Energy Resources and Use

Renewable & Non-Renewable Energy Use in Countries Around the World

Description

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

Grade Level

5 – 12

Objectives

Students will:

- Identify the need for increased dependence on renewable energy sources
- Explain relationships between energy consumption, human population, and methods of energy production

Time

1 Hour

Common Core State Standards

English Language Arts Standards >> Reading: Informational Texts >> Grade 5
CCSS.ELA-LITERACY.RI.5.4: Determine the meaning of general academic and domain-specific words and phrases in a text relevant to a grade 5 topic or subject area.

English Language Arts Standards >> Speaking & Listening >> Grade 5
CCSS.ELA-LITERACY.SL.5.1: Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 5 topics and texts, building on others' ideas and expressing their own clearly.

English Language Arts Standards >> Science & Technical Subjects >> Grade 6-8
CCSS.ELA-LITERACY.RST.6-8.3: Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.
CCSS.ELA-LITERACY.RST.6-8.4: Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6-8 texts and topics.

English Language Arts Standards >> Science & Technical Subjects >> Grade 9-10
CCSS.ELA-LITERACY.RST.9-10.3: Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text.
CCSS.ELA-LITERACY.RST.9-10.4: Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 9-10 texts and topics.

English Language Arts Standards >> Science & Technical Subjects >> Grade 11-12
CCSS.ELA-LITERACY.RST.11-12.3: Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text.
CCSS.ELA-LITERACY.RST.11-12.4: Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 11-12 texts and topics.

New Mexico State Science Standards

(Strand – Standard – Benchmark – Performance Standard)

5th Grade
1-1-1-1: Plan and conduct investigations, including formulating testable questions, making systematic observations, developing logical conclusions, and communicating findings.
1-1-1-3: Use graphic representations (e.g., charts, graphs, tables, labeled diagrams) to present data and produce explanations for investigations.
1-1-3-3: Make predictions based on analyses of data, observations, and explanations.
2-1-2-3: Know that there are different forms of energy.
2-2-1-4: Describe how human activity impacts the environment.

6th Grade
1-1-1-3: Justify predictions and conclusions based on data.
1-1-3-2: Use probabilities, patterns, and relationships to explain data and observations.
3-1-1-1: Examine the role of scientific knowledge in decisions (e.g., space exploration, what to eat, preventive medicine and medical treatment).

7th Grade
1-1-1-2: Use models to explain the relationships between variables being investigated.
2-1-2-1: Know how various forms of energy are transformed through organisms and ecosystems, including: effect of mankind's use of energy and other activities on living systems (e.g., global warming, water quality).

8th Grade
1-1-1-2: Use a variety of technologies to gather, analyze and interpret scientific data.
2-1-2-3: Distinguish between renewable and nonrenewable sources of energy.

Developed by the Asombro Institute for Science Education (www.asombro.org)

3-1-1-1: Analyze the interrelationship between science and technology (e.g., germ theory, vaccines).
3-1-1-4: Critically analyze risks and benefits associated with technologies related to energy production.

9th – 12th Grade
1-1-1-4: Convey results of investigations using scientific concepts, methodologies, and expressions, including: scientific language and symbols, diagrams, charts, and other data displays, mathematical expressions and processes (e.g., mean, median, slope, proportionality, clear, logical, and concise communication, reasoned arguments.
2-2-1-4: Critically analyze how humans modify and change ecosystems (e.g., harvesting, pollution, population growth, technology).
3-1-1-3: Evaluate the influences of technology on society (e.g., communications, petroleum, transportation, nuclear energy, computers, medicine, genetic engineering) including both desired and undesired effects, and including some historical examples (e.g., the wheel, the plow, the printing press, the lightning rod).
3-1-1-9: Describe how scientific knowledge helps decision makers with local, national, and global challenges (e.g., Waste Isolation Pilot Project [WIPP], mining, drought, population growth, alternative energy, climate change).

Next Generation Science Standards

5th Grade
5-ESS3-1: Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources and environment.

Middle School
MS-ESS2-1: Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process.
MS-ESS3-3: Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.
MS-ESS3-4: Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems.

High School
HS-ESS3-1: Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.
HS-ESS3-2: Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.

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: 74 green beads, 26 black beads
  - United States: 13 green beads, 87 black beads
  - China: 22 green beads, 78 black beads
  - Mexico: 19 green beads, 81 blacks beads
  - Brazil: 93 green beads, 7 black beads
  - New Zealand: 80 green beads, 20 black beads
  - Canada: 75 green beads, 25 black beads
- Ziploc bags to place black (non-renewable) beads in [14 total]
- Containers for counting beads [14 total]

* Not included in kit

Background

Human production and consumption of energy is the primary contributing factor to global climate change. Burning fossil fuels for electricity generation, transportation, and industry releases greenhouse gases into our atmosphere, enhancing the greenhouse effect and trapping more thermal energy. The effects of an enhanced greenhouse effect are increasing global temperatures and climate change.

In addition to releasing greenhouse gases, the global use of fossil fuels for energy production is unsustainable long-term. Fossil fuels, a non-renewable energy resource, 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 to our atmosphere.

As the global population rapidly moves towards 8 billion, the way humans produce and consume energy will come into the spotlight. With an increasing global population, as well as 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 non-renewable energy, but production methods can be expensive to install and can cause ecological damage. This lesson gives students background on renewable and non-renewable energy, examples of each, and an opportunity to explore how population and energy demands can impact a country's ability to meet its energy needs.

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 that are 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 to students.
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: Review the greenhouse effect with students using the diagram from *Insulating You, Insulating Earth*.
    a. Ask students to think back to the experiment with the towels and space blankets and which trial produced a greater temperature increase [answer: towel + space blanket].
    b. Encourage students to think back to the model they used to examine the greenhouse effect. What did the space blanket represent in the model? [answer: extra carbon dioxide and other greenhouse gases in the atmosphere from burning fossil fuels for energy production].
    c. Explain that in this lesson we are going to explore how different countries use different types of energy and learn more about types of renewable energy that can be a substitute for fossil fuels.
2. Slide 3: Energy resources can be classified into two categories: renewable and non-renewable.
    a. Renewable energy sources are replenished at a similar rate to the rate in which they are being consumed.
    b. Non-renewable resources are not replenished at a similar rate.
    c. It may be important to note that there is some gray area with the classification of renewable and non-renewable energy. For example, biomass energy cannot be

replenished at the same rate it is used because it requires the growth of an organism, but it is often considered a renewable energy because it replenishes much faster than fossil fuels.

Procedures: Constant Energy Consumption (~15 minutes)

1. Slide 4: Explain that we are going to explore how different countries are able to meet their energy needs by looking at the amount of renewable versus non-renewable energy each country uses.
    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 (black beads).
    c. Explain that their bags represent different countries.
    d. Each bag has 100 beads representing 100% of the energy that country consumes. The percent green represents the percent of that country's energy consumption that comes from renewable sources; the percent black represents the percent of that country's energy consumption that comes from non-renewable sources. You can explain to students that these percentages are based on real data of how much renewable and non-renewable energy each country uses.
2. Explain how students will complete Part 1: Constant Energy Consumption.
    a. Slide 5: Tell students that they will model the energy consumption in their country each year by removing 10 beads from their bag. Part 1 has five rounds representing five years of energy consumption.
    b. Slide 6: Each time they remove beads from the bag they will count how many green beads and how many black beads were in their sample. They record the number of green beads in the column "Renewable (green) energy beads consumed (out of 10)" and the number of black beads in the column "Non-renewable (black) energy beads consumed (out of 10)".
    c. Students set aside the black beads into their Ziploc bag and place the green beads back into their paper bag.
    d. Explain that this models the difference between non-renewable energy and renewable energy. The non-renewable energy is not available again after it is used, while the renewable energy regenerates at the same rate that it is consumed.
    e. Students fill out the final column, indicating how many beads are remaining in their bag after the removal of black beads each year. Point out that each year after year one, they subtract the black beads removed from the total from the year prior, not from 100.
3. Slide 7: Introduce the seven countries that students will be modeling.
    a. Have them make a prediction in Part 1 on their handout. "I think that (country) will have the most energy remaining after five years."
        i. Many students may reference the image they saw on Slide 4 and predict that Sweden will have the most energy remaining. Encourage students to draw on any background knowledge they have of these seven countries to make their prediction, reminding them that there are five other countries that were not shown.
    b. Ask students to share their prediction if they would like, giving an explanation for why they chose that country.
    c. Have students write their country name on top of their data table in Part 1 on their handout.
4. Slide 8: Leave this slide up as students complete Part 1: Constant Energy Consumption.
    a. Students will complete five years of energy consumption.

b. After five years are complete, they report how many energy beads they had remaining in their bag at the end of five years.
c. Have students report their data and write it on the Part 1: Whole Class Data on the board. Remind students that they need to complete this data table on their handout as other groups report.

5. Slide 9: Have students complete Part 1: Results.

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

1. Slide 10: Explain that we are going to take some time 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 non-renewable.
    b. Have students complete the table on page 2 of their handout, indicating whether each type of energy is renewable or non-renewable and listing one advantage and one disadvantage of each type of energy.
2. Slide 11: Review the difference between renewable and non-renewable types of energy.
    a. Encourage students to think about these definitions as they learn about different types of energy production.
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 Hatch Solar Energy Center. When it was built in 2011, it was the largest solar power plant in North America.
    d. Completed in 2014, Ivanpah Solar Electric Generating System is the largest solar power plant in the world. It is located in the Mojave Desert, CA.
    e. Advantages of solar energy include: renewable, can go on roofs, silent.
    f. Disadvantages of solar energy include: expensive, 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 northeast of Fort Sumner, NM.
    d. The largest wind energy center in the world is Alta Wind Energy Center in Tehachapi Pass, CA.
    e. Advantages of wind energy include: does not produce pollution, can be placed on existing farms, renewable.
    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) – non-renewable
    a. Fossil fuels are formed from the remains of dead organisms that were buried by geologic processes and placed under high heat and pressure.
    b. These combustible materials are used as the chemical energy (fuel) to boil water, produce steam, and produce electricity (see slide 15 for more details).
    c. The advantages of fossil fuels include: abundant (coal and natural gas), cheap (although true costs may not yet be accounted for), uses technology that is well developed.
    d. The disadvantages of fossil fuels include: CO_2 and other emissions, dangerous to mine, damages landscape, non-renewable.
    e. Slide 15: This image shows how fossil fuels are used to create electricity.

i. 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." The fossil fuels are the chemical energy.
ii. 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.
iii. As the turbines rotate, they turn a generator. The kinetic energy of the rotation inside the generator is harnessed to produce electricity.
iv. This electricity is then moved to your home.
v. Notice that the fossil fuels were simply the fuel source to get the turbines rotating. Many renewable energy options are simply using a different method to get the turbines spinning, such as wind, hydroelectric, and geothermal.

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. Downward flow of water drives turbines that produce electricity.
    c. The largest hydroelectric facility in New Mexico 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 dam when energy is needed), dams can last for a long time.
    f. Disadvantages: can damage environment, 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 the earth and uses it for power.
    b. Steam from the earth is captured to drive turbines that generate electricity.
    c. The largest geothermal plant in New Mexico is the Dale Burgett Geothermal Plant in Lordsburg, NM.
    d. The largest geothermal plant in the world is a series of plants called The Geysers in the Mayacamas Mountains, CA.
    e. 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.
    f. The disadvantages of geothermal energy include: expensive installation, require water and electricity to operate, can cause environmental damage.

Procedures: 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 to students we are seeing a global increase in energy demands. Ask students: what is causing an increase in the demand 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 like these affect our demand for energy? [answer: more energy needed].
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 both an increase in energy consumption per capita, as well as an increase in population globally.
c. Now that we understand how renewable energy sources are more sustainable long-term, we are going to test that sustainability against increasing consumption.
d. Have students run model again, increasing their consumption by 10 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 after four years 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 questions 1 – 2.
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 the Earth's atmosphere, causing increased climate change.
    b. Increased temperatures can mean for an increased demand for electricity for cooling systems.
    c. In the graph, heating degree-days are decreasing. This 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 will continue to be, more demand for electricity to power air conditioning systems.
    e. Climate change will impact the way we use energy. 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 increasing energy needed to cool our homes. Often, cooling requires more energy than heating. Increasing global temperatures could result in an increased need for energy in the long run.
3. Have students respond to Conclusion questions 1 – 2 on page 4 of their handout.

This lesson has been adapted for New Mexico Climate Champions from "Renew-a-Bead" by TeachEngineering. <https://www.teachengineering.org/activities/view/cla_activity1_renewable>