CLIMATE IN THE CURRICULUM

Teacher's Activity Guide to Renewable Energy
Grades 4-12

Developed by Kathy Nguyen

SOCAN
Confronting Climate Change

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TEACHER BACKGROUND: ENERGY

ENERGY IS THE <u>ABILITY TO DO WORK</u>

There are two types of energy:

- Stored (**<u>potential</u>**) energy- due to position, structure of matter, or composition
- Working (**<u>kinetic</u>**) energy-matter in motion or in use

For example, the food a person eats contains chemical energy, and a person's body stores this energy (potential energy) until they use it during work or play (kinetic energy).

Potential Energy	*Kinetic Energy*
Water behind a dam (due to position)	*Falling* water
Car parked on a hill (due to position)	Car *rolls* down hill
Wound clock spring	Clock hands begin to *move*
Gasoline or sugar (due to chemical composition)	Energy appears as *movement* of the car or muscles and as engine or body *heat*

Energy comes in different forms:

- Heat (thermal)
- Light (radiant)
- Mechanical (motion-kinetic/stored-potential)
- Sound
- Electrical
- Chemical
- Nuclear
- Gravitational

Potential Energy		
Energy form	*Energy stored in*	*Example*
Chemical	Bonds of molecules. Chemical energy converted when bonds are broken	Batteries, biomass, petroleum, natural gas, coal
Mechanical	Objects by tension.	Compression springs, stretched rubber bands
Nuclear	Nucleus of an atom-the energy that holds the nucleus together. Large amounts of energy released when nuclei are combined or split apart	Nuclear power plants split uranium atoms- **fission**. Sun combines nuclei of hydrogen atoms- **fusion**.
Gravitational	Object's height. The higher the object, the more	Hydropower- dam piles up water from a river into reservoir

	gravitational energy is stored.	
Kinetic Energy		
Energy form	*Energy due to*	*Example*
Radiant	Bundles of photons	Sunlight
Thermal	Random motion of small particles	Warmth around fire or car's engine
Motion	Motion of large pieces of matter	Movement of car's wheels
Sound	Ordered periodic motion of small particles	Sound from headphones, music
Electrical	Tiny charged particles called electrons	Lighting, electrical wires

ENERGY BE CHANGED FROM ONE FORM INTO ANOTHER

The **First Law of Thermodynamics** states that energy cannot be created or destroyed; it only changes form.

The most common way to observe this change is as heat. In a flashlight battery, the chemical energy in the battery is converted into electrical energy and, finally into light and some heat energy (put your hands over the light source to feel the heat).

Other examples of the change of energy into other forms includes:

- When natural gas burns in a home or office furnace, chemical energy stored in the gas is converted into heat energy
- The Sun's radiant energy is converted by plants into chemical energy (a process called photosynthesis).

People use energy for everything from making a jump shot to sending astronauts into space!

Activity 1: **ENERGY DETECTIVES**

Time: 20-30 minutes
Grades: 4-8

Purpose: Students will look for energy, collecting evidence of energy to come up with their own collaborative definition of energy.

Materials:
- Copies of Detective Data Sheet
- Copies of clues

Content Standards:

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

MS-PS3-2. Develop a model to describe that when the arrangement of objects interacting at a distance changes, different amounts of potential energy are stored in the system.

Procedure:
1. Ask students to think about what is energy, brainstorm as a class. Create a brain map of words students associate with energy, or energy terms they are already familiar with.
2. Give each student group a copy of the Detective Data Sheet and a copy of the clues. Point out that their goal is to search for the answer to "What is Energy?"
3. Based on the clues given, students go in search for evidence in the classroom/their background knowledge to find the answer.
4. Once they have written each clue on their Data Sheet, have each group come up with a definition.
5. Have each group share their definition to the rest of the class

Activity Extensions
1. Discuss with students: Can you feel energy? (Heat waves or energy in wind can move us around on a windy day or cause a sailboat to skip across a lake.) Can you see energy? (Yes, sunlight.) Can you hear energy?
2. Have students look up the definition of energy in the dictionary (the capacity for vigorous activity; available power) and compare with the physics definition (the ability to do work). Discuss how these definitions compare with the definition students came up with.
3. Use energy use meter to measure the energy use of electronics in the classroom (computer, projector, lamps, pencil sharpener, etc.)

Adapted from R.E.A.C.T. (Renewable Energy Activities-Choices for Tomorrow)

DETECTIVE DATA SHEET

CLUES:

1. Energy can make things change
2. Heat comes from energy
3. Movement comes from energy.

EVIDENCE

We know that energy was here because…	Energy Source (sun, wind, electricity, other?)

After you have collected energy evidence, have each person in your group create a definition for energy. Next, have your whole group agree on a collective definition and write it at the bottom of the page.

Group Answer: ***WHAT IS ENERGY?***

EXTRA CLUES FOR PUZZLED DETECTIVES

1. Electrical and solar energy give us light.
2. Sun energy grows our food.
3. Lightning is a natural form of electrical energy.
4. Gasoline, made from crude oi1, gives us energy to make cars go.
5. Energy heats our homes and school.
6. Energy keeps our refrigerator cold.
7. Sailboats need wind energy.

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Activity 2: **WHAT IS ENERGY? STUDENT RESEARCH**

Time: 30 minutes
Grades: 4-8

Purpose: In this activity, students will learn what energy is, where it comes from, and how humans use it. Students will:

- Define the term energy
- List the 5 forms of energy
- Define and give examples of potential and kinetic energy
- Explain different ways humans use energy
- Compare and contrast renewable vs. non-renewable energy
- Explain how fossil fuels are formed

Materials:

- Copies of "Energy!" student handout
- Computer lab or student laptops (alternatively this can be done a class)
- Energy use meter
- Videos/Links
    - Energy Kids Notes: http://www.energystar.gov/index.cfm?c=kids.kids_index
    - US Electricity Energy Sources: http://www.eia.gov/tools/faqs/faq.cfm?id=427&t=3

Content Standards:

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

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

MS-ESS3-3. Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.*

MS-ESS3-2. Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects.

Procedure

1. If student have not done Activity 1: Energy Detectives, ask students what is energy? What do you know about energy? Class brainstorm.
2. Pass out Energy! Notesheet
3. Survey the classroom, what are some things we use energy for? (record in student notesheet)
    a. Which ones are renewable, non-renewable, How can we change this?
    b. Kill-A-Watt Electronic Use Meter Exploration

    i. A kilowatt is a unit of electric power- have students brainstorm and measure the energy use of different electronics in the classroom (computers, lamps, projectors, pencil sharpeners, etc.)

4. Students will explore the energy star kids website to define energy, explore different forms of energy, how humans use, it, and can conserve it.
5. Come back as a class and summarize/discuss what students discovered on the notesheet.

Information on Energy Star Kids:

<u>What is energy?</u>

Energy is the ability to do work. Energy if found everywhere in the world and comes in many forms:

FORMS OF ENERGY:

- Light
- Heat
- Electricity
- Sound
- Motion

Energy is in everything. We use energy in everything we do, from making a jump shot to baking cookies to sending astronauts into space.

Think of energy as the stuff that makes things happen. Without energy, your body wouldn't grow, your car wouldn't move, the lights in your house wouldn't work, and that's just to name a few.

We need energy for everything we do in life, and we need lots of it!

There are two types of energy: stored (potential) energy and working (kinetic) energy. For example, the food you eat contains chemical energy, and your body stores this energy until you release it when you work or play.

<u>Where does energy come from?</u>

Energy is all around us. It's in the light we see, it's in the food we eat, it's in the ground we walk on. In fact, energy is everywhere! The problem is, we can't always use that energy. Sometimes it is stored/potential energy, and needs to be converted to be working/kinetic energy.

- How is energy changed?
  *Energy cannot be created nor destroyed, it can be transferred or transformed.

<u>Energy Sources:</u>

- Renewable: come from things that won't run out, reuse over and over again
- Non-renewable: comes from things that will run out one day, or cannot be regenerated within a feasible time span.

<u>What can happen?</u>

Energy allows us to do so many things that make our live better. But energy isn't free, and there are several prices to be paid. Explore the landscape to see some of the consequences of using energy

- Limited supply of things that give us energy, so use wisely

- Energy costs money, the less you use, the more you save!
- Using too much of certain types of energy like fossil fuels can pollute the environment, and contribute to global warming. The less we use, the cleaner and healthier we keep our planet!

Saving Energy: What are five ways you can save energy?

Activity Extensions

1. Ask students: where does the energy we use come from? Brainstorm as a class:
   a. Discover US Electricity Energy use on: http://www.eia.gov/tools/faqs/faq.cfm?id=427&t=3
2. Fossil Fuel Story (10 min)
   a. Students who finish early with their notes will be given tasks in acting out the story of fossil fuels
   b. Options:
      i. Charades: Actors are given the steps, and will act them for the class to figure out the story and place it in order
         1. After class has figured it out, students read out cards in order to give further information and clarify
      ii. If you are short on time: Actors read out the step cards, and class has to put the steps in order
   c. Steps:
      i. The Carboniferous Period occurred from about 300 million years ago. At the time, the land was covered with swamps filled with huge trees, ferns and other large leafy plants. The water and seas were filled with algae.
         ***Contrary to what many people believe, fossil fuels are not the remains of dead dinosaurs. In fact, most of the fossil fuels we find today were formed millions of years before the first dinosaurs.
      ii. As the trees and plants died, they sank to the bottom of the swamps of oceans. They formed layers of spongy material called peat.
      iii. Over hundreds of years, the peat was covered by sand and clay and other minerals, which turned into sedimentary rock.
      iv. More and more rock piled on top of more rock and it weighed more and more. It began to press down the peat. The peat was squeezed and squeezed until the water came out of it and eventually over millions of years, it turned into coal, oil, or petroleum, and natural gas.
      v. Humans mine and burn/use the fuel to power our cars, transportation, and generate electricity

ENERGY!

http://www.energystar.gov/index.cfm?c=kids.kids_index OR google: Energy Star Kids

What are some things that use energy in the classroom?

What is energy anyway?

Energy is….

Forms of Energy:

-
-
-
-
-

Types of Energy

-
-

Where does energy come from?

How is energy changed?

-
-
-
-

Developed by Kathy Nguyen for SOCAN-Climate in the Curriculum

Energy Sources

- Renewable energy:

- Non-renewable energy:

What can happen?

What are some consequences of energy use?

-
-
-
-

What are 5 things you can do to save energy?

-
-
-
-
-

*** If you finish early, explore the FUN FACTS tab and the QUICKEST EVER SLIDE SHOW ON GLOBAL WARMING to review climate change!

RENEWABLE ENERGY

Activity 3: Renewable or Not?

Activity 4: Energy Resource Charades

Activity 5: Energy Resource Experts

TEACHER BACKGROUND: RENEWABLE ENERGY

ENERGY SOURCES CAN BE CATEGORIZED AS RENEWABLE OR NONRENEWABLE

When people use electricity in their homes, the electrical power was probably generated by burning coal, by a nuclear reaction, or by a hydroelectric plant on a river, to name just a few sources. Therefore, coal, nuclear, and hydro are called energy sources. When people fill up a gas tank, the source might be petroleum refined from crude oil or ethanol made by growing and processing corn.

Energy sources are divided into two groups:

Renewable (an energy source that can be easily replenished)
Nonrenewable (an energy source that cannot be easily recreated)

People get most of their energy from nonrenewable energy sources, which include fossil fuels (oil, natural gas, and coal). These energy sources are called fossil fuels because they were formed over millions of years by the action of heat from the earth's core and pressure from rock and soil on the remains (or fossils) of dead plants and creatures like microscopic diatoms.

Another nonrenewable energy source is uranium, whose atoms can be split (through a process called nuclear fission) to create heat and eventually electricity.

People use renewable and nonrenewable energy sources to generate secondary energy sources like the electricity needed for homes, businesses, schools, and factories. Electricity powers computers, lights, refrigerators, washing machines, and heating and cooling systems.

Most of the gasoline used in cars and motorcycles, and the diesel fuel used in trucks, tractors, and buses are both made from crude oil and other hydrocarbon liquids that are nonrenewable resources. Natural gas, used to heat homes, dry clothes, and cook food, is also a nonrenewable resource.

WHAT ARE THE PRACTICAL SOURCES OF ENERGY?

The practical sources of energy include the fossil fuels, natural gas, petroleum (or oil), and coal. Fossil fuels are referred to as nonrenewable energy sources because, once used, they are gone.

Scientists are exploring the practicality of other sources called renewable energy sources. These include sun, wind, geothermal, water, and biomass. The renewable energy resources are important in long range energy planning because they will not be depleted.

ENERGY	
Renewable	Nonrenewable
1. Sun 2. Water 3. Wood 4. Wind 5. Biomass 6. Geothermal 7. Ocean Tides	1. Coal 2. Natural gas 3. Petroleum 4. Nuclear fission

Natural Gas

Sometimes natural gas is confused with gasoline, the fuel in cars. They are not the same. Gasoline is a mixture of liquids, and natural gas is mainly methane and is piped into homes and office buildings where it is used as an energy source for heating, cooking washing, and drying. It is raw material to make other chemicals, and is the cleanest bumming fossil fuel. This means it contributes little environmental pollutants when bummed.

Petroleum or Oil

This is the black, thick liquid pumped from below the earth's surface wherever you see an oil rig. To make it useful, it is refined. Refining separates the gasoline portion, which is used in transportation. Products from the remaining portions include synthetic rubber, detergents, fertilizers, textiles, paints, and pharmaceuticals.

Coal

Coal is the most abundant fossil fuel. It is not a widely used energy source due to the cost of mining and its impurities, which cause pollution (acid rain). There are two ways to mine coal; underground mining and strip mining. Disadvantage to these methods is the environmental change caused in the process. New ways of using coal are being explored, such as liquefication, in which a product similar to oil is produced.

Nuclear Fission

This is splitting of the uranium atom. In the 1930's scientists found that splitting the nucleus of an uranium atom releases a tremendous amount of heat energy. This knowledge was used to make atom bombs. Today, power companies use the heat produced by nuclear fission to produce electricity. Some people think nuclear energy should be our main source of future energy. Other people feel that the dangers are too great from radioactive waste products, meltdowns, and radiation exposure of workers. Currently the nonrenewable resources supply the majority of our energy needs because we have designed ways to transform their energy on a large scale to meet consumer needs. Regardless of the source of energy, the energy contained in the source is changed into a more useful form -electricity Electricity is sometimes referred to as a secondary energy source. All the other sources are primary.

Solar
The sun is 93 million miles away and yet, this ball of hot gases is the primary source of all energy on earth. In the high temperature of the sun, small atoms of hydrogen are fused, that is, the centers of the two atoms are combined. Fusion releases far greater energy than splitting the atom (fission, see below). Without sunlight, fossil fuels could never have existed. The sun is the supplier of energy, which runs the water cycle. The uneven heating of the earth produces wind energy. Solar energy can be used to cook food, heat water and generate electricity. It remains the cleanest energy source an it is renewable. It is the hope for the energy source of the future and scientists at NREL are actively working on ways for solar energy to supply more our energy needs!

Wind
The unequal heating of the earth's surface by the sun produces wind energy, which can be converted into mechanical and electrical energy. For a long time, the energy of wind has been to drive pumps. Today windmills can be connected to electric generators to turn the wind's motion energy into electrical energy, and wind over 8 miles per hour can be used to generate electricity .It is a renewable, but unpredictable, energy source.

Wood
Wood provides U .S. homes and industries as much power as nuclear plants. Burning is the major global source of carbon dioxide in the atmosphere. Worldwide, wood is poor man's oil, providing 50-60% of the people with the barest energy necessities. Roughly half of the earth's forests have disappeared since 1950. Wood is considered a renewable energy source.

Hydroelectric (Falling Water)
When water is collected behind dams on large rivers, it provides a source of energy for the production of electricity. The enormous power of falling water is capable of turning giant turbines. These turbines drive the generators, which produce electricity. The degree of power is determined by the amount of water and the distance it falls. Hydroelectric power plants do not cause pollution, but there are fewer and fewer places to build dams. The environmental problem arises because a dam is typically built on a river creating a lake where land once stood. Water is a renewable energy source.

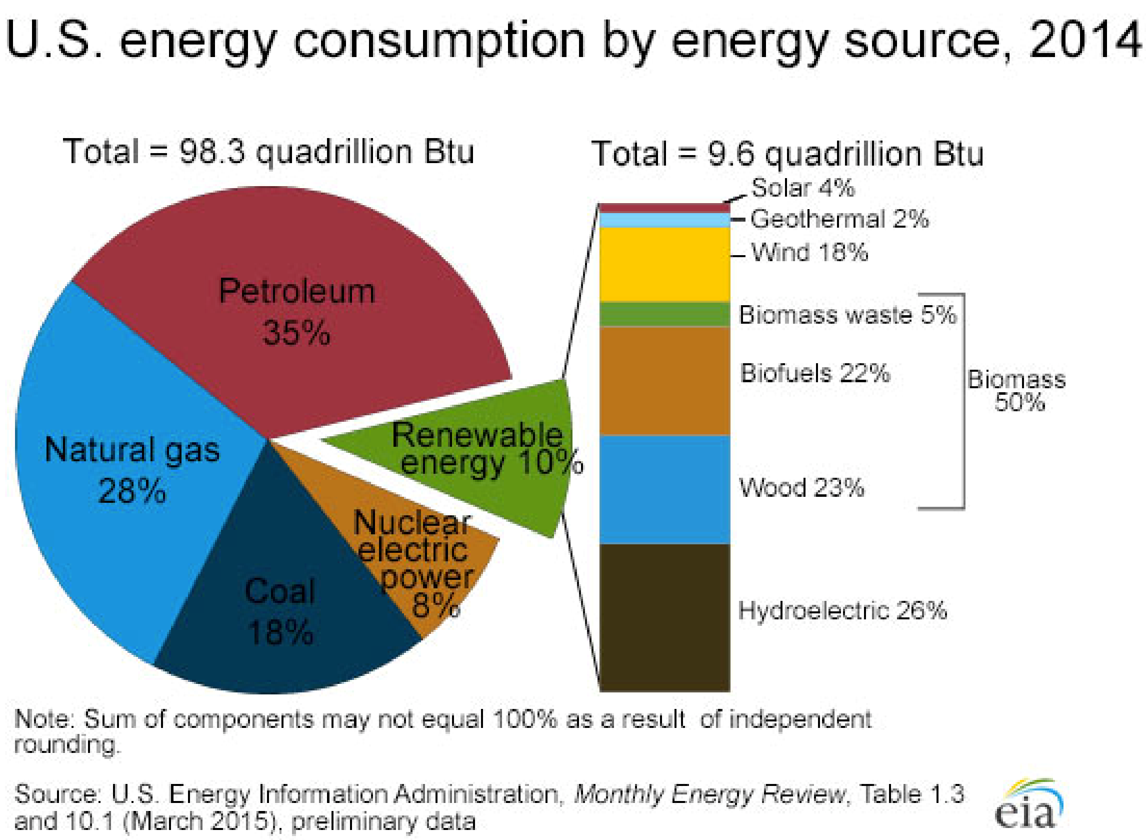
Ocean Tides
Ocean tides are very powerful forces. To harness the rising and falling of the tides would be an expensive process, but it would be a very important future source for Eastern United States. Perhaps underwater windmills or floating generating stations could utilize this potential energy source to produce electricity.

Geothermal
Geothermal energy refers to the energy deep within the earth. It shows itself in the fountains of boiling water and steam known as geysers. Geothermal energy was generated by the decay of natural radioactive materials within the earth. In addition it is the heat energy remaining within the earth from gravitational formation of the earth. This energy source is not popular in the

United States, but Yellowstone has some geysers. Geothermal energy is used to heat some homes, greenhouses, and factories. The actual usable geothermal sites are few, but is considered a renewable energy source.

Biomass

This is garbage! As bacteria decomposes organic waste such as manure, septic tank sludge, food scraps, pond- bottom muck, etc., methane is produced. This methane is the same as natural gas from the ground. There are power plants in the United States, which use methane derived from these organic wastes (mainly manure). Some cities produce electricity by burning garbage in especially designed power plants.



The chart above shows what energy sources the United States used in 2014. Nonrenewable energy sources accounted for 90% of all energy used in the nation. Biomass, which includes wood, biofuels, and biomass waste, is the largest renewable energy source accounting for about half of all renewable energy and 5% of total energy consumption.

HOW IS ELECTRICITY MADE?
One of the fossil fuels (usually coal) is burned in a power plant to heat water. The hot water turns into steam and forces a machine called a turbine to turn. The turbine powers a generator into electricity which is sent through power lines to provide energy for buildings of all types.

In summary, *coal -hot water -steam -turbine -generator -electricity*.

Electricity can also be made from water behind a dam or by windmills. Falling water or rotating windmill blades will cause the turbine to generate electricity.

Electricity is the most useful form of energy. We take it for granted because it is such an important part of our life style. It makes our everyday endeavors convenient and practical. For example, electricity makes alarm clocks ring in the morning to wake us for school, keeps our food cool in the refrigerator so that cereal tastes good with milk, operates the blow dryer that styles hair, and runs the furnace that blows warm air throughout our homes in the winter to keep us warm.

WHY IS IT IMPORTANT NOT TO WASTE ELECTRICITY?
The conversion of energy from one form to another is covered by a natural law -the Law of Conservation of Energy. This law states that energy can be neither created nor destroyed, it can only be changed from one form to another. This change, however, is one of quantity, not quality. As energy does work, it changes from higher (more concentrated) form of energy to a lower form of energy .For example, of the electrical energy that goes into a typical light bulb, 5% becomes light, the other 95% of the electrical energy is lost as heat. In another example, the chemical energy of gasoline is converted into heat energy in an automobile. A small portion (10%) is converted into mechanical energy that moves the car. The remaining portion (90%) is lost to the environment. You notice this when you stand near an idling car's engine and feel the heat. This concept helps explain why it is important to save (conserve) energy.

HOW CAN WE SAVE ENERGY?
Energy saved is energy gained for another day! Saving energy will cut down on pollution and help our fossil fuels last longer, at least, until renewable energy sources become more practical. Conservation is the least expensive source of energy available today. Every bit of electricity that is not used to light a room that no one is in, could be used to operate a computer. Power companies have found that mining this kind of wasted energy is often more profitable than generating more energy. The amount of energy that a utility can get its users to save can be sold to other users; incentive programs for saving energy turn out to be profitable to the utility companies. Because of peak-use problems, the utility must have enough energy available to satisfy the needs of all users at peak hours. This often means building an entire power plant (or more) just to cover the demand over a 2-4 hour portion of the day. When everyone conserves energy, the utility can meet peak demand without a new plant, and the building and maintenance expenses that it would incur. Finding a way to do more with less, benefits everyone.

Consumers can actively participate in energy conservation through recycling. Some communities have recycling centers and perhaps your school has a site recycling center. Often recycling centers provide containers for gathered materials, handle all the pick-up, and even supply educational materials to boot!

Citizens need to realize that each and every one of us does make a difference. The solution to energy problems will be solved by individuals. While it may seem nebulous we are the ones who need to pass laws or quit polluting, it will be us who will write letters to, and cast votes for, the lawmakers. Likewise it will be individuals who ride the bus or a bike, instead of driving our own cars. The sum of our individual, daily decisions determines the net outcome of the world's energy use. We want to encourage an honest effort.

Activity 3: **RENEWABLE OR NOT?**

Time: 45-60 minutes
Grades: 4-8

Purpose: In this activity, students will learn the difference between renewable and non-renewable resources and discover why sustainable use of natural resources is important.

Objectives:
Students will:
- Identify renewable and non-renewable resources and explain the difference between them.
- Explain the importance of conserving non-renewable resources.
- Define sustainable yield.

Materials:
Per Class:
- 14 slips of paper: 2 First Generation, 4 Second Generation, and 8 Third Generation.
- Large jar or container
- Popcorn or other snack (goldfish, m&ms, etc., or non-edible: beans)
- 14 paper bags/containers

Per Group:
- Scissors
- "Renewable or Not" student handout
- Paper plate/ paper towel

Content Standards:
4-ESS3-1. Obtain and combine information to describe that energy and fuels are derived from natural resources and their uses affect the environment.
5-ESS3-1. Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources and environment.
MS-LS2-1. Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem
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.

Procedure:
Part A: Sorting What's What (10 min)
1. Give each team a copy of the student page.
2. Students will get clues from the student worksheet and give each group member one.

3. Students should read their clue card and share the information with the rest of their team. Then each team should use these bits of information to determine a definition for renewable and non-renewable resources.
4. Teams will discuss the questions on the student worksheet with one member designated to record their responses and one designated to report them.
5. Have each group share their responses with the class. Write key words or responses on the board.

Part B: Popcorn Generation (5 minutes)

1. Fill a large jar or container with popcorn and have your paper bag with 7 slips of paper ready.
2. Have 7 students draw a slip of paper from the bag and also give each of them an empty paper bag.
   They should not tell anyone what the paper says.
3. Ask two First Generation students to come up to the big jar of popcorn. Explain that the food in the jar represents the world's supply of a non-renewable resource. Tell them they can take as much of the non-renewable resource as they want. Let them fill up their bags while the rest of the students watch.
4. When the First Generation students are done, invite the four Second Generation students to go up and take as much of the remaining "non-renewable resource" as they want. After they finished, have the Third Generation students come up and take what they want.

5. Discuss with students what is happening to the world's "non-renewable resource" (popcorn) supply. What happened to the total amount of the resource? How much was left for each successive generation? Was anything left for a Fourth Generation? Did any of the students who were part of the demonstration think about who might be eating after them, or were they only trying to get as much popcorn as they could?
6. What connections do the students see between what happened in the demonstration and what happens in the real world?

Part C: Green vs. Need (10 min)

1. Divide the group into teams of four.
   a. Group Roles:
      i. Recorder, records how many each person took, how many the group has left
      ii. Popcorn keeper, in charge of replenishing popcorn
2. Give each team 16 pieces of popcorn. Explain that students will play a game in which the popcorn represents the team's supply of a renewable resource that is replenished after each round of play. Each student can take freely from the team supply; however, the team should keep the following in mind:

RULES

- At the end of the game, each team member will get to eat all the popcorn that he or she collected.
- Each team member needs to take at least one piece of popcorn per round to live.
- At the end of each round, the popcorn in the team pile will be replenished by one-half of it's existing amount.

3. Begin round one. Allow students on each team to take freely from their team's popcorn pile. Students should record how many pieces they have taken and how many are left in the team pile.
4. Find out how many pieces each group has in its team pile, and give the group half that amount in new pieces.
5. Play three or four more rounds, stopping after each to find out if any of the students didn't survive (remember, this happens if there is not enough popcorn for them to get a piece).
6. After four or five rounds, have students share what happened in their teams. In which teams did all the students survive? Which teams think they would be able to keep a resource forever as long as the resource kept renewing itself? On these teams, how many pieces did students take each round?

Check-In
Discuss these questions with the entire group.

- What are the advantages and disadvantages of using a resource in a sustainable way? (Advantage: it can last forever. Disadvantage: you need to control your use of it?)
  ****Sustainable yield=** maximum rate at which people can use a renewable resource without reducing the ability of the resource to renew itself
- What are the advantages and disadvantages are there to using a resource in a non-sustainable way? (Advantages: people can use as much as they want of an available resource; they can make a lot of money in short term. Disadvantage: they can destroy the resource base for themselves and future generations.)
- In this activity, the population of each group stayed the same. In reality, however, the human population is increasing rapidly. What would have happened if one or more additional people had been added to your group?
- How would the following potentially impact the quantity and quality of resources: Natural disasters? Improved education systems for all? Disease?

TEACHER INFO SHEET

BACKGROUND INFORMATION

Natural resources are all of the things we use in our physical environment to meet our needs and wants, such as water, land, materials for clothing, etc. We can put all of the things that we use into two categories **non-renewable** and **renewable resources**.

Non-renewable resources exist in finite or limited amounts. Once they are used up, they are gone forever. For example, **fossil fuels** are formed through natural processes that take millions of years. If we use all of the available fossil fuels, no additional amounts of them will ever be available to us—at least not for millions of years.

Renewable resources are materials that can be replenished through natural and/or human processes. For example, even though trees die or are cut down, new trees are naturally reseeded or can be replanted by humans. Solar energy, wind, and tides are renewable resources that are constantly or perpetually being renewed or restored.

The maximum rate at which people can use a renewable resource without reducing the ability of the resource to renew itself is called **sustainable yield**. For example, a sustainable yield of timber would mean harvesting only the volume of trees that they forest could grow. This term also applies to water and wildlife. The sustainable yield of any resource varies from region to region and is different depending on the resource.

Renewable resources have the ability to replenish themselves, however the sustainable yield of that resource must be considered. If resources are consumed at a greater rate or capacity than they can be replenished, they will become nonexistent. A non-renewable resource is a natural resource that cannot be remade, regrown or regenerated on a scale comparative to its consumption. It exists in a fixed amount that is being consumed or used up faster than it can be made by nature. Fossil fuels (such as coal, oil, and natural gas) and nuclear power are non -renewable resources as thy do not naturally reform at a rate that makes the way we use them sustainable.

Answers to questions on the Student Worksheet:

1. Renewable: Corn, sunshine, tides, trees, tuna, geothermal or hot springs, wind, salmon, water. Although these resources are considered renewable, some can be regionally depleted by non-sustainable management practices.
2. Answers will vary depending on what's in your classroom.
3. Answers will vary. For example, students may suggest that wood may be used as a substitute for plastic or metal in chairs and other equipment.
4. Answers will vary. Students may suggest that some materials are cheaper than others, that products made from renewable resources are better since the materials to make them can always be available, or that some materials from non-renewable resources are superior to others because they're lighter in weight or have other properties.
5. If the students don't come up with answers to this question, don't worry. And don't give them an answer! The Popcorn Generation activity should teach students conditions under which this could occur.
6. Solar, energy, winds, tides, etc.

RENEWABLE OR NOT? STUDENT WORKSHEET

CLUES

1 On Earth, there are limited amounts of fossil fuels such as oil, coal and natural gas. There are also limited amounts of minerals such as iron, copper, and phosphates. These resources either cannot be replaced by natural processes or require millions of years to replenish. On Earth, there are limited amounts of fossil fuels such as	3 Renewable natural resources include plants, animals, and water, when they are properly cared for. Minerals and fossil fuels such as coal and oil are examples of non-renewable natural resources.
2 Some non-renewable and renewable natural resources can be recycled or reused. This process decreases the rate at which the supplies of these resources are depleted. For example, aluminum cans can be recycled and turned into new cans or other aluminum products many times. Recycling reduces the need to mine bauxite, the mineral used to make aluminum. Another example is recycling oil. The motor oil from your vehicle can be reprocessed into fuels or re-refined into other oils.	4 Trees, wildlife, water, and many other natural resources are replaced by natural processes. Plants and animals can also be replenished by human activities. Water is continuously cycled and reused. Sunlight, wind, geothermal heat, tides and flowing water are resources that are constantly or perpetually being renewed or restored.

QUESTIONS

1. Categorize the following as renewable or non-renewable resources:

Corn	Sunshine	Tuna	Wind
Oil	Tides	Gold	Water
Coal	Trees	Sand	

2. Look around the classroom and list as many items as you can that are made from renewable natural resources. Make another list of all the items made from nonrenewable natural resources.

3. What renewable natural resources could be used to replace the non-renewable ones used in the items listed in question #2?

4. What advantages and disadvantages might there be for using renewable natural resources in place of the non-renewable ones?

5. Which resources, if any, would continue to be available no matter how much people used them?

Activity 4: **ENERGY RESOURCE CHARADES**

Time: 15-20 minutes
Grades: 4-8

Purpose: In this activity, students will learn about the different sources of energy by playing charades. Students will act out and guess the energy source and if they are renewable or not.

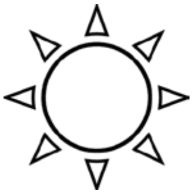
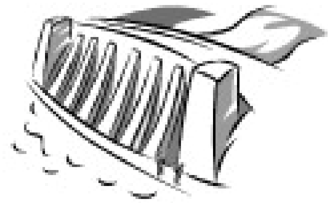
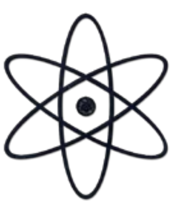
Materials:
- Stopwatch
- Energy source slips of paper

Content Standards:

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

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

Procedure:
1. Divide students into teams or do this as a whole class activity.
2. Students pick a energy resource from a hat and act it out to the class, can be timed or untimed.
3. This game can be a lead into Activity 5: Energy Resource Experts, or lead to a class discussion or lesson about the different energy sources. See teacher background.

 SUN	 WATER
 WOOD	 WIND
 BIOMASS	 GEOTHERMAL
 OCEAN TIDES	 COAL
 NATURAL GAS	 OIL/PETROLEUM
 NUCLEAR	

ENERGY SOURCE CHARADES SLIPS

Activity 5: **ENERGY RESOURCE EXPERTS**

Time: 3-6 hours
Grades: 6-12

Purpose: Students learn the difference between renewable and non-renewable resources and discover why sustainable use of natural resources is important.

Materials:
- Computers with internet access
- Poster paper
- Markers, colored pencils, decorating supplies
- “Energy Resource Experts” student handout packet

Objectives:
Students will:
- Identify energy resources as renewable or non-renewable
- Research and explain the technology of different energy resources.
- Present to the class and take notes on different types of energy sources.
- Explain the advantages and disadvantages of each type of energy source.

Content Standards:

4-ESS3-1.	Obtain and combine information to describe that energy and fuels are derived from natural resources and their uses affect the environment.
5-ESS3-1.	Obtain and combine information about ways individual communities use science ideas to protect the Earth’s resources and environment.
MS-ESS3-3.	Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.*
MS-ESS3-5.	Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.
MS-LS2-1.	Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem
WHST.6-8.2	Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content.

Procedure:
1. Divide students into research groups of 2-4. Assign a energy resource to each group or let groups choose.
2. If students need extra help, model how to get the required information, and fill out the student research packet while watching the video.

   a. Ex: Geothermal: pause video at each piece of information to highlight to students what they should be picking out of the video from the poster requirements.
   b. http://www.switchenergyproject.com/topics/energyresources
3. Poster Requirements:
   a. Drawing or representation of the type of energy
   b. Definition of the energy resource
   c. Renewable or non-renewable
   d. Technology of how it works
   e. At least 3 advantages and 3 disadvantages
4. After students are given one or two class periods to do research, and complete their poster, each group will have 10 minutes to present their energy source.
5. Students will take notes for each of the criteria on the student resource packet.

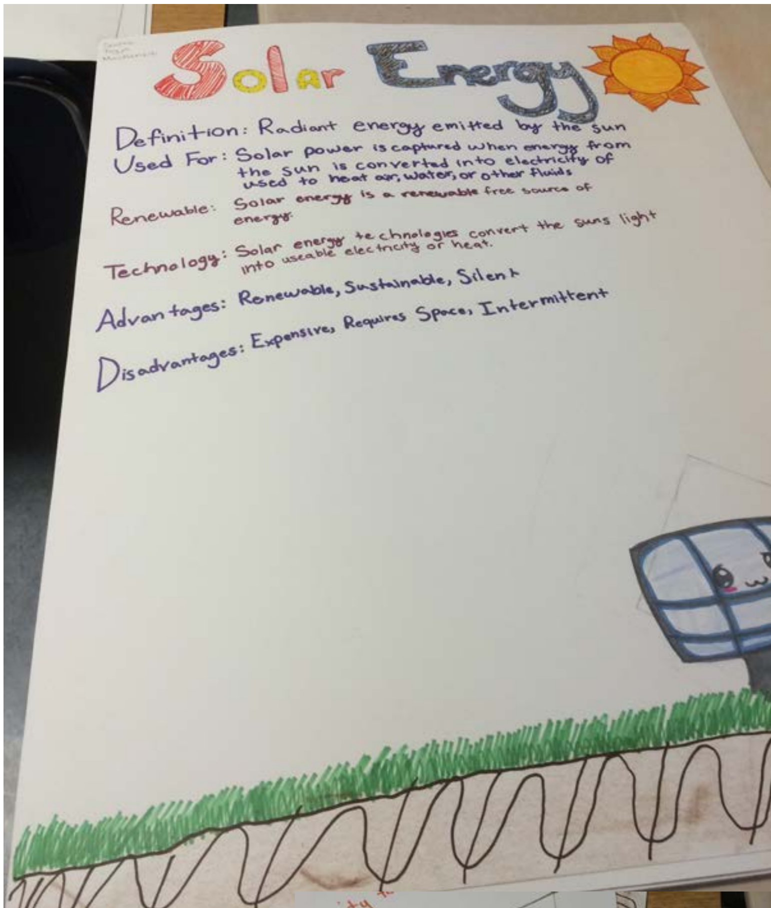
Assessment Suggestions:

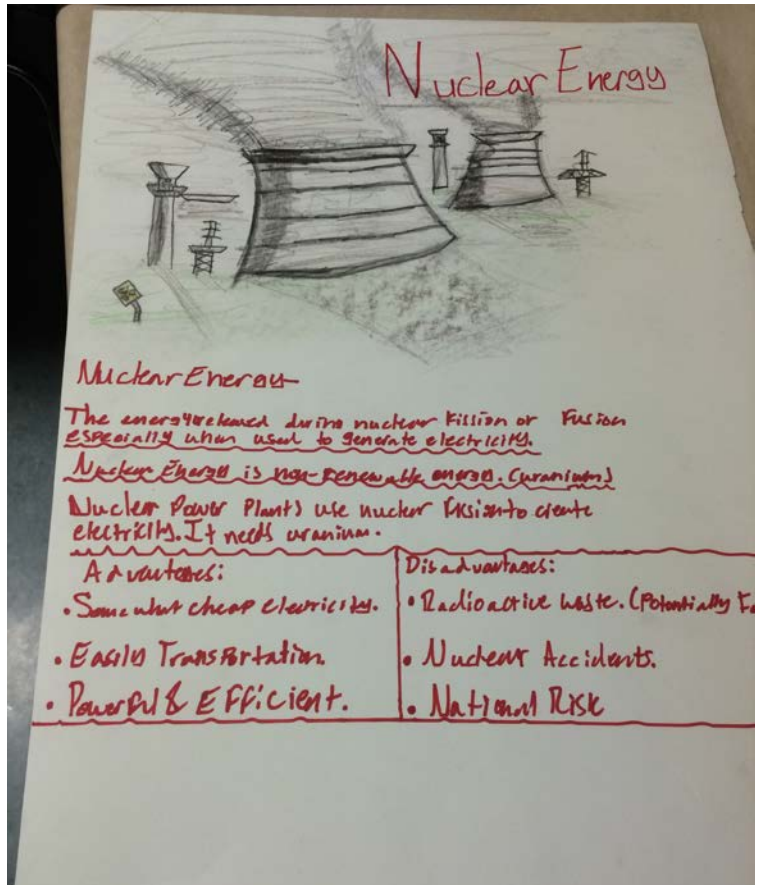
- Students should be graded on
  - Preparedness of presentation
  - Ability to answer questions accurately
  - Poster presentation
  - Knowledge of content

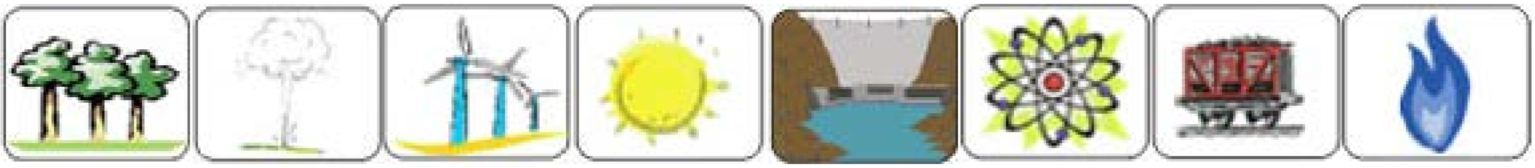
Resources:

http://www.worldenergy.org/data/resources/
http://www.switchenergyproject.com/topics/energyresources
http://energy.gov/science-innovation/energy-sources
http://energyinformative.org/

SAMPLE STUDENT POSTERS:







Energy Resource Experts

Poster Requirements

1. Title: Name of Energy Source
2. Drawing or representation of the type of energy
3. Definition of the energy resource, what is it, what is it used for?
4. Renewable or non-renewable
5. Technology of how it works
6. At least 3 advantages and 3 disadvantages

**Presentations: each group gets 10 minutes to present.

**You will take notes on the criteria of the energy sources. Take notes on your own energy source as well.

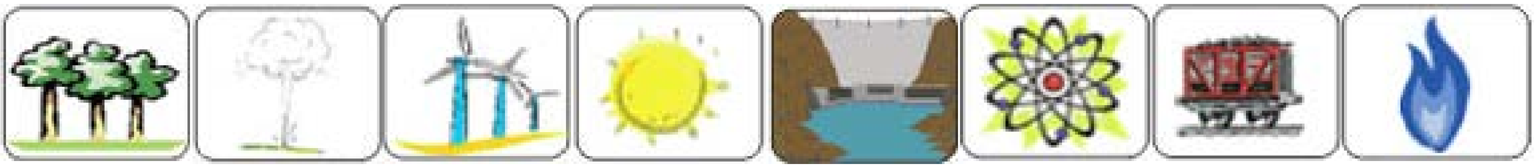
RESOURCE:

Renewable or Nonrenewable (circle one)

What is it? What is it used for?

How does it work? (Technology)

Advantages	**Disadvantages**
•	•
•	•
•	•



RESOURCE:

Renewable or Nonrenewable (circle one)

What is it? What is it used for?

How does it work? (Technology)

Advantages	**Disadvantages**
•	•
•	•
•	•

RESOURCE:

Renewable or Nonrenewable (circle one)

What is it? What is it used for?

How does it work? (Technology)

Advantages	**Disadvantages**
•	•
•	•
•	•

RENEWABLE ENERGY: WIND

Activity 6: Wind Turbine Engineers

TEACHER INFO SHEET

Wind Energy Basics

Basic information on wind energy and wind power technology, resources, and issues of concern.

Wind Energy and Wind Power

Wind is a form of **solar energy**. Winds are caused by the uneven heating of the atmosphere by the sun, the irregularities of the earth's surface, and rotation of the earth. Wind flow patterns are modified by the earth's terrain, bodies of water, and vegetative cover. This wind flow, or motion energy, when "harvested" by modern **wind turbines**, can be used to generate **electricity**.

How Wind Power Is Generated

The terms "**wind energy**" or "**wind power**" describe the process by which the wind is used to generate **mechanical power or electricity**. Wind turbines convert the kinetic energy in the wind into mechanical power. This mechanical power can be used for specific tasks (such as grinding grain or pumping water) or a generator can convert this mechanical power into electricity to power homes, businesses, schools, and the like.

Wind Turbines

Wind turbines, like aircraft propeller blades, turn in the moving air and power an**electric generator** that supplies an electric current. Simply stated, a wind turbine is the opposite of a fan. Instead of using electricity to make wind, like a fan, wind turbines use wind to make electricity. The wind turns the blades, which spin a shaft, which connects to a generator and makes electricity.

Wind Turbine Types

Modern wind turbines fall into two basic groups; the **horizontal-axis** variety, like the traditional farm windmills used for pumping water, and the **vertical-axis** design, like the eggbeater-style Darrieus model, named after its French inventor. Most large modern wind turbines are horizontal-axis turbines.

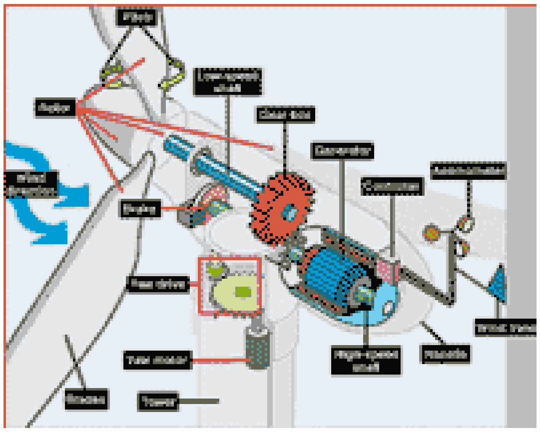
Turbine Components

Horizontal turbine components include:

- **blade** or **rotor**, which converts the energy in the wind to rotational shaft energy;
- a **drive train**, usually including a gearbox and a generator;

- a **tower** that supports the rotor and drive train; and
- other equipment, including controls, electrical cables, ground support equipment, and interconnection equipment.

Wind turbine diagram - click for enlarged image.



Turbine Configurations

Wind turbines are often grouped together into a single wind power plant, also known as a **wind farm**, and generate bulk electrical power. Electricity from these turbines is fed into a utility grid and distributed to customers, just as with conventional power plants.
See Wind Energy Photos page for wind farm photographs.

Wind Turbine Size and Power Ratings

Wind turbines are available in a variety of sizes, and therefore power ratings. The largest machine has blades that span more than the length of a football field, stands 20 building stories high, and produces enough electricity to power 1,400 homes. A small home-sized wind machine has rotors between 8 and 25 feet in diameter and stands upwards of 30 feet and can supply the power needs of an all-electric home or small business. **Utility-scale turbines** range in size from 50 to 750 kilowatts. Single small turbines, below 50 kilowatts, are used for homes, telecommunications dishes, or water pumping.
See Wind Energy Photos page for wind turbine photographs.

Wind Energy Resources in the United States

Wind energy is very abundant in many parts of the United States. Wind resources are characterized by **wind-power density classes**, ranging from class 1 (the lowest) to class 7 (the highest). Good wind resources (e.g., class 3 and above, which have an average annual wind speed of at least 13 miles per hour) are found in many locations (see United States Wind Energy Resource Map). Wind speed is a critical feature of wind resources, because the energy in wind is proportional to the **cube** of the wind speed. In other words, a stronger wind means a lot more power.

Advantages and Disadvantages of Wind-Generated Electricity

A Renewable Non-Polluting Resource

Wind energy is a **free, renewable resource**, so no matter how much is used today, there will still be the same supply in the future. Wind energy is also a source of**clean, non-polluting, electricity**. Unlike conventional power plants, wind plants emit no air pollutants or greenhouse gases. According to the U.S. Department of Energy, in 1990, California's wind power plants offset the emission of more than 2.5 billion pounds of carbon dioxide, and 15 million pounds of other pollutants that would have otherwise been produced. It would take a forest of 90 million to 175 million trees to provide the same air quality.

Cost Issues

Even though the cost of wind power has decreased dramatically in the past 10 years, the technology requires a **higher initial investment** than fossil-fueled generators. Roughly 80% of the cost is the machinery, with the balance being site preparation and installation. If wind generating systems are compared with fossil-fueled systems on a "life-cycle" cost basis (counting fuel and operating expenses for the life of the generator), however, wind costs are much more competitive with other generating technologies because there is no fuel to purchase and minimal operating expenses.

Environmental Concerns

Although wind power plants have relatively little impact on the environment compared to fossil fuel power plants, there is some concern over the **noise** produced by the rotor blades, **aesthetic (visual) impacts**, and birds and bats having been killed (**avian/bat mortality**) by flying into the rotors. Most of these problems have been resolved or greatly reduced through technological development or by properly siting wind plants.

Supply and Transport Issues

The major challenge to using wind as a source of power is that it is **intermittent** and does not always blow when electricity is needed. Wind cannot be stored (although wind-generated electricity can be stored, if batteries are used), and not all winds can be harnessed to meet the timing of electricity demands. Further, good wind sites are often located in **remote locations** far from areas of electric power demand (such as cities). Finally, wind resource development may compete with other uses for the land, and those **alternative uses** may be more highly valued than electricity generation. However, wind turbines can be located on land that is also used for grazing or even farming.

Information From: http://windeis.anl.gov/guide/basics/

Activity 6: WIND TURBINE ENGINEERS

Time: 50+ minutes
Grades: 4-12

Purpose: To use engineer and design to and discover how wind turbines generate electricity and to explore how different blade shapes affect the amount of power generated.

Students will:

- Explain how wind energy and wind turbines work using the terms kinetic energy, mechanical energy, electricity, and generator.
- Explain how engineering can help solve society's challenges.
- Show teamwork and problem solving skills by designing and engineering wind turbines in a group of 2-4.

Materials:

- Cardstock
  - o Printed pinwheel designs
  - o Blank for create your own wind turbine blades
- Scissors
- Small DC electric motor
- Alligator clip leads
- Multimeter
- Fans
- "Wind Turbine Engineers" student handout

Content Standards:

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

4-PS3-4. Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.*

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

MS-PS3-2. Develop a model to describe that when the arrangement of objects interacting at a distance changes, different amounts of potential energy are stored in the system.

MS-ESS3-3. Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.*

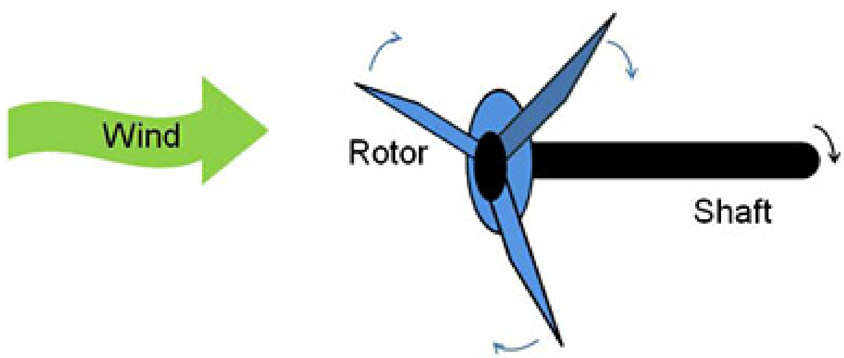
MS-ETS1-2. Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

MS-ETS1-3. Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.

MS-ETS1-4. Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

Procedure:

1. Students read student resource sheet as a class, of what is wind energy and how do wind turbines work, underling key terms and phrases.
2. Review what wind energy is→ converts kinetic energy to mechanical energy to electricity, students fill this in into their lab worksheets.
3. Emphasize how fans and wind turbines are similar and different.
    a. The motor can be turned into a fan by connecting it to an electrical source, or it can be turned into a generator by using the energy from the wind to create electricity.
4. Explain how to use all the equipment
    a. Demonstrate sample wind turbine
    b. Attach blades to the motor, and add a stopper (eraser end or putty) on the rotor.
    c. Attach alligator clips to motor and multimeter: green to black, red to red.



5. Which group can design the most efficient wind turbine- get the highest voltage
    a. Each person in the group should have at least one different design
6. Students must draw the designs of each person in their group, indicate the number of blades they have, and what was the highest voltage that design was able to get.
7. Go over discussion questions as a class
    a. Have students share which design was the most effective and why they think it was so. What patterns do they notice from the data. Extend activity by graphing data.
8. Give students time in class (15 minutes) to discuss with their group mates or partners the other discussion questions.
9. Go over a few answers as a class.
10. Show video of how wind turbines work as a recap: http://energy.gov/energysaver/articles/small-wind-electric-systems

Lesson Extensions

- Virtual Wind Turbine Lab: Investigate affects of location, wind speed, turbine height, blade type, etc. Can be used as pre-investigation or post-investigation http://scienceofeverydaylife.com/innovation/labs/wind-energy/wind.swf
- Lesson can be extended as an Engineering and Design project
  - http://tryengineering.org/lesson-plans/working-wind-energy

Resources

- Pinwheel patterns: http://www.electricpinwheels.com/Free_Pinwheel_Templates.html

WIND TURBINE ENGINEERS

Objective: To discover how wind turbines generate electricity and to explore how different blade shapes affect the amount of power generated.

Wind energy converts _____________ energy to _____________ energy.

* In a group, design different turbines. Try to come up with the most effective one!
**Each individual in the group must produce at least one design.

Wind Turbine Blueprint:

- Draw your wind turbine
- Label the parts of the turbine (shaft, rotor, blade) and shape of your blades
- Draw arrows to show way the wind is blowing and which way the blades are spinning

Blade Shape (drawing)				
Blade Length (cm)				
Voltage (multimeter: 2000m V)				

Discussion Questions: Evaluate your team's results

1. What design was the most effective? Which design was the least?

2. Why was the design the produced the most power effective at converting wind (kinetic) energy to electrical energy?

3. If you could have access to materials that were different from the ones you used what would they be? How would this have improved the design of your wind turbine?

4. Do you think that engineers have to adapt their original plans during the construction of systems or products? Why might they?

5. If you had to do it all over again, how would your planned design change? Why?

6. What drawbacks does a wind turbine have as a reliable source of energy? What technologies exist that might compensate for these drawbacks?

7. What advantages does the windmill have as a renewable source of energy?

RENEWABLE ENERGY: SOLAR

Activity 7: Solar Cooker Challenge

Activity 8: Solar Panel Inquiry Lab

Activity 9: Solar Photon Musical Chairs

Activity 7: **SOLAR COOKER CHALLENGE**

Time: 60+ minutes
- 30-60 minutes to build solar cooker
- 30+ minutes to cook s'mores or snacks depending on weather.

Grades: 4-8

Purpose: Engineering design challenge to design and build a solar cooker, and to test it out to see if it works well enough to make s'mores.

Students will:
- Build a solar cooker either parabolic or box shaped with a group
- Define and explain the three components of a solar cooker that make it work: concentration, absorption, and retention, and be able to explain what materials do those things in their solar cookers
- Describe how sunlight is converted into heat in the solar cookers using the terms light, solar energy, heat, thermal energy, potential energy, and kinetic energy.
- Explain how solar cookers can be used in everyday life.
- Compare the environmental impact of solar energy as opposed to fossil fuels.

Materials:
- "Solar Cooker Challenge" student handouts
- Pizza boxes/shoe boxes
- Box cutters/sharp scissors
- Plastic wrap
- Aluminum foil
- Black construction paper/butcher paper
- Skewers
- Tape
- Glue
- Ruler

S'mores ingredients
- Marshmallows
- Chocolate
- Graham crackers
- Ziploc bags

Content Standards:

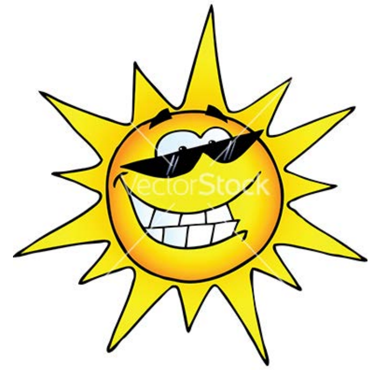
4-ESS3-1. Obtain and combine information to describe that energy and fuels are derived from natural resources and their uses affect the environment.

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-PS3-4. Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.*
5-ESS3-1. Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources and environment.
MS-ESS3-3. Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.*
MS-ESS3-5. Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.
MS-PS3-3. Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer.*
MS-ETS1-1. Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.
MS-ETS1-2. Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.
MS-ETS1-3. Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.
MS-ETS1-4. Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

Procedure

1. Play PBS video on solar lab cooker 6th grade inquiry http://www.pbslearningmedia.org/resource/phy03.sci.phys.mfe.zsolar/cooking-cookies-with-solar-power/
    a. Video shows 2 types of cookers: parabolic and box. Stop the video before it says which one is the most efficient one and have students guess what they think!
2. Introduce lab—read the lab as a class
    a. Circle vocab words and underline definitions and key phrases.
    b. Review main vocab: concentration, absorption, and retention with students
    c. Pre-lab questions as a class/individual work time
3. Students answer pre-lab questions before starting to build their solar cooker.
4. Have students build solar cooker using the instructions on their handouts, or have them freely engineer their own design!
5. Record data, optional: create class data charts
6. Answer conclusion questions, review as a class.
7. Eat S'mores

Name: ____________________



Solar Cooker Challenge Lab

Objective: To discover how solar ovens work and to answer the ultimate question:
Which type of solar cookers is the most powerful in cooking s'mores?

Introduction:

Most of you know how it can be hot enough to fry an egg on the pavement. But have you ever seriously considered cooking with the sun?

The sun continuously provides Earth with tremendous amounts of solar energy, most of which comes in the form of visible light. Sunlight, when transformed into usable heat, can be a practical source of energy for everyday jobs such as cooking food, heating water, or warming houses. In some parts of the world, solar cooking is very popular.

Solar cookers work because sunlight carries lots of power. For example, when sunlight hits a surface with an area of 1 square meter, there is about 1,000 watts of energy from the sun on that surface. Compare this to your toaster oven, which uses about 1,000 watts.

There are three main components to most solar cookers, or you could say three main principles to effective solar cooking: **concentration**, **absorption**, and **retention**.

Concentration (reflection, or reflectance): Concentration of the sun's rays is performed most often by reflecting panels, petals and such surfaces that can "focus" or concentrate the rays of light. Reflecting panels are made of materials that are shiny and reflective such as silver, chromium, and aluminum

Absorption (ability to attract or hold heat): Dark colors absorb heat well, while light colors do not. Thus, most common solar oven interiors are usually black in color as well as the color of the cookware used for cooking the food.

Retention (means or capacity to retain heat): If a solar cooker is not well insulated and if it does not have a cover, or lid, then all of the concentrated heat (energy) and all of the absorbed heat would quickly dissipate into the air and be lost to the surrounding environment. A solar cooker must have the means to "trap" or hold the concentrated heat allowing it to accumulate and to "build up" to sufficiently high enough levels to be able to effectively cook.

In this lab, you will be using the following materials to build one of two types of solar cookers and make a s'more. As a class, our goal is to determine, which type of solar cooker (parabolic or box) is the most powerful.

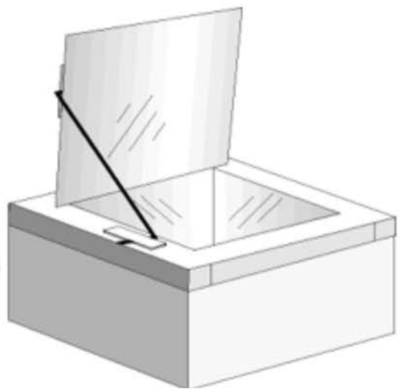
Materials:

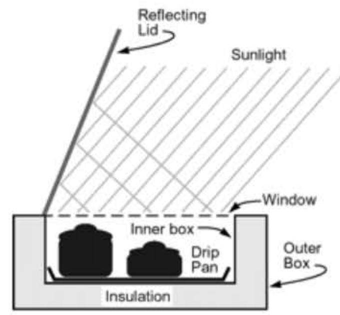
- Pizza boxes
- Cardboard boxes
- Box cutters/sharp scissors
- Plastic wrap
- Aluminum foil
- Black construction paper/butcher paper
- Skewers
- Tape
- Glue
- Ruler
- Thermometer

Just as there are many kinds of conventional cookers (ovens, stovetops, broilers, microwave ovens), there are many kinds of solar cookers. These are the three main types:

Box Cookers

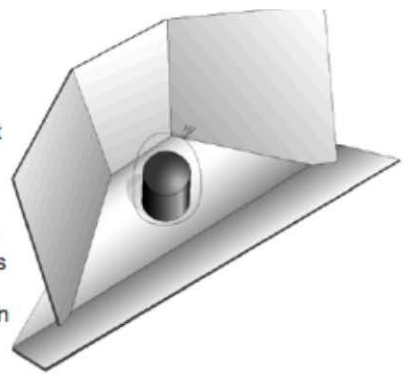
A box cooker is a well-insulated box-within-a-box with a glazed top and a hinged lid that reflects the rays of the sun into the box. When the lid is propped open and the box is turned to face the sun, food in dark, covered pots in the oven reaches cooking temperatures.

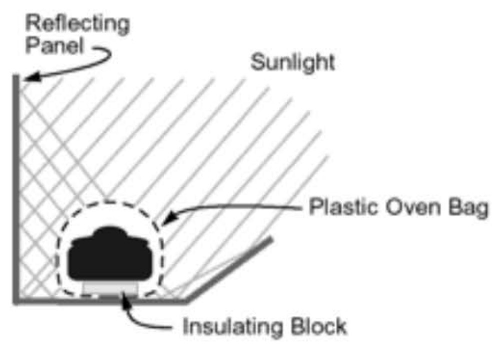




Panel Cookers

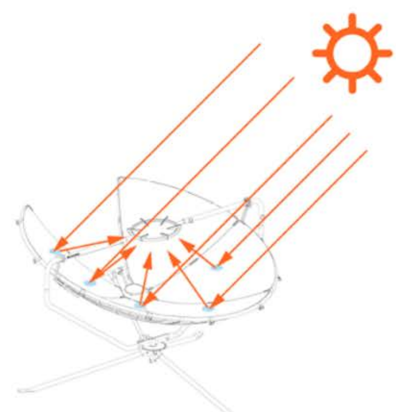
A panel cooker is a reflective panel that directs sunshine onto a dark-colored cooking pot enclosed in a clear insulating shell such as a plastic high-temperature cooking bag or an inverted bowl. The shell lets in sunlight and traps the heat. Food in the dark-colored pot typically cooks at temperatures between 200°F and 275°F.





High-Temperature Cookers

High-temperature reflector cookers typically use a parabolic mirror to focus sunlight on a cooking vessel. The focal point of the parabola can become very hot indeed—typically reaching temperatures of 600°F and above—in a very short time, making cooking with one of these similar to cooking on a conventional stovetop. Besides a parabola, other mirror geometries can be used to create the focal point: segmented near-parabolas, Fresnel mirrors, and the "three-circle" geometry popular in China. All use the same principle.



Other creative designs of solar cookers can be found here: http://solarcooking.org/plans/

Pre-Lab Questions:

1. Solar ovens convert solar energy (________) to thermal energy (_________). The food it cooks is _________ energy to be eaten and converted for motion or metabolism into ___________ energy.

2. Which solar cooker do you think is the more powerful? Box (pizza box) or parabolic (cone)? **Hypothesis**: If….then….because…..

3. Experiment Variables:
   - Independent Variable: _________________
   - Dependent Variable: ___________________
   - Control: ____________________

4. Circle the type of solar cooker you are building: Parabolic or Box?

5. In the box below, draw your solar cooker design.
   Be sure to label your **concentrating, absorbing, and retaining** materials.

Results

1. Design of your solar cooker (parabolic or box) _________________
2. Temperature reached in your team's solar cooker (C) ____________________
3. Control s'more temperature (C) ___________________
4. Class Averages Temperatures (C)
    a. Parabolic solar cooker ____________
    b. Box solar cooker ______________

Conclusion

8. Which solar cooker was the most powerful (highest temperature)? Why?

9. Why is it important to have a "control" s'more? What does the control demonstrate in this investigation?

10. What is the function of each of the following parts of the two solar cookers: foil, the black surface under the marshmallow, plastic wrap, and plastic baggie?

11. Describe how sunlight is converted into heat by the two solar cookers.

12. What aspects can you improve to increase the efficiency of your solar cooker?

13. Besides cooking food, can you think of other ways to use a solar cooker around your house?

14. How is solar energy different compared to conventional energy sources, such as fossil fuels? What environmental impact does it have?

Challenge Question:
Read the following passage about the greenhouse effect and Earth's greenhouse gasses on the next page.

15. What are the similarities between the greenhouse effect and the solar cookers?

The Greenhouse Effect and Greenhouse Gasses

Have you ever been inside a greenhouse on a cold winter day? It might be cold outside, but inside the greenhouse lush green plants flourish in the warmth and sunshine. Greenhouses are made of glass and are designed to hold heat inside. Our planet's atmosphere traps energy just like a greenhouse. Energy from the Sun can enter the Earth's atmosphere, but not all of it can easily find its way out again.

What blocks the Sun's energy from escaping from the Earth? Unlike a greenhouse, the Earth does not have a layer of glass over it! Instead, molecules in our atmosphere called greenhouse gasses absorb the heat. Greenhouse gasses include water vapor, methane, ozone, nitrous oxide, and carbon dioxide. There may not be much of some of these gasses in our atmosphere, but they can have a big impact. Each greenhouse gas molecule is made of three or more atoms that are bonded loosely together. These molecules are able to absorb heat, which makes them vibrate. They eventually release the heat energy and it is often absorbed by another greenhouse gas molecule.

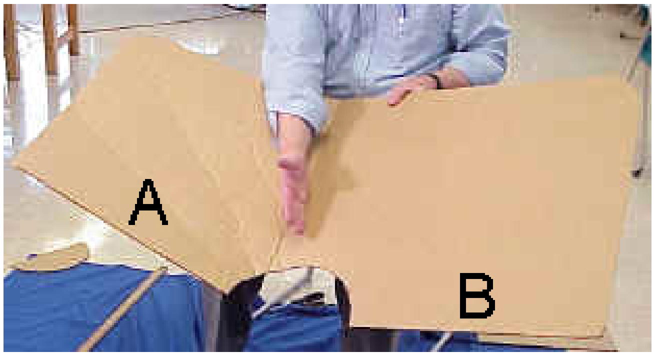
The **greenhouse effect** is useful because trapping some energy keeps the temperatures on our planet mild and suitable for living things. Without its atmosphere and the greenhouse effect, the average temperature at the surface of the Earth would be zero degrees Fahrenheit. However, too many greenhouse gases can cause the temperature to increase out of control. Such is the case on Venus where greenhouse gases are abundant and the average temperature at the surface is more than 855 degrees Fahrenheit (457 degrees Celsius).

You might hear people talking about the greenhouse effect as if it is a bad thing. It is not a bad thing, but people are concerned because Earth's greenhouse is warming up very rapidly. This is happening because we are currently adding more greenhouse gases to our atmosphere, causing an increased greenhouse effect. The increased Greenhouse effect is causing changes in our planet that can affect our lives.

Cone Solar Cooker Construction Steps

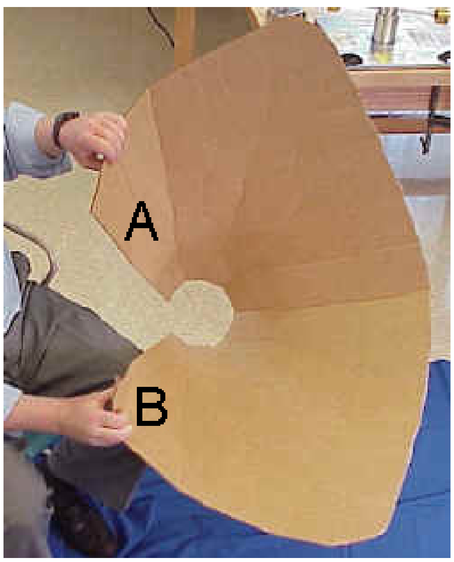
1) Cut a Half-circle out of the Cardboard

Cut a half circle out of the cardboard, along the bottom as shown below. When the funnel is formed, this becomes a full-circle and should be wide enough to go around your cooking pot. So for a 7" diameter cooking pot, the radius of the half-circle is 7". For a quart canning jar such as I use, I cut a 5" radius half-circle out of the cardboard.



2) Form the Funnel

To form the funnel, you will bring side A towards side B, as shown in the figure. The aluminum foil must go on the INSIDE of the funnel. Do this slowly, helping the cardboard to the shape of a funnel by using one hand to form creases that radiate out from the half-circle. Work your way around the funnel, bending it in stages to form the funnel shape, until the two sides overlap and the half-circle forms a complete circle. The aluminum foil will go on the INSIDE of funnel. Open the funnel and lay it flat, "inside up", in preparation for the next step.



3) Glue Foil to Cardboard

Apply glue or adhesive to the top (inner) surface of the cardboard, then quickly apply the aluminum foil on top of the glue, to affix the foil to the cardboard. Make sure the shiniest side of the foil is on top, since this becomes your reflective surface in the Funnel. I like to put just enough glue for one width of foil, so that the glue stays moist while the foil is applied. I also overlap strips of foil by about 1" (or 2 cm). Try to smooth out the aluminum foil as much as you reasonably can, but small wrinkles won't make much difference. (If even cardboard is not available, one can simply dig a funnel-shaped hole in the ground and line it with a reflector, to make a fixed solar cooker for use at mid-day.)

4) Join side A to side B to keep the funnel together.

The easiest way to do this is to punch three holes in the cardboard that line up on side A and side B (see figure). Then put a metal brad through each hole and fasten by pulling apart the metal tines. Or you can use a nut-and-bolt to secure the two sides (A & B) together.

Be creative here with what you have available. For example, by putting two holes about a thumb-width apart, you can put a string, twine, small rope, wire or twist-tie in one hole and out the other, and tie together.

When A and B are connected together, you will have a "funnel with two wings". The wings could be cut off, but these help to gather more sunlight, so I leave them on.

Tape or glue a piece of aluminum foil across the hole at the bottom of the funnel, with shiny side in.

This completes assembly of your solar funnel cooker!

For stability, place the Funnel inside a cardboard or other box to provide support.

Developed by Kathy Nguyen for SOCAN-Climate in the Curriculum

PIZZA BOX SOLAR OVEN

Materials

- Pizza box
- Two clear sheet protectors
- Black construction paper
- Duct tape
- Clear masking or packing tape
- Box knife
- Scissors
- Thermometer
- Wooden skewer
- Glue stick (Elmer's glue will work, too)
- Tin foil
- Ruler
- Pen

1. On the lid of a pizza box, use a ruler and pen to measure and draw a square that is 1-2" from the sides of the box.
2. Cut along three sides of the square you just made by using box cutters or a pair of scissors.
3. Measure and cut a large piece of foil to line the bottom of the pizza box.
4. Apply glue to the bottom of the pizza box and glue the large piece of foil into place, smoothing in down.
5. Measure and cut another large piece of foil to cover the bottom of the flap you cut on the pizza box lid.
6. Apply glue to the bottom of the pizza box lid and glue the tin foil piece into place.
7. Use scissors to cut a piece of black construction paper that is 1-2" smaller at each edge than the bottom of the pizza box.
8. Use clear masking or packing tape to tape the black construction paper to the bottom of the pizza box. Try to center the black construction paper.
9. Find a sheet protector and pull the two pieces apart. Tape these pieces together at one of their long edges. Tape the new, large piece of plastic on the inside of the box lid, NOT the flap. The plastic should span the flap opening. If it doesn't, make a larger plastic sheet!
10. Use a wooden skewer to poke two small holes (don't poke the skewer all the way through) on the lid between the flap and the side of the lid. Poke the holes about 2" apart.
11. Wrap a thin piece of tape around the skewer, near the flat end, so that one end of the tape is above the other end. Check out the photo at the right to see exactly how to wrap the tape.
12. Tape the skewer to the flap so that the flat end of the skewer is near the end of the flap. Use the skewer and the holes you poked in the lid as a kickstand for the flap.
13. If you want to see just how hot your Solar Oven gets, tape a thermometer to the bottom of the box so that it can be seen through the plastic window.
14. Set up your oven with the flap up and place it in the sun. It may take a little while, but you'll watch your s'mores heat up, melt, and be ready to eat!

- See more at: http://www.stevespanglerscience.com/lab/experiments/solar-oven#sthash.WGQaZ5M9.dpuf

TEACHER INFO

SOCAN R.E.D. Renewable Energy Demonstrator

SOCAN RED is a Solar Powered Generator that was designed and built both as a learning and a teaching tool by the Green Energy group. It also serves as a marketing display unit to be used at SOCAN events as a way to engage the public in discussing both renewable energy and global climate change. As part of the Farnley Tyas Grant, that has graciously funded this project, it is also our goal to use SOCAN RED in our Educational outreach to schools in Southern Oregon.

Component - Function List:

Photovoltaic Solar Panel - SolarWorld 235W Sunmodule made in Hillsboro, Oregon

- Photovoltaic (PV) cells act a photosensitive diodes that convert light into Direct Current (DC) electricity.

- Details from SolarWorld website (http://www.solarworld-usa.com/solar-101/how-solar-panels-work)

Cell Layers

- A top, phosphorus-diffused silicon layer carries free electrons – un-anchored particles with
negative charges.
- A thicker, boron doped bottom layer contains holes, or absences of electrons, that also can
move freely.
- In effect, precise manufacturing has instilled an electronic imbalance between the two layers.

Sun Activation

1- Photons bombard and penetrate the cell.
2- They activate electrons, knocking them loose in both silicon layers.
3- Some electrons in the bottom layer sling-shot to the top of the cell.
4- These electrons flow into metal contacts as electricity, moving into a circuit throughout a 60-cell module.
5- Electrons flow back into the cell via a solid contact layer at the bottom, creating a closed loop or circuit.
- Note: Solar panels do not create a 'current flow' until both of its connectors are plugged in 'completing a circuit' allowing the electrons to flow as direct current

- Charge Controller - MPPT 250 BZ Products

- In an off-grid portable solar generator the current from the solar panel goes into a Charge Controller which acts as an electronic gate that 'conditions' the wattage and amperage so that it can safely manage the load going into the battery to keep it properly charged and also prevent overcharging.

- In a grid-tied systems it is not necessary to have a charge controller. The DC current from the panels goes directly into an Inverter that converts the DC into Alternating Current (AC) which is what we use in our homes. Simply put, Direct Current creates a constant stream of electrical current in one direction (like most batteries), while Alternating Current quickly cycles the current back and forth in both directions.

- Battery - Trojan AGM Sealed Deep-Cycle

- In our off-grid system, the battery serves 2 important functions. The first one is fairly obvious, a fully charged deep-cycle battery like this one will store enough energy to provide electricity for hours after the sun has gone down. The second function of the battery is to condition the energy into an standard voltage and act in concert with the charge controller to provide a place for unused current to be used. If DC current is on and flowing and not doing anything the energy will turn to heat (enough heat to melt copper wiring).

- Battery Capacity Meter - Midnite Solar MNBCM

- Tracks the state of the batteries state of charge and will let user know not to drain the battery below 40% charge.

- Inverter - Morningstar SureSine-300 Watt Pure Sine Inverter

- The inverter's job is to change the 12-14 volts of DC from the battery into 120 volts of AC power that we use in our homes. Pure Sine Inverters' provide the highest quality of clean, static-free energy possible allowing high-end electronics and computers to be used safely and perform at their best. Clean, smooth AC power will also extend the life of most electronic devices.

- Fused Power Strip

- Using a power strip with a replaceable fuse allows us to size the fuse for our system's output.
The fuse will also protect plugged in devices from an unlikely power surge.

- Kill A Watt Monitor

- Measure the energy used by appliances plugged directly into the meter. It will also display the energy consumed over time and can be programmed to display cost on energy used.

SOLAR ELECTRICITY

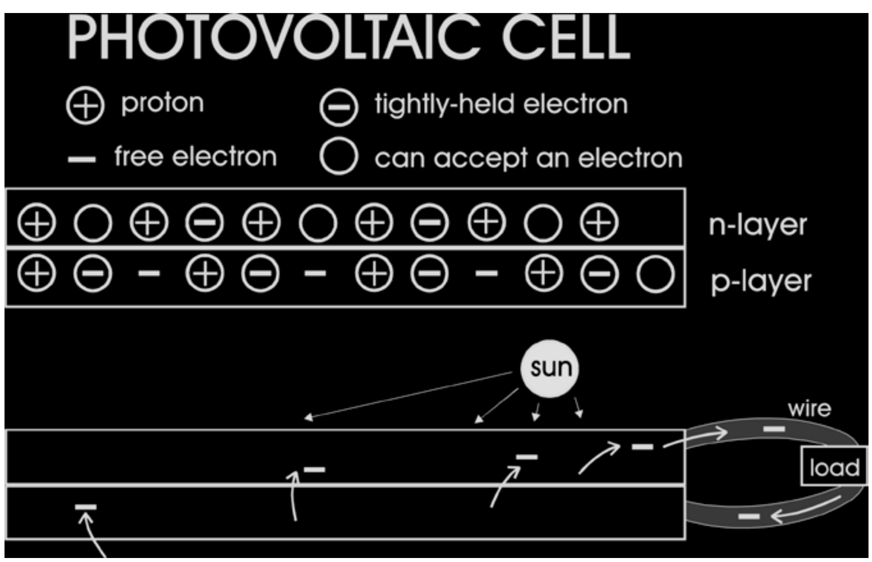
Solar energy can also be used to produce electricity. Two ways to make electricity from solar energy are photovoltaics and solar thermal systems.

Photovoltaic comes from the words photo meaning light and volt, a measurement of electricity. Photovoltaic cells are also called PV cells or solar cells for short. You are probably familiar with photovoltaic cells. Solar-powered toys, calculators, and roadside telephone call boxes all use solar cells to convert sunlight into electricity.

Solar cells are made of two thin pieces of silicon, the substance that makes up sand and the second most common substance on earth. One piece of silicon has a small amount of boron added to it, which gives it a tendency to attract electrons. It is called the p-layer because of its positive tendency. The other piece of silicon has a small amount of phosphorous added to it, giving it an excess of free electrons. This is called the n-layer because it has a tendency to give up electrons, a negative tendency. When the two pieces of silicon are placed together, some electrons from the n-layer flow to the p-layer and an electric field forms between the layers. The p-layer now has a negative charge and the n-layer has a positive charge.

When the PV cell is placed in the sun, the radiant energy energizes the free electrons. If a circuit is made connecting the layers, electrons flow from the n-layer through the wire to the p-layer. The PV cell is producing electricity--the flow of electrons. If a load such as a lightbulb is placed along the wire, the electricity will do work as it flows. The conversion of sunlight into electricity takes place silently and instantly. There are no mechanical parts to wear out.

Compared to other ways of producing electricity, PV systems are expensive. It costs 10-20 cents a kilowatt-hour to produce electricity from solar cells. On average, people pay about eight cents a kilowatt- hour for electricity from a power company using fuels like coal, uranium or hydropower. Today, PV systems are mainly used to generate electricity in areas that are a long way from electric power lines.



Activity 8: **SOLAR PANEL INQUIRY**

Time: 20-30 minutes
Grades: 4-12

Purpose: To use understand how photovoltaic solar cells work to capture sunlight energy can convert it to electric energy.

Students will:

- Diagram the layers of a solar panel and list in steps how light is converted to electricity
- Test the affects of light intensity (canopy cover), angle of panel, and size of solar cell on the amount of electricity created by a mini solar panel.

Materials:

- Solar cells (.5V, 1V, 1.5V)
- Alligator clip leads
- Multimeter
- Solar Panel Photovoltaic Volt diagram handout
- "Solar Panel Inquiry" student handout

Content Standards:

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

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-PS3-4. Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.*

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

MS-ESS3-3. Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.*

MS-PS3-2. Develop a model to describe that when the arrangement of objects interacting at a distance changes, different amounts of potential energy are stored in the system.

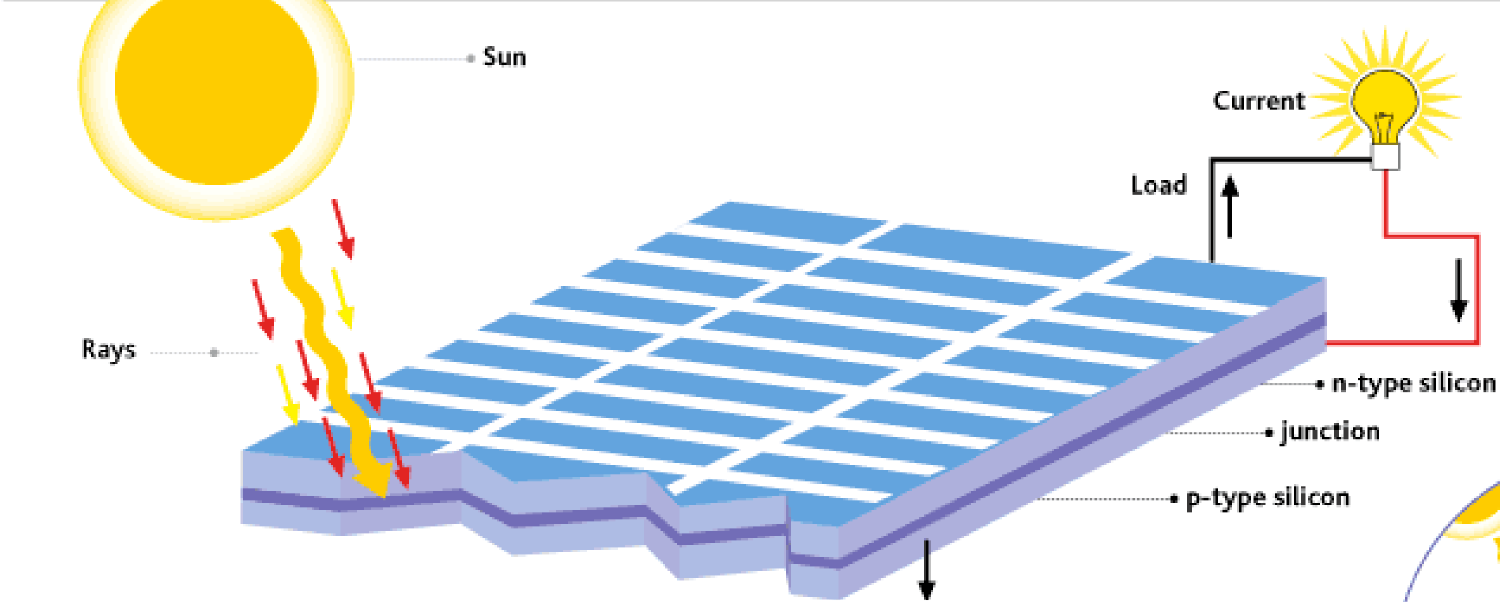
HS-ESS3-4. Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.*

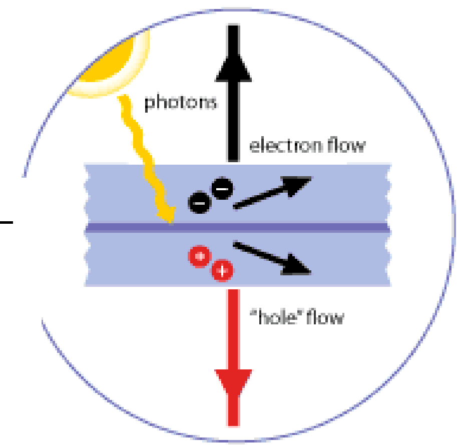
Procedure

1. Introduce the concept that there are different forms of energy, such as light, mechanical, electrical, chemical, and heat energy State that solar cells are objects that convert light energy into electrical energy.
2. Hold up a mini– solar electric panel and show students that it is made up of solar cells.

3. Using SOCAN Red's Energy Demonstrator Info and Solar Electricity Teacher info, explain to students how photovoltaic cells work and guide them to fill out the Photovoltaic Cell Diagram
4. Give each group a 1V solar cell and a lab handout. After students explore the affects of angle and light intensity on the 1V panel, have them explore the affects of solar cell size with the .5V and 1.5V solar cells.
5. Investigate the effects of angle, size of panel, and light intensity/canopy cover.
6. Record data
7. Compare results. Optional extension: graph results and make predictions.

Conventional Solar Cell





Photovoltaic cell: ____

1)

2)

3)

4)

5)

Name ____ Date ______________________

Solar Panel Inquiry Student Data Sheet

Temperature _______________°C

Solar Panel Size (.5V, 1V, or 1.5V)	**Angle (°)**	**Light Conditions**	**Notes/Observations**

Light conditions:

- Canopy cover (under shade of tree or building)
- Clear blue sky
- Heavily overcast sky
- Thin clouds passing by
- Heavy clouds passing by
- Light hazy sky
- Other: describe…

Developed by Kathy Nguyen for SOCAN-Climate in the Curriculum

Activity 9: **SOLAR PHOTON MUSICAL CHAIRS**

Time: 50 minutes
Grades: 4-8

Purpose: To simulate the movement of electrons at the p-n junction to create an electrical current in a solar cell.

Students will:

- Play a modified game of musical chairs to model how photons and electrons move in a solar panel to generate power
- Simulate electron movement through an electric field to deposit electricity into an external load in order to understand how electrons are dislodged by the sun's rays to create electricity.
- Explain how solar panels convert sun rays into electricity using the terms photons, electrons, and p-n junction

Materials:

- Student solar panel and inquiry hand outs
- 10-15 ping pong balls or other similar item
- 1 die
- 1 basket or bucket
- Table or desk to store potential orbs
- Optional: signs for students to wear to identify the P and N side
- "Photon Musical Chairs Comprehension" student handout.

Content Standards:

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

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-PS3-4. Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.*

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

MS-ESS3-3. Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.*

MS-PS3-2. Develop a model to describe that when the arrangement of objects interacting at a distance changes, different amounts of potential energy are stored in the system.

HS-ESS3-4. Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.*

Procedure

Goal of the game: To simulate electron movement in a photovoltaic (PV) cell, and to collect more "electricity orbs" than the opposing team(s).

Teams: Two or three per class, with nine or eleven students per team (odd numbers needed)
Each team should have:

- P-type silicon players
- N-type silicon players (equal numbers of these two groups)
- Photons (one player at a time)

1. Arrange all but one student into 2 parallel lines facing each other, an arm's width between the two lines, and an arm's width between players in the same line. The space between the P-type group and N-type group is the p-n Junction.
2. The remaining student is the photon and stands at one end of the lines with the die.
3. The "sandwich" made by the two types of silicon (phosphorous and boron) is what creates the electrical field that forces the free electrons to travel in one direction. To represent this field, students may only move in a clockwise direction.
4. Place the bucket somewhere in the clockwise path that the student "electrons" will travel when they are dislodged by the "photon." This bucket represents the "loads" being powered by the solar cell. These loads could represent any device that runs off of electricity in the classroom and the "electricity orbs" that students place inside the bucket represent the power being delivered to allow those loads to operate.
5. Each student will now represent being either a negatively charged electron, or a positively charged space, or "hole".

Steps of Simulation

1. Before each turn, students facing each other will play "rock, paper, scissors" to determine who is a positively charged space and who is an electron with a negative charge (winner's choice). Teacher will hand electricity orbs to students who choose to be electrons. These students should hold the orbs up for all to see.
2. Next, the teacher will choose a photon absorption number. This number represents the changing environmental conditions (weather, angle of the sun, age of the solar panel, etc.) that are responsible for the rate at which photons make their way into the p-n junction.
3. Students will need to equal this number through rolls of the die before the student representing a photon can be released. The photon absorption number should be changed periodically and posted on the board, which will require the photon to be alert.
    a. Students should be made aware that not all photons are absorbed into the p-n junction. In fact, only about 20% ever make it to the electrons; some bounce off the glass coating of a solar panel and others don't have the right amount of energy to allow an electron to move from the valence band to the conduction band. For instance, if the teacher determines that a photon needs 18 points to be absorbed in the cell, they will have to roll accordingly before they move into the p-n junction.

4. The photon (student) for each team must now roll the die to reach the photon absorption number. The student must roll the die as many times as needed until the sum of the rolls matches or exceeds the absorption number.
5. Once the photon (student) rolling the die reaches the target photon absorption number or above, the photon student can make his or her way into the middle of the p-n junction (between the parallel lines of students) to be "absorbed." Once in the p-n junction, the photon will quickly choose three electrons (students with electricity orbs) to dislodge. The photon will then take one of the electron's places, but not the orb.
    a. Please note that the photon taking an electron's place does not represent what actually happens in a photovoltaic cell. This motion has been added to the game to provide added musical chairs-type motivation for the electrons to move quickly.
6. When electrons are "dislodged," they aim to deposit their electricity orb in the bowl and fill an open space in the p-n junction before the spaces are filled, similar to the game musical chairs. (So there are three "free" electrons and only two spots available.)
    a. To do this they must step out of their line, away from the p-n junction, and make at least one circuit around the group (passing their starting spot before settling into a new one), while remembering to deposit their electricity orb into the bowl. Remind the electrons that the electric field created by the p-n junction forces them to move in a clockwise direction.
    b. Explain to students that they have become electrically charged free electrons, dislodged by the energy of the photon, and are desperately seeking a new home. It is this movement that fosters the creation of electricity. Emphasize the correlation between physical movement and electricity. Namely, electricity is generated through the movement of electrons. Thus, the game seeks to emphasize that greater movement can generate greater amounts of electricity in a solar cell or panel.
7. Once all electricity orbs have been deposited into the bowl, there will be one free electron left without a home, that space having been occupied by the photon. At this point, that student becomes the new photon and should begin rolling the die to reach the new absorption number. Meanwhile, the students in the p-n junction should once again determine who will be the electrons. Make sure each of those students is holding an electricity orb.
8. 8. After play has gone on for about 10 minutes, declare the game over and count the number of balls in the bowl to determine a winning team. The team that has most efficiently reached the absorption numbers will end up with more electricity orbs in their battery bucket. This should reinforce the concept that better equipment and more favorable environmental conditions will lead to a better photon absorption rate.

9. Have students fill out the student handout "Photon Scramble Comprehension" and lead a discussion based on the answers.

*Lesson can be used before or after students diagram and take notes on how photovoltaic cells work in Activity 8.

Name: _______________________________________ Date: ______________ Class: __________

Solar Photon Musical Chairs Comprehension

1. How did this game illustrate the production of an electrical current from sunlight?

2. What did the game leave out?

3. Was your level of physical exertion equal to the amount of "electricity" your team produced? Explain.

4. Did you figure out a way to work together or was it every electron for himself/herself? What do you think is a more realistic representation of how electrons actually behave?

5. What factors influence the efficiency of solar panels?

6. Why do electrons only flow in one direction?

7. Why does the p-n junction exist in solar panels?

RENEWABLE ENERGY: BIOMASS

Activity 11: Chemistry of Biofuel

TEACHER BACKGROUND: BIOMASS

Biomass is organic material (material from plants or animals) that can be burned to produce heat or can be converted into liquid or gaseous fuels.

Biomass combustion does produce carbon dioxide, a heat-trapping gas. However, if all land used to grow biomass is replanted, there is no net addition of carbon dioxide to the atmosphere. Before 1900, biomass—in the form of wood—was the United States' main energy source, but today it provides only four to five percent of the nation's primary energy needs. It could supply more. Using waste for biomass is especially promising. Crop and animal wastes or organic municipal wastes can be burned or converted into fuels instead of being dumped in landfills. Methane is collected from some landfills and burned for energy, and ethanol from grain surpluses is converted into a gasoline additive in some parts of the country. There is also considerable potential for growing biomass energy crops for thermal energy or fuel.

Converting biomass to liquid or gaseous "biofuels" is convenient for fueling vehicles. Gasification, pyrolysis, and fermentation are some of the processes that can turn biomass into fuels such as syngas, methanol, or ethanol.

Biodiesel

Biodiesel is made from vegetable oil or animal fat (triglycerides) reacted with methanol or ethanol and a catalyst (lye), yielding biodiesel (fatty acid methyl or ethyl esters) and glycerin as a by-product

Fatty acid chains are removed from the chemical reaction by a catalyst (KOH), then bound with methanol, creating biodiesel. Glycerol, the remaining part of the triglyceride, is a byproduct of the reaction, which is later removed before use.

One gallon of petroleum diesel fuel, once combusted, releases 22.384 pounds of CO_2 into the atmosphere. Biodiesel does not contribute extra CO_2 into the
atmosphere.

Biodiesel reduces particulate matter emissions by at least 55%, VOCs by 55%, and CO by 45% compared to fossil diesel.

Biodiesel is lower in sulfur—reduction in SO_2 in the atmosphere (which contributes to acid rain). Jet fuel: 3,000+ ppm sulfur; US off-road diesel: 500+ ppm; US regular road diesel 15-500 ppm; US ultra-low sulfur diesel: 15 ppm (2004 US Transportation Research Board report)
Biodiesel can be made from just about any kind of fat or oil to be used for airplanes, commercial trucks, personal diesel trucks, cars, SUVS, and farm equipment.

Resources: Chemistry Biofuel Lab:

https://www.clarkson.edu/highschool/k12/project/documents/energysystems/LP_4%20-biofuels%20complete.pdf

CLIMATE CHANGE--TAKE ACTION

Activity 11: Stakeholders Energy Debate

Activity 11: **STAKEHOLDERS ENERGY DEBATE**

Time: 3-6 hours (over a time of a few class periods)
Grades: 8-12

Purpose: This lesson explores the controversial issues surrounding the energy debate in the United States. Students will research recent initiatives being taken in this area and analyze their implications. They will then assume the roles of pivotal stakeholders in this debate and testify to a mock congressional committee responsible for making decisions about public land and energy resources.

Objectives:

Students will:

- identify sources of energy used in the United States;
- distinguish between fossil fuels and renewable energy;
- describe how energy production and consumption can impact public lands;
- learn about alternatives to fossil fuels; and
- participate in a debate over whether to use public lands as sources of energy.

Materials:

- Computer with internet access

Content Standards:

MS-ESS3-3.	Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.*
MS-ESS3-5.	Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.
MS-LS2-1.	Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem
HS-ESS3-5.	Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth systems.
HS-ESS3-6.	Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.

RI.8.8	Trace and evaluate the argument and specific claims in a text, assessing whether the reasoning is sound and the evidence is relevant and sufficient to support the claims.
RST.6-8.1	Cite specific textual evidence to support analysis of science and technical texts.
RST.6-8.2	Determine the central ideas or conclusions of a text; provide an accurate summary of the text distinct from prior knowledge or opinions.

RST.6-8.7	Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).
SL.8.1	Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 8 topics, texts, and issues, building on others' ideas and expressing their own clearly.
SL.8.4	Present claims and findings, emphasizing salient points in a focused, coherent manner with relevant evidence, sound valid reasoning, and well-chosen details; use appropriate eye contact, adequate volume, and clear pronunciation.

Procedure

Opening:
Have students list the ways they depend upon energy in their everyday lives. Then ask them to identify those activities that are dependent upon fossil fuels (e.g., oil, coal, and natural gas). List answers on the board.
Next, ask them to think about and then discuss as a group the following questions:

- Where do these energy resources come from?
- How are our public lands connected to these resources?
- What is meant by the term "alternative energy"?
- What are some examples of alternative energy sources?

Conduct a discussion about the advantages and disadvantages of renewable and nonrenewable sources of energy. Ask students if they know of any renewable sources of energy in their area (e.g., windmills, hydroelectric dams, and solar panels). Write the six most common renewable energy sources on the board or overhead (e.g., hydroelectric, geothermal, wind, biomass, tidal, and solar).

Divide the class into six groups and assign each group to research one source of energy. Have groups provide the following information about their alternative energy source to the class: a definition, three examples of how the source is used, and three advantages and three disadvantages of using the source. Much of this information can be found on the Web sites listed under Related Links below. Once they have completed this research, have the groups make a summary presentation of their findings to the rest of the class.

Development:
Explain to students that they will now be participating in a mock hearing of the U.S. Senate Committee for Energy and Natural Resources. The hearing is being held to determine whether or not to explore for renewable energy sources on a specific parcel of public land. You may provide the students with a fictitious or real-life public land example.
Each group will assume the role of one of the stakeholders in the debate, trying to persuade the committee that its opinion is the right one. Review the list of possible stakeholders below, add

additional appropriate stakeholders for your example, and discuss how each might contribute to the debate.

Assign or have student groups select the stakeholder they wish to represent from the following (or other relevant stakeholder positions):

- Economists
- Energy experts
- Members of Youth for Environmental Action
- Native Americans
- President of the American Petroleum Institute
- President of the Sierra Club
- Senator
- Tourism officials
- U.S. Secretary of the Interior
- Unemployed people
- Wildlife experts

Give students a few days to conduct research related to their role. They can start online research with the Web sites in the Related Links section, below. Caution students that, in a highly controversial issue like this, certain information might be presented with a bias. For example, one particular group may present possible environmental damage as minimal, while another will present it as significant. Students must use their best judgment about what is factual and may even want to try to find additional sources to validate information.

Closing:
Conduct the committee hearing. Each group will have 10 minutes to state its case. Then the committee (which can be played by students, faculty, or even parents) will be permitted to ask additional questions. After each group testifies, ask the committee to determine which group was most persuasive and why.

Suggested Student Assessment:
Have students write counterarguments to the position they represented in the committee hearing. They should identify groups most likely to disagree with their positions and list three issues these opponents would raise and what their arguments might be.

Extending the Lesson:

- Review the recent energy problems occurring in the United States and ask students to suggest ways to solve these problems. Have students take action by writing a letter or sending an e-mail to their congressional representatives. Use sites such as Congress.org to find out how to contact individual members.

- Research career opportunities related to resource management, conservation, and energy.

Other suggested current issues/resources:

- The Solutions Project: Potential for alternative renewable energy http://thesolutionsproject.org/infographic/

- LNG pipeline- proposed construction of a 230-mile Pacific Connector liquefied natural gas (LNG) pipeline through Oregon
  http://www.oregonlng.com/pipeline/
  http://rogueriverkeeper.org/what-we-do/hot-topics/proposed-liquified-natural-gas-pipeline-lng

Adapted from National Geographic-The Great Energy Debate