THE FORMATION OF FOSSIL FUELS

Adapted from the NY Energy Education Project

Overview: This lesson helps students see their role in our national consumption of energy. It includes a look at the energy contained in all the things we use—from crayons to packaging.

Objectives:
Students will be able to…

- Extract relevant information from the reading material
- Measure accurately and show information on a scale
- Perform basic division problems

Students will understand:

- Fossil fuels were formed millions of years ago.
- Other sources of energy are replaced continuously. They are said to be renewable.
- Fossil fuel resources are finite.
- Fossil fuels may be used up at some future time. Because they are not replaced during the time span of human history, they are said to be nonrenewable.

Time:

- One period for advance discussion
- One period for Worksheets A, B, and C
- One period for preparing time lines (Worksheet D) and completing questions.
- One period for calculations (Worksheet E) and follow-up discussion of entire activity.

Subjects: Science, Social Studies, Math, Technology

Suggested Grade Level: 6 – 10

Materials: Adding machine tape, student worksheets, meter stick, pencil

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PREPARATION & BACKGROUND

Advance Planning

Discuss with the students:

- the various sources of energy
- the concept of the quad as a unit for measuring an amount of energy
- the major concepts involved in the formation of coal, oil and natural gas.

The time for the activity can be reduced if the strips of adding machine tape are cut ahead of time.

Background

Student reading should provide the necessary background for doing the activity. A quad is 10^{15} Btu of energy. It is usually used where very large amounts of energy are quantified and compared.

The statistics given on Worksheet E are based on estimates from the U.S. Department of Energy's Energy Information Administration. However, you should be aware that estimates of fossil fuel reserves vary widely. The estimates given here are averages, and include undiscovered reserves as well as reserves that are actually known and measured.

Students should be made aware of these uncertainties about reserves. They also need know that energy use changes from year to year. So their calculations on Worksheet E are only as valid as their assumptions, which are:

a. That the estimate of reserves are correct, and

b. That energy use will remain at the same level as it was in 2007.

PROCEDURE

1. Carry out the discussions outlined in the "Advance Planning" section. Have students read Worksheet A, and then discuss Worksheet B with the whole group as reinforcement. Let students try to do Worksheet C individually and then compare and discuss answers.

2. Have students make their time lines. It is recommended that each student in the class make one. Use floor and hallways to stretch them out. Tape down the ends or put a book on each end. When they are finished, answer the questions related to the time lines as a group.

3. You may wish to assign the energy use calculations (Worksheet E) for homework. This is slightly higher level work and will require some thought. Students should be given time to think it through. Then have students explain their methodology. Discuss how valid their calculations are, using the questions as a basis.

FOR DISCUSSION

1. What do renewable and nonrenewable mean? Is it valid to compare energy sources only on this basis? How else can we compare energy sources?
2. Why are nonrenewable resources of such concern to us?
3. What is meant by energy conservation?
4. In what ways do you and your family try to conserve energy?

TYPICAL RESULTS

The answers to the fill-ins on Worksheet C are as follows:

1. sun
2. sun
3. renewable
4. photovoltaic
7. hydropower
8. biomass energy
9. coal
10. oil

5. heat
6. wind
11. natural gas
12. nonrenewable

The time lines should clearly show the non-renewables as widely separated from the renewables.

The number of years (Worksheet E) that each fuel will last, based on constant use, is:

coal	1,051.4 years
oil	8.5 years
natural gas	11.5 years

ASSESSMENT

Give a vocabulary quiz on "Words You'll Learn." Assign an essay in which the students are to:

1. Summarize the concepts of renewable and nonrenewable.
2. Express their ideas about the supplies of nonrenewable sources and our use of them.

Collect the time lines and give an evaluation of satisfactory or unsatisfactory, based on how accurately each was done.

MODIFICATIONS

Bar graphs can be constructed of the energy reserves, energy use, and time to depletion. These can be color coded and will graphically show the results of Worksheet E.

This lesson does not cover geothermal, ocean-thermal, nuclear, or tidal energy. These might be great topics for students to research and plug into the timeline.

The Formation of Fossil Fuels

There are many sources of energy in our world. We can get energy from the sun, from wind, and from falling water. We can also get energy from materials that contain stored energy. Fossils fuels take a long time to form. If we go back in geological history, we find that it took millions of years for our fossil fuels to come to be. Because of the time needed to form these fuels, and because the conditions for formation must be just right, most geologists feel that little or no new fossil fuel is being produced. For this reason, we call fossil fuels "nonrenewable."

In this activity, you will learn some things about renewable and nonrenewable sources of energy. You will see, on a chart you will make, why some fuels are called renewable, and some nonrenewable. You will investigate how much fossil fuel we have and how much we use.

Objectives:

Students will…

- Demonstrate an understanding of renewable vs. nonrenewable sources of energy
- Explain why the supply of fossil fuels is limited, and
- Understand basic energy vocabulary.

Skills and Knowledge You Need:

- Ability to read and interpret a chart
- Ability to do division problems
- Ability to make measurements using a meter stick

Words You'll Learn:

Biomass energy, quad, fossil fuels, renewable energy, hydropower, solar heat, nonrenewable energy, time line, photovoltaic electricity

Materials:

Adding machine tape—2 meters long, Worksheets A, B, C, D, and E, meter stick, and pencil

PROCEDURE

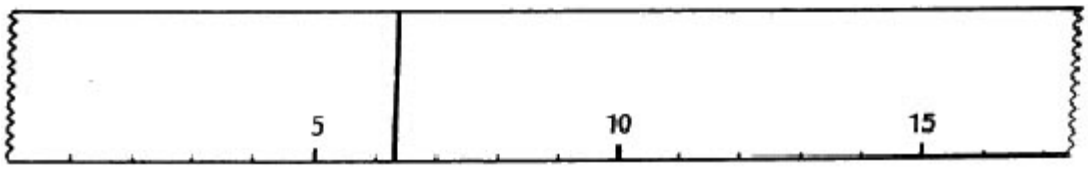
1. Read Worksheet A, and study the diagram on Worksheet B.

2. Make a list of the sources of energy you read about. Make sure that you know what each one is. Your teacher will help you find definitions, if necessary.

3. Study Worksheet C and fill in the blanks, using the information you learned from the reading and the diagram.

4. Look at Worksheet D. This is a listing of the times required for energy to be produced from different sources. In order to understand this more clearly, you are going to construct a time line which will show you how these times compare with each other.

5. Place the 2 meter length of adding machine tape flat on a counter or the floor. Using a meter stick, begin at one end of the tape and place marks one centimeter apart for the entire length of the paper., Number every fifth centimeter mark (see sample below).



6. Using Worksheet D, label your time line at the proper place with the name of each source of energy. Place a heavy mark on the time line to indicate the division between renewable and nonrenewable sources of energy.

7. Answer questions on Worksheet D based on the energy production time line you have made.

8. Study the tables on Worksheet E. Then use the information supplied in the tables to calculate how long U.S. fossil fuel reserves will last. Answer the question on the worksheet based on your calculations.

LOOKING BACK

This activity has led you through a series of steps. You learned the names of some sources of energy. You found out that some sources of energy are renewable and some are nonrenewable. Then you calculated how long we can expect our fossil fuel supplies to last.

Fossil fuels are considered to be nonrenewable. There is a definite amount of each one on our earth and in time they will be used up. They are not being produced naturally, and if they were it would take such long periods of time to produce them that only people far in the distant future would benefit. Perhaps you can think of ways to conserve these precious fuels.

GOING FURTHER

1. Find out how much a quad of energy is.

2. Estimate how many quads of energy are used in your school each year.

3. Make a list of ways you and your family might conserve fossil fuels.

4. Assume that the use of each fuel will increase by 1% annually. Calculate the number of years each fuel will last.

Worksheet A: Energy and Time

Energy is all around us, and comes from many sources. One of the most important sources of energy is the sun. The energy of the sun is the original source of most of the energy found on earth.

We get solar heat energy from the sun, and sunlight can also be used to produce electricity from solar (photovoltaic) cells. The sun heats the earth's surface and the air above it, causing wind. Water evaporated by the sun forms clouds and rain to give us flowing streams and rivers. Both wind and flowing water (hydropower) are sources of energy.

So you see, the sun is the source of many kinds of energy found in nature. These kinds of energy are all around us all the time. They are produced quickly, and replace themselves constantly as we use them. For this reason we say they are renewable.

The sun's energy can also be stored. Plants store energy from the sun as they grow. Fruits, vegetables, and wood from trees, for example, all contain stored solar energy. We call it biomass energy, from "bio" for "life" or "living." These kinds of energy are also renewable, but of course it takes longer to grow a plant or a tree than it does to get heat directly from sunlight.

When energy is stored in a material, we call that material fuel. Food and wood are biomass fuels. When you have old, old biomass that has become concentrated, you have what we call "fossil fuel."

The Formation of Fossil Fuels

Fossil fuels are found deposited in rock formations. They were formed between 350 million and 50 million years ago. The processes by which they formed are not totally understood. Decayed remains of ancient plants and/or animals were buried by sediments. Through the action of heat and pressure over millions of centuries, they were chemically changed. Coal, oil, and natural gas are the results.

Coal was formed from the remains of ferns, trees, and grasses that grew in great swamps 345 million years ago. These remains formed layers as they sank under the water of the swamps. The plant material partially decayed as these layers formed beds of peat, a soft brown substance that is up to 30% carbon. Peat is the earliest stage of coal formation.

Shallow seas later covered the swamps and slowly deposited layers of sand and mud over the peat. These sediments exerted pressure on the peat over thousands of years. Slowly chemical changes took place transforming it into lignite or brown coal, which is about 40% carbon. Millions of years later, increasing pressure and let changed the lignite into bituminous or soft coal (about 66% carbon) and finally into anthracite or hard coal (over 90% carbon).

Oil and natural gas are also found in beds of sedimentary rock. The sediments were deposited by shallow seas millions of years ago. The remains of plants and animals living in the seas settled to the bottom and were buried under layers of sediment. These layers were subjected to heat and pressure over millions of years. The sediments were transformed into beds of rock, and the plant and animal remains underwent slow chemical change and formed oil and natural gas.

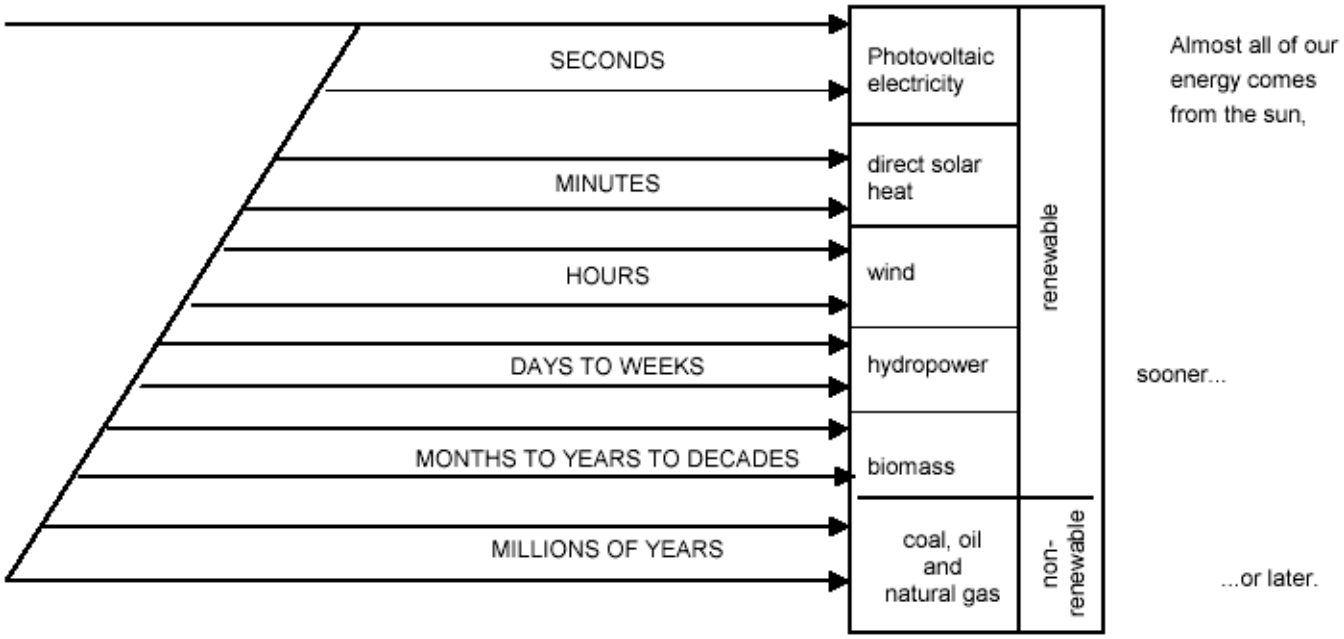
As you can see, the fossil fuels take millions of years to form. They cannot be replaced quickly. In fact, in terms of our lifetime they cannot be replaced at all. For that reason we call them nonrenewable

Renewable or Nonrenewable

There are still other kinds of energy: ocean thermal energy, geothermal energy, and nuclear energy, for example. We cannot discuss all of them here, but your teacher can give you information about them.

Are they renewable or nonrenewable? You can decide for yourself. If a source of energy is replaced as we use it, so that we can never use it up, it is called renewable. If there is a definite, limited supply of a source of energy, and it cannot be replaced, it is called nonrenewable. This is an important idea, because it helps us to decide how we should use each of our many sources of energy.

Worksheet B: Energy – Sooner ... or Later



Worksheet C: Understanding Sources of Energy

Directions: After studying Worksheets A and B, fill in the blanks below.

1. The _____ is the original source of almost all the energy on earth. Energy appears in many different forms, but if you trace it back far enough you find that it all started at the same place: the _____.

2. Some sources of energy exist in almost unlimited supply. As soon as we use some energy, it is replaced by more. For this reason, we say that these sources of energy are _____.

3. Perhaps the "fastest" energy is _____ electricity, which is produced when sunlight strikes solar cells. These are the round, bluish wafers that are mounted on space satellites to give them electric power from sunlight when they are in space.

4. It only takes the sun a few minutes to give us direct solar _____. You can feel it in a car that sits in the sun. Houses and buildings can be designed to collect sunlight the same way. You can also build solar collectors to trap the sun's heat.

5. The sun heats the earth and the earth warms the air above it. Heated air rises (just like a hot air balloon). When cooler air rushes in to displace the heated air we have _____. The energy can be used to sail ships or drive machines to pump water or produce electricity.

6. The sun heats the surface water of lakes and oceans. Some of the water evaporates when it is heated. Then it forms clouds, falls as rain, and collects in lakes and rivers. As this water flows back to the sea it provides _____ which can drive a turbine to generate electricity.

7. The plants of the earth are solar collectors. By the process of photosynthesis they use sunlight to produce stored chemical energy that is used for food or fuel. Plant energy is called_____.

8. Some sources of energy take so long to produce that if we use them up they can't be replaced. _____, _____, and _____ are like that. Dead plants and animals must decay for hundreds to millions of years to produce these fossil fuels. That is why we say they are.

Worksheet D: Making an Energy Time Line

Directions: Using the chart below, follow Procedure steps 4–6 to construct your time line.

Sources of Energy	Production Time	Position of Time Line
photovoltaic electricity	seconds	1 cm
direct solar heat	minutes	2 cm
wind	hours	3 cm
hydropower	days and weeks	4 cm
biomass	months, years, or decades	5 cm
coal, oil, natural gas	millions of years	200 cm

QUESTIONS

1. Some sources of energy are said to be renewable, that is, replaceable in a reasonable period of time. Other sources of energy are said to be nonrenewable because their replacement would take a very long time. Which sources of energy, on your time line, are renewable and which do you think are nonrenewable?

2. Which sources of energy, on your time line, are most commonly used?

3. Can you think of any problems related to the most commonly used fuels?

Worksheet E: Fossil Fuel Reserves— How Long Will They Last?

Table 1

Estimated U.S. Reserves—2007

Coal	11,280 quads
Oil	130 quads
Natural Gas	192 quads

Table 2

U.S. Energy Use—2007

Coal	23 quads
Oil	40 quads
Natural Gas	24 quads

(Source: http://www.eia.doe.gov/ & http://www.eia.doe.gov/emeu/aer/pdf/pages/sec1_9.pdf)

Note: The numbers after each type of fuel are given in units called quads. The quad is a unit which expresses a very large amount of energy. For example, a whole city might use one quad of energy in a year.

Directions: Using the tables above, calculate how many years each fuel will last. Assume that the United States will consume the same amount of fuel every year, until it runs out.

Source of Energy	Calculation	Number of Years
Coal	$23 \overline{)\,11{,}288}$ = number of years U.S coal reserves will last at the 2002 rate of use	
Oil		
Natural Gas		

Questions **(based on your calculations)**

1. Which fuel will last the longest? Shortest?

2. What is the problem with doing this type of calculation? To be sure that your answer is correct, what other things would you have to be sure of?