Youth Education & Interpretation It's in Our Nature

"Coal Cookies": A Limited Resource

MISSOURI DEPARTMENT OF NATURAL RESOURCES

GRADE LEVEL:

Elementary/Middle School

SUBJECT AREAS:

Sciences

DURATION:

Preparation Time: 20 minutes

Activity Time: one to two 50-minute class sessions

SETTING:

Classroom

SKILLS:

Application, Analysis, Synthesis, Evaluation

KEY WORDS:

Raw materials, nonrenewable, renewable, fossil fuels, coal

SUMMARY

Students will mine a cookie for "coal" (chocolate chips) and compare the estimated amount of chocolate chip reserves with the actual amount recovered. The activity is designed to help students experience the limited nature of nonrenewable fuel resources and issues of predicting how long fossil fuel resources will last.

OBJECTIVES

THE STUDENT WILL:

- Estimate the amount of resources, as represented by chocolate chips, found in a chocolate chip cookie
- "Mine" the cookie to determine the actual amount of chocolate chip reserves and compare to estimated yields
- Evaluate the environmental impact caused by coal mining and coal consumption
- Discuss the difference between the total amount of coal available and the amount that can be practically obtained
- Explore the difference between nonrenewable and renewable energy sources
- Predict the role of renewable energy sources in the future

MATERIALS

FOR EACH STUDENT:

- Paper clip or toothpick
- Paper plate or napkin
- Small paper cup
- *Chocolate Chip Reserves Chart* for recording the estimated and actual chocolate chip amount (one per student)
- Question worksheet (one per student)

BACKGROUND

RENEWABLE ENERGY SOURCES:

Energy sources based on natural cycles that are replenished in a relatively short time frame. These resources can be managed to provide long-term power needs and will not run out. Trees and crops can be replanted. The Sun shines each day. Rivers flow to the sea and winds can be expected to continue to blow. Examples of renewable energy systems include geothermal energy, solar energy, biomass energy, wind energy and hydropower.

NONRENEWABLE ENERGY SOURCES:

Energy sources based on limited reserves created several million years ago by unique geological and physical conditions. Such reserves will eventually run out as the available deposits are depleted. The most common of these types of fuels are often referred to as fossil fuels and include petroleum, coal, and natural gas.

INTRODUCTION

As recently as 200-300 years ago humans met most of their energy needs using renewable energy sources such as wood for heat, watermills for grinding crops or wind to propel sailing vessels. Fossil fuels such as oil, gas and coal now provide the majority of the energy we use to fuel our modern technological and industrial based societies.

CHARACTERISTICS OF COAL

In the past coal has been used to power steamships and railroad engines, to heat homes and provide heat for steel production. Today the primary use for coal is in the generation of electrical power. More than 30% of the electricity generated in the United States comes from combusting coal and Missouri gets more than 75% of its electricity by burning coal. (US Energy Information Administration, 2015).

Coal generates more environmental impacts than any other energy source. Coal mining disturbs large areas of land creating surface water quality problems and ecosystem impacts. Burning coal produces large amounts of air pollutants that have been linked to mercury contamination, smog, global warming and other environmental problems. High sulfur coals are especially problematic, creating greater levels of air pollution and problems with acid rain. Although Missouri has deposits of coal, the high sulfur content prevents its use as an energy source.

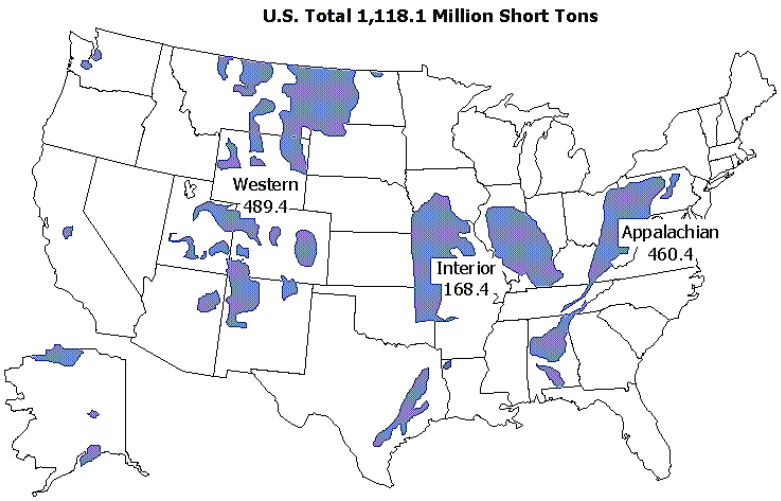
HOW LONG WILL IT LAST?

Of all the fossil fuels by far the most abundant is coal. North American coal beds are widely distributed (see map) with significant variation in the quality of the coal and its accessibility.

Estimating the exact amount of coal available and how long such reserves will last is difficult. Factors such as the current rates of consumption, the expense of mining in remote areas along with increasing environmental costs must all be considered.

The world will not only require energy in the future, but those energy needs are predicted to grow. We will most certainly eventually run out of fossil fuels and the development of renewable energy systems such as hydroelectric, geothermal, wind and solar will only become more critical.

UNITED STATES COAL DEPOSITS SOURCE



PROCEDURE

WARM UP

Set the stage by asking the students the following questions:

- *What is the difference between renewable energy sources and nonrenewable energy sources?*
- *How long will our current supplies of coal last?*
- *What are some alternative sources of energy to fossil fuels?*

Review with the class the basic concepts of renewable and nonrenewable energy sources. Present the class with some information on the use of coal, where coal resources in the United States are located and the environmental effects of coal mining and use.

MINING THE COOKIE FOR COAL (CHOCOLATE CHIPS)

Each student is given a paper plate, a chocolate chip cookie, a paper cup and a paper clip.

- Instruct the students to perform all their "mining operations" on top of the paper plate (to contain the "mining wastes").
- Each student should first estimate the expected chocolate chip reserves that will be mined from their cookie and record this on the chocolate chip reserves chart.

The students will estimate how much of the chart they think will be covered with chocolate chips mined from the cookie and should mark this estimation on the chart.

- Have the students straighten-out a paper clip and begin to "mine" their cookie for chocolate chips. As the chocolate pieces are separated they should be placed in the cup.

Instruct the students not to use their hands to break the cookie but rather they should try to perform all operations using the paper clip. The students should try to separate as much of the cookie material from their chocolate chips as possible.

Once the students have mined all the chocolate they can from their cookie, they should pour the extracted chocolate chips onto the chart and compare the amount recovered to their initial estimation.

- Have the students observe what is left of their cookie and discuss how this reflects the impacts of mining operations.
- Instruct the students to "clean up" their mining site by using their digestive systems to bioremediate the mining wastes and extracted ore deposits.

…In other words they can eat the cookie remains along with the chocolate chips!!!

ASSESSMENT

Have each student answer the following questions (see question worksheet). Alternatively these questions can be addressed during teacher led class discussions.

1. Think about how your cookie looked after you finished mining. How does this relate to environmental impacts associated with real coal mining?
2. Based on your experience cookie mining can you explain why in actual coal mining situations some deposits of coal are more expensive to obtain?
3. Why is it difficult to predict exactly how long the fossil fuels in the Earth will last?
4. Define the following terms and give some examples:

Renewable energy source:

Nonrenewable energy source:

EXTENSIONS

Have the students mine another cookie and this time only remove deposits of chocolate that can be mined without significant environmental disturbance.

• Were the students able to mine all the chocolate reserves available?

• Ask the students to discuss ways to reduce the environmental impacts of actual coal mining.

• Have the students research renewable sources of energy that could be used to replace fossil fuels and present their findings to the class.

GOING FURTHER

During both the mining and use of coal, significant environmental impact occurs. Have the class discuss the following issue.

What is the balance between how much coal resources are technically available and the increasing environmental and economic costs associated with obtaining and using all of this coal?

This activity was adapted from the National Renewable Energy Laboratory (NREL) Teacher Activity Guide.

For more information:
DNR Youth Education and Interpretation
P.O. Box 176
Jefferson City, MO 65102-0176
1-800-361-4827 or (573) 522-2656 office
e-mail: naturalresources.ed@dnr.mo.gov
http://dnr.mo.gov/education

MISSOURI DEPARTMENT OF NATURAL RESOURCES

MISSOURI LEARNING STANDARDS:

SCIENCE GRADE LEVEL STANDARDS:

Earth and Space Sciences

ESS3 — Earth and Human Activity

Concept A: Natural Resources

- **6-8.ESS3.A.1:** Construct a scientific explanation based on evidence for how the uneven distributions of Earth's mineral, energy, and groundwater resources are the result of past and current geoscience processes and human activity. [Clarification Statement: Emphasis is on how these resources are limited and typically non-renewable, and how their distributions are significantly changing as a result of removal by humans. Examples of uneven distributions of resources as a result of past processes include but are not limited to petroleum (locations of the burial of organic marine sediments and subsequent geologic traps), metal ores (locations of past volcanic and hydrothermal activity associated with subduction zones), and soil (locations of active weathering and/or deposition of rock).]

Concept C: Human Impacts on Earth's Systems

- **6-8.ESS3.C.1:** Analyze data to define the relationship for how increases in human population and per-capita consumption of natural resources impact Earth's systems. [Clarification Statement: Examples of data include grade-appropriate databases on human populations and the rates of consumption of food and natural resources (such as freshwater, mineral, and energy). Examples of impacts can include changes to the appearance, composition, and structure of Earth's systems as well as the rates at which they change.]
- **6-8.ESS3.C.2:** Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment. [Clarification Statement: Examples of the design process include examining human environmental impacts, assessing the kinds of solutions that are feasible, and designing and evaluating solutions that could reduce that impact. Examples of human impacts can include water usage (such as the withdrawal of water from streams and aquifers or the construction of dams and levees), land usage (such as urban development, agriculture, or the removal of wetlands), and pollution (such as of the air, water, or land).]

Concept D: Global Climate Change

- **6-8.ESS3.D.1:** Analyze evidence of the factors that have caused the change in global temperatures over the past century. [Clarification Statement: Examples of factors include human activities (such as fossil fuel combustion, cement production, and agricultural activity) and natural processes (such as changes in incoming solar radiation or volcanic activity). Examples of evidence can include tables, graphs, and maps of global and regional temperatures, atmospheric levels of gases such as carbon dioxide and methane, and the rates of human activities.]

NGSS:

Earth and Space Sciences

MS-ESS3 Earth and Human Activity

- **MS-ESS3-1:** Construct a scientific explanation based on evidence for how the uneven distributions of Earth's mineral, energy, and groundwater resources are the result of past and current geoscience processes. [Clarification Statement: Emphasis is on how these resources are limited and typically non-renewable, and how their distributions are significantly changing as a result of removal by humans. Examples of uneven distributions of resources as a result of past processes include but are not limited to petroleum (locations of the burial of organic marine sediments and subsequent geologic traps), metal ores (locations of past volcanic and hydrothermal activity associated with subduction zones), and soil (locations of active weathering and/or deposition of rock).]
- **MS-ESS3-3:** Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.* [Clarification Statement: Examples of the design process include examining human environmental impacts, assessing the kinds of solutions that are feasible, and designing and evaluating solutions that could reduce that impact. Examples of human impacts can include water usage (such as the withdrawal of water from streams and aquifers or the construction of dams and levees), land usage (such as urban development, agriculture, or the removal of wetlands), and pollution (such as of the air, water, or land).]
- **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. [Clarification Statement: Examples of evidence include grade-appropriate databases on human populations and the rates of consumption of food and natural resources (such as freshwater, mineral, and energy). Examples of impacts can include changes to the appearance, composition, and structure of Earth's systems as well as the rates at which they change. The consequences of increases in human populations and consumption of natural resources are described by science, but science does not make the decisions for the actions society takes.]

Science and Engineering Practices

Constructing Explanations and Designing Solutions

Constructing explanations and designing solutions in 6-8 builds on K-5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories.

- Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (MS-ESS3-1)
- Apply scientific principles to design an object, tool, process, or system. (MS-ESS3-3)

Engaging in Argument from Evidence

Engaging in argument from evidence in 6-8 builds on K-5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world(s).

- Construct an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem. (MS-ESS3-4)

Disciplinary Core Ideas

ESS3.A: Natural Resources

- Humans depend on Earth's land, ocean, atmosphere, and biosphere for many different resources. Minerals, fresh water, and biosphere resources are limited, and many are not renewable or replaceable over human lifetimes. These resources are distributed unevenly around the planet as a result of past geologic processes. (MS-ESS3-1)

ESS3.C: Human Impacts on Earth Systems

- Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species. But changes to Earth's environments can have different impacts (negative and positive) for different living things. (MS-ESS3-3)
- Typically as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise. (MS-ESS3-3), (MS-ESS3-4)

Crosscutting Concepts

Cause and Effect

- Relationships can be classified as causal or correlational, and correlation does not necessarily imply causation. (MS-ESS3-3)
- Cause and effect relationships may be used to predict phenomena in natural or designed systems. (MS-ESS3-1), (MS-ESS3-4)

Influence of Science, Engineering, and Technology on Society and the Natural World

- All human activity draws on natural resources and has both short and long-term consequences, positive as well as negative, for the health of people and the natural environment. (MS-ESS3-1), (MS-ESS3-4)
- The uses of technologies and any limitations on their use are driven by individuals or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. Thus technology use varies from region to region and over time. (MS-ESS3-2), (MS-ESS3-3)

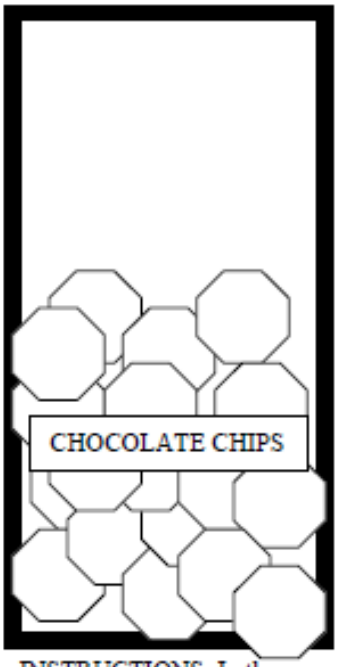
Science Addresses Questions About the Natural and Material World

- Scientific knowledge can describe the consequences of actions but does not necessarily prescribe the decisions that society takes. (MS-ESS3-4)

COAL COOKIES
A LIMITED RESOURCE
RESERVES CHART

CHOCOLATE CHIPS MINED

EXAMPLE:



INSTRUCTIONS: In the space provided to the right estimate how much of the space you think will be filled with mined chocolate chips and draw a line to mark your estimate. When you get done mining your cookie pour out the chocolate chips collected and mark how much of the space is covered. This actual mining yield will then be compared to the estimated yield.

CHOCOLATE CHIPS MINED

STUDENT RESULTS:

COAL COOKIES
A LIMITED RESOURCE
QUESTION WORKSHEET

1. Define the following terms and give some examples:

   Renewable energy source:

   Nonrenewable energy source:

2. Based on your experience while *cookie mining*, can you explain why during actual coal mining situations some deposits of coal are more expensive to remove?

3. Think about how your cookie looked after you finished mining. Compare these results to what might happen in a real coal mining operation.

4. Was there a difference between your estimated and measured reserves of chocolate chips? Why is it difficult to predict exactly how long the fossil fuels in the earth will last?

5. What are some renewable sources of energy that could be used to replace fossil fuels?