexchange be used for both heating and cooling a building? Why or why not?