GEOTHERMAL ENERGY

Heat Transfer

OBJECTIVE:

Understand water displacement due to temperature's impact on density and discover the relationship of science and innovation in geothermal systems.

ESSENTIAL QUESTIONS:

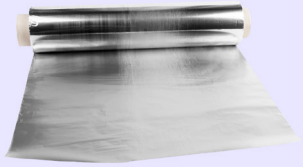
How does water density support geothermal energy systems?

Where and how can geothermal energy systems be used?

MATERIALS:

Heat Transfer Materials

2 Clear Glass Jars



Aluminum Foil

A Pencil

Hot Water

Food Dye

Cold Water

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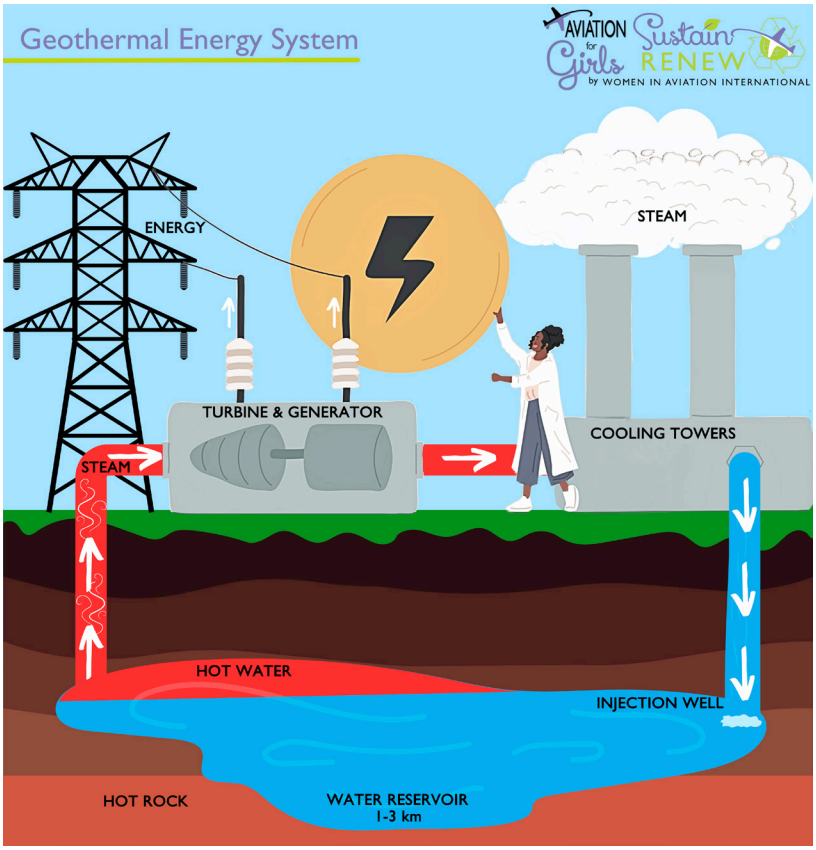
BACKGROUND INFORMATION:

Geothermal energy is heat energy that comes from the Earth. It can be used to generate electricity and heat and cool buildings, like airport terminals. It works by drilling wells into the Earth and pumping water down to a reservoir at approximately 1-3 kilometers deep.

As the temperature inside the Earth increases by 25-30 degrees Celsius with every kilometer of depth, this natural heat is used to heat the water injected into the reservoir.

Due to the density of water decreasing as temperature increases, hot water rises up and produces steam that drives turbines that generate electricity. The water is then pumped to cooling towers and recycled to be injected back into the reservoir.



Geothermal power plants produce 99% less carbon dioxide and greenhouse gas emissions compared to similar sized fossil fuel power plants. There are multiple airports with geothermal energy systems in place to support heating, cooling and produce electricity through geothermal renewable resources such as the Louisville Muhammad Ali International Airport (SDF) in Louisville, Kentucky, the Nashville International Airport (BNA) in Nashville, Tennessee, the Vancouver International Airport (YVR) in Richmond, British Columbia, and the Paris-Orly Airport (ORY) in Orly, France.

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MANAGEMENT:

1. 15-30 minutes
2. In a classroom setting work in small groups to follow the step procedures on page 4. One student can be in charge of cold water, one for hot water, and one for foil and the recording notes on the observation sheet.
3. For events, demonstrate with larger groups and engage through assistants. One participant can add red dye, one blue, one can pour the cold water etc and everyone can work on their own observation sheet.
4. Have cleanup materials on hand or consider using cookie trays to contain potential spills.

WORD BANK:

Drag – the air resistance encountered as an aircraft tries to move forward
Geothermal Energy – Heat energy sourced from the Earth and is a renewable resource
Density – the weight of a substance for a specific volume
Greenhouse Gas Emissions – the release of gases like carbon dioxide, methane, and nitrous oxide into the atmosphere from burning non-renewable resources like fossil fuels for energy and transportation

Education Standards:

NGSS

K-2-ETS1-1. Ask questions, make observations, and gather information about a situation people want to change to define a simple problem that can be solved through the development of a new or improved object or tool.

4-PS3-2. Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.

4-ESS3-1. Obtain and combine information to describe that energy and fuels are derived from natural resources and their uses affect the environment.

MS-PS1-4. Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed.

HS-PS3-4. Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics).

ITEEA Standards for Technological and Engineering Literacy:

STEL-1F - Describe the unique relationship between science and technology, and how the natural world can contribute to the human-made world to foster innovation.

STEL-1N - Explain how the world around them guides technological development and engineering design.

STEL-8A - Analyze how things work.

Common Core State Standards for ELA Literacy

CCSS.ELA-LITERACY.W.2.8
Recall information from experiences or gather information from provided sources to answer a question.

CCSS.ELA-LITERACY.W.4.1
Write opinion pieces on topics or texts, supporting a point of view with reasons and information.

CCSS.ELA-LITERACY.W.4.7
Conduct short research projects that build knowledge through investigation of different aspects of a topic.

CCSS.ELA-LITERACY.RST.6-8.3
Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.

Common Core State Standards for Math

CCSS.MATH.PRACTICE.MP4
Apply the mathematics to solve problems arising in everyday life, society, and the workplace.

CCSS.MATH.CONTENT.3.MD.A.2
Measure and estimate liquid volumes and masses of objects using standard units of grams (g), kilograms (kg), and liters (l). Add, subtract, multiply, or divide to solve one-step word problems involving masses or volumes that are given in the same units, e.g., by using drawings (such as a beaker with a measurement scale) to represent the problem.

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PROCEDURE:

Heat Transfer Steps

STEP 1

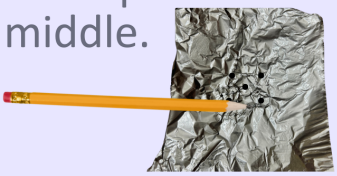
Chill and heat water. Use ice to create cold water.

STEP 2

Add one drop of blue food coloring in a clear cup. In a separate cup, add one drop of red.

STEP 3

Prepare four sheets of aluminum foil or plastic with a few holes poked in the middle.



STEP 4

Fill the blue cup with cold water. Fill the red cup with hot water. Fill cups to the tippy top!

STEP 5

Cover the red cup with a piece of foil. Flip and stack on the blue cup.

STEP 6

Flip both cups so the cool is on top of the hot.

Make observations!

DISCUSSION QUESTIONS:

1. Why does the water stay separated when the hot is on top?
2. What happens to the water when the cold is on top?
3. What natural elements support the geothermal system?
4. Where can geothermal energy be used?
5. What is the relationship between science, nature, and technology in geothermal energy systems?
6. What are some potential challenges and solutions to geothermal energy systems?

Heat Transfer

EXTENSIONS:

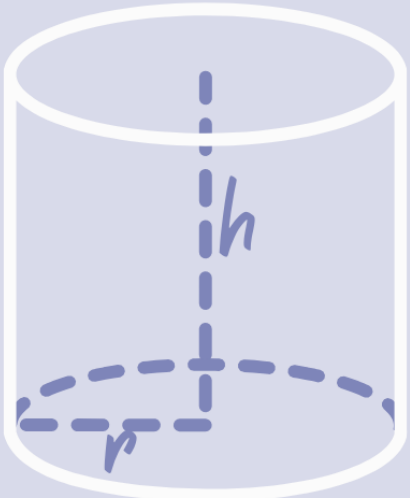
Measure the temperature with a thermometer to determine what temperature difference allows the hot water to not mix with the cool water.

Find the volume of your container and measure the temperature of your hot and cold liquid to calculate mass using the Water Density Chart. After you calculate the mass, determine the potential energy of the water.

1. Calculate the filled volume of a horizontal cylinder tank.
2. Volume(V) = π x radius(r)2 x height(h)
3. Measure the water's temperature and use the Water Density Table and Volume to calculate the mass.
4. Mass(m) = Density(p) x Volume(V)
5. Calculate the potential energy of water using the mass according to Einstein's theory of mass-energy equivalence. The energy contained within a certain amount of water is equivalent to its mass(m) multiplied by the speed of light squared (c2 = 299792458 m/s)
   Energy (E)= mass (m) x c2 (speed of light squared)

Water Density Table

Temperature(°F/°C)	Density(grams/cm3)	Weight(pounds/ft3)
32°F/0°C	0.99987	62.416
39.2°F/4.0°C	1.00000	62.424
40°F/4.4°C	0.99999	62.423
50°F/10°C	0.99975	62.408
60°F/15.6°C	0.99907	62.366
70°F/21°C	0.99802	62.300
80°F/26.7°C	0.99669	62.217
90°F/32.2°C	0.99510	62.118
100°F/37.8°C	0.99318	61.998
120°F/48.9°C	0.98870	61.719
140°F/60°C	0.98338	61.386
160°F/71.1°C	0.97729	61.006
180°F/82.2°C	0.97056	60.586
200°F/93.3°C	0.96333	60.135
212°F/100°C	0.95865	59.843



$V = \pi r^2 h$

$m = pV$

$E = mc^2$

Heat Transfer

CULMINATING ACTIVITY:

Make connections to density altitude in aviation. Apply the same principle of decreasing density with heat and calculate density altitude. Density Altitude = Pressure Altitude + (120 x (Outside Air Temperature (OAT °C) – International Standard Atmosphere Temperature (ISA °C))

Research geothermal airports. Discover how they were built and what energy, cooling, and heating support they cover at the airport.

Heat Transfer

Sustain RENEW

AVIATION for Girls BY WOMEN IN AVIATION INTERNATIONAL

Warm Over Cold

Hypothesis:

Observations:

Illustrate Result:

Cold Over Warm

Hypothesis:

Observations:

Illustrate Result:

Conclusions: