Energy Resources and Use

Renewable and Non-Renewable Energy Use and Global Climate Change

Description

To demonstrate the sustainability of renewable energy as an alternative to nonrenewable energy, students will use green and orange beads to track the available energy throughout time as energy consumption increases.

Phenomenon

Human behavior is changing Earth's atmosphere and affecting the climate.

Objectives

Students will:

- Explain relationships between energy consumption, human population, methods of energy production, and global climate change
- Identify the need for increased use of renewable energy sources
- Identify large-scale trends in energy production and consumption

Grade Level

5 – 8

Time

1 Hour

Materials

- *Energy Resources and Use* handout [1 per student]
- PowerPoint presentation
- Computer and projector*
- Paper bags with country names and beads [2 bags for each country; 14 total]
  - Sweden: 37 green beads, 63 orange beads
  - United States: 8 green beads, 92 orange beads
  - China: 8 green beads, 92 orange beads
  - Mexico: 10 green beads, 90 orange beads
  - Brazil: 42 green beads, 58 orange beads
  - New Zealand: 47 green beads, 53 orange beads
  - Canada: 16 green beads, 84 orange beads
- Ziploc bags to place orange (non-renewable) beads in [14 total]
- Containers for counting beads [14 total]
- Also included in kit – bead master list for teacher reference

* Not included in kit

Background

As we saw in Energy Audit, human consumption of energy contributes to global climate change. Producing electricity to power household appliances and electronics often requires burning fossil fuels and releasing greenhouse gases into the atmosphere. Additionally, burning fossil fuels for transportation and industry releases greenhouse gases, further enhancing the greenhouse effect and trapping more

thermal energy. As modeled in Insulating You, Insulating Earth, one consequence of an enhanced greenhouse effect is increasing global temperatures, which change regional climates.

Not only does burning fossil fuels contribute to climate change, but the global use of fossil fuels for energy production is unsustainable long-term. Fossil fuels, nonrenewable energy resources, take millions of years to produce. Humans are using fossil fuels at a significantly faster rate than they can be replenished. While there are many advantages to fossil fuels (e.g., accessible, inexpensive), there is a finite amount of fossil fuels, and the use of them releases greenhouse gases into our atmosphere.

As the global population rapidly moves towards eight billion, the way humans produce and consume energy will enter the spotlight. With an increasing global population and increasing energy consumption per capita, energy demands will increase. In time, fossil fuel resources will deplete, forcing humans to transition to alternative energy sources.

Renewable energy sources (e.g., solar, wind, hydroelectric) can be replenished at a similar rate to their use. Renewable energy is more sustainable long-term than nonrenewable energy, but production methods can be expensive and cause ecological damage. This lesson exposes the large-scale human behavior that is changing the composition of Earth's atmosphere resulting in climate change while also giving students background on renewable and nonrenewable energy. Students will explore how population and energy demands can affect a country's ability to meet its energy needs and how the use of nonrenewable energy sources has both societal and environmental impacts.

Tips from Teachers:

- Consider assigning countries to groups randomly.

Tips for Entire Class Participation

- Have students work in small groups (1-3 students each) to collect data.
- Within small groups, students can take on different roles. One student can pull beads from the bag; another can collect the data and write it in the table on the handout.
- Due to the large number of groups, some students can work independently while others work in groups (dependent on class size).

Preparation

1. Plan to break students into 14 groups of 1-3 students each.
2. Draw the whole class data tables for both Part 1: Constant Energy Consumption and Part 2: Increasing Energy Consumption found in the handout on the board, or be prepared to show them with a document camera.
3. Have paper bags with beads, Ziploc bags, and containers for counting beads ready to distribute.
4. Set up a computer and projector and display the PowerPoint presentation.

Teaching Guide

Introduction: Renewable and Non-Renewable Energy (~5 minutes)

1. Slide 2: Remind students of the phenomenon of the energy module: Human behavior is changing Earth's atmosphere and affecting the climate.
    a. Remind students of Insulating You, Insulating Earth; they used a model to examine the effect of increased greenhouse gases in the atmosphere. Have students recall the human behavior that is the source of the greenhouse gas emissions that are changing Earth's atmosphere: burning fossil fuels for energy production emits carbon dioxide and other greenhouse gases into the atmosphere.

b. Remind students of Energy Audit; they looked closely at how their own energy use contributes to the release of greenhouse gases into Earth's atmosphere. Explain that in this lesson, students will look at large-scale energy use to understand how human behavior changes the Earth's atmosphere and other implications of this behavior, such as unsustainable energy consumption.

2. Slide 3: To better understand how energy is produced and used on a large scale, it is helpful to distinguish between renewable and nonrenewable energy resources.
    a. Renewable energy sources are replenished at a rate similar to the rate at which they are being consumed.
    b. Nonrenewable resources are not replenished at a rate similar to the rate of consumption.
    c. There is some gray area with the classification of renewable and nonrenewable energy. For example, biomass energy cannot be replenished at the same rate it is used because it requires the growth of an organism. Still, it is often considered renewable because it replenishes much faster than fossil fuels.
    d. Different types of energy can contribute to climate change at different rates. Typically, renewable energy sources emit less carbon dioxide and other greenhouse gases than nonrenewable energy sources.

Constant Energy Consumption (~15 minutes)

1. Slide 4: Explain that we are going to explore how different countries use energy and the implications of this behavior on both the composition of the atmosphere and the sustainability of their energy resources.
    a. Give each student an *Energy Resources and Use* handout.
    b. Divide students into 14 groups (1-3 students per group). Give each group a bag of pre-counted beads with a different amount of renewable energy (green beads) and non-renewable energy (orange beads).
    c. Explain that their bags represent different countries.
    d. Each bag has 100 beads representing 100% of the energy that country consumes. The percentage of green beads represents the percentage of that country's energy consumption from renewable sources; the percentage of orange beads represents the percentage of that country's energy consumption from nonrenewable sources. These percentages come from real data from each country (https://irena.org/Statistics/Statistical-Profiles).
    e. This activity will allow us to understand the degree to which different countries contribute greenhouse gases to the Earth's atmosphere.
2. Explain how students will complete Part 1: Constant Energy Consumption.
    a. Slide 5: Tell students that they will model energy consumption in their country each year by randomly drawing ten beads from their bag. Part 1 has five rounds representing five years of constant energy consumption.
    b. Slide 6: Each time they remove beads from the bag, they will count how many green beads and how many orange beads were in their sample and record the data in the table on their handout.
    c. Students set aside the orange beads into their Ziploc bag and place the green beads back into their paper bag. This models the difference between nonrenewable energy and renewable energy. The nonrenewable energy is not available again after it is used, while the renewable energy regenerates at the same rate that it is consumed. Remind students that nonrenewable energy sources release greenhouse gases into the atmosphere.
    d. Students fill out the final column, indicating how many beads are remaining in their bag after removing orange beads each year. Point out that each year after year one, they subtract the orange beads removed from the total in the year prior, not from 100.

3. Slide 7: Introduce the seven countries that students will be modeling and have students write their country name on top of their data table in Part 1 on their handout. There will be two groups for each country, and we will examine the results at the end of Part 1. Leave this slide up as students complete Part 1: Constant Energy Consumption. Students will complete five years of energy consumption.
4. Slide 8: After five years are complete, students report how many energy beads they had remaining in their bag.
    a. Have students report their data and write it in the Part 1: Whole Class Data table on the board. Remind students that they need to complete this data table on their handout as other groups report.
5. Slide 9: This shows the actual percentages of renewable and nonrenewable energy used by each country. It reflects the number of beads of each color in the bag for each country at the start of the trial. Have students use the whole class data and the data on this slide to complete Part 1: Results on their handout.

Background Information: Types of Energy Production (~15 minutes)

1. Slide 10: Explain that we are going to review different types of energy production.
    a. As each slide comes up, decide as a group whether the type of energy production is renewable or nonrenewable.
    b. As you go through the slides, have students complete the table on page 2 of their handout indicating whether each type of energy is renewable or nonrenewable and listing one advantage and one disadvantage of each type of energy.
2. Slide 11: Review the difference between renewable and nonrenewable energy.
    a. Remind students that renewable energy sources emit fewer greenhouse gases than nonrenewable energy sources. Choices around energy production are examples of human behavior that affect Earth's atmosphere and ultimately cause climate change.
3. Slide 12: Solar energy – renewable
    a. Solar energy is radiant energy produced by the sun that humans can harness for power.
    b. Photons (particles of light) knock electrons loose in a solar panel, creating an electrical current.
    c. The largest solar power plant in New Mexico is the Roswell and Chaves County Solar Energy Centers near Roswell, NM.
    d. Completed in 2020, the Noor Complex Solar Power Plant in Morocco is the largest solar energy plant in the world.
    e. Advantages of solar energy include: renewable, can go on roofs, silent, does not directly emit greenhouse gases.
    f. Disadvantages of solar energy include: expense, intermittent, dependent on weather, can cause pollution during production.
4. Slide 13: Wind energy – renewable
    a. Wind energy captures the kinetic energy produced by wind and harnesses it for power.
    b. Wind turbines (propellers) are connected to a generator to generate electricity.
    c. The largest wind energy center in New Mexico is Sagamore Wind Farm in Roosevelt County, NM.
    d. The largest wind energy center in the world is the Gansu Wind Farm in China.
    e. Advantages of wind energy include: does not produce pollution, can be placed on existing farms, renewable, does not directly emit greenhouse gases.
    f. Disadvantages of wind energy include: threats to wildlife, not aesthetically pleasing, expensive to set up.
5. Slide 14: Fossil fuels (coal, oil, and natural gas) – nonrenewable

a. Fossil fuels are formed from the remains of dead organisms buried by geologic processes and placed under high heat and pressure.
b. These combustible materials are used as chemical energy (fuel) to boil water, produce steam, which is used to generate electricity (see slide 15 for more details).
c. The advantages of fossil fuels include: abundant (coal and natural gas), cheap (although actual costs may not yet be accounted for), uses well-developed technology.
d. The disadvantages of fossil fuels include: CO_2 and other greenhouse gases released to the atmosphere, dangerous to mine, damages landscape, nonrenewable.

6. Slide 15: This image shows how fossil fuels are used to create electricity.
    a. In electricity production from fossil fuels, the fuel source (coal, oil, or natural gas) is burned; you can see this in the image where it says, "chemical energy turned into heat." Fossil fuels are chemical energy.
    b. The thermal energy generated from burning fossil fuels is used to boil water. The steam from the boiling water is then captured to turn turbines.
    c. As the turbines rotate, they turn a generator. The kinetic energy of the generator rotation is harnessed to produce electricity, which is then delivered to your home via powerlines.
    d. Notice that the fossil fuels were simply the fuel source to get the turbines rotating. Many renewable energy options, such as wind, hydroelectric, and geothermal, are merely using a different method to get the turbines spinning.
6. Slide 16: Hydroelectric energy – renewable
    a. Hydroelectric energy captures the kinetic energy in the movement of water as gravity pulls it downwards and uses that energy for power.
    b. The downward flow of water drives turbines that produce electricity.
    c. The largest hydroelectric facility in NM is the Navajo Dam on the San Juan River.
    d. The largest hydroelectric facility in the world is Three Gorges Dam in Hubei, China, on the Yangtze River.
    e. Advantages of hydroelectricity include: renewable, can be flexible dependent on energy needs (can release water from the dam when energy is needed), dams can last for a long time, does not directly emit greenhouse gases.
    f. Disadvantages: can damage the environment, harm wildlife, and displace people; expensive to build; breeches in dams can lead to flooding and deaths.
7. Slide 17: Geothermal energy - renewable
    a. Geothermal energy production harnesses thermal energy derived from inside the Earth and uses it for power. Steam from the Earth is captured to drive turbines that generate electricity.
    b. The largest geothermal plant in New Mexico is the Lightning Dock Geothermal Plant near Lordsburg, NM.
    c. The largest geothermal plant in the world is a series of plants called The Geysers in the Mayacamas Mountains, CA.
    d. The advantages of geothermal energy include: renewable, long-lasting, uses thermal energy that is already there rather than producing new thermal energy, not weather dependent, does not directly emit greenhouse gases.
    e. The disadvantages of geothermal energy include: expensive installation, requires water and electricity to operate, can cause environmental damage.

Increasing Energy Consumption (~15 minutes)

1. Slide 18: Introduce Part 2: Increasing Energy Consumption
    a. Ask students if they can identify any limitations to our model in Part 1: Constant Energy Consumption. Are people globally using the same amount of energy year after year? [answer: no, globally humans are using an increasing amount of energy].

b. Explain that we are seeing a global increase in energy demand. Ask students what is causing an increase in the need for energy? [answer: population growth, technology, increasing temperatures].
c. Show students the United States Census Bureau website with the estimated current United States Population and World Population. http://www.census.gov/popclock/
    i. Ask students how they think population increases affect our energy demand? [answer: more energy needed].
    ii. Ask students to consider how an increase in population will affect the atmosphere's composition in the long run? [answer: a greater need for energy will affect the composition of the atmosphere if we continue to rely on burning fossil fuels to meet the increased demand]

2. Slide 19: Explain procedures for Part 2 data collection.
    a. Students will follow the same procedures as Part 1, but they will increase their energy consumption each year.
    b. This is meant to model an increase in energy consumption per capita and an increase in the global population.
    c. Now that we understand how renewable energy sources are more sustainable long-term, we will test that sustainability against increasing consumption.
    d. Have students run the model again, increasing their consumption by ten beads per year.
    e. Students will stop after five years OR when their consumption (number of beads to remove) exceeds the number of beads they have remaining. For example, the United States and China will likely not make it to five years, so students can stop after four years. This indicates that their country could no longer meet the needs of the energy demand.
    f. Have students share their energy remaining at five years OR their energy remaining after four years if they did not make it to five years (for these countries, make a note with an asterisk in the data table that these countries did not make it five years). As students share their results, write them in the class data table on the board and have students complete the class data table in Part 2 of their handout.

Results and Conclusions (~10 minutes)

1. Have students respond to Part 2: Results question 1.
2. Slide 20: Energy Use and Climate Change. Explain the graphic on this slide.
    a. Continued use of fossil fuels will further release CO_2 and other greenhouse gases into Earth's atmosphere, causing increased climate change.
    b. Increased temperatures can cause an increased demand for electricity for cooling systems.
    c. The graph shows that heating degree-days are decreasing, which means that the number of days where heating is used is decreasing (a result of warmer temperatures). There is less need to heat buildings because temperatures outside are warmer.
    d. Cooling degree-days are increasing. This means that the number of days where cooling is used is increasing (also a result of warmer temperatures). There is more need to cool buildings because temperatures outside are warmer. There has been, and it is predicted there will continue to be, more demand for electricity to power air conditioning systems.
    e. Climate change will affect the way we use energy, and the way we use energy affects the rate of climate change. If the number of days we need energy to heat homes decreases, we will use less energy; this decrease in energy may be offset by the increased energy required to cool our homes. Often, cooling requires more energy than heating. Rising global temperatures could result in an increased need for energy in the long run.
3. Slide 21: Have students respond to Conclusion questions 1 – 2 on page 4 of their handout.