NWCCD Summer Energy Education Program

2012 Student Workbook

NWCCD is proud to offer this Summer Energy Education Program for students located in the Northeast Wyoming region. Full program materials are available at:
www.sheridan.edu/energyeducation/index.html

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Summer Energy Education Program

2011 STUDENT WORKBOOK

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E pur (Eppur) si muove.

”And yet, it moves” or
“Nevertheless, it does move.”

~ Galileo Galilei, an Italian astronomer and physicist, referring to the motion of the earth around the sun, in contrast with Church teaching of the time which held that the earth was stationary. Galileo is said to have uttered this in secret after he was publicly forced to renounce Copernican theory (ca. 1633).

Energie is the operation, efflux or activity of any being: as the light of the Sunne is the energie of the Sunne, and every phantasm of the soul is the energie of the soul.

~ Henry More, an English philosopher, reported to be one of definitions of the term energy in English (1642).

Activity: Picturing Dinner

Purpose

Energy makes our world go round. Literally, everything we do requires a source of energy. Even the food that we eat to provide our bodies with energy requires energy to produce.

Equipment

1. Paper
2. Pencils
3. Markers

Procedure

Think of your favorite meal. Draw a picture that shows all the energy that went into bringing that meal to your table.

Questions:

1. If you're thinking of food that's a plant (or comes from one), what energy did it depend on to grow?

2. If you're thinking of food that's from an animal, what energy did it depend on to grow?

3. What preparation/transportation steps were involved in getting your food to and storing it at the supermarket?

4. What kinds of energy were involved in preparing your food once it was at your house?

Activity: Racing from Potential to Kinetic

Purpose

Two important types of energy are kinetic energy (energy something has because it is moving) and potential energy (energy stored in something because of its position). A pendulum is a simple example of this conversion between forms of energy.

Equipment

1. Model cars
2. Tracks and ramps
3. Photogate
4. Meter stick

Procedure

Your task is to measure the speed of a model car at the bottom of a ramp when released from various heights. You must keep the photogate centered over the middle arrow in the last section of track. Only the section of track attached to the supporting meter stick should be used as the ramp. After each group has collected their individual set of data we will compile the data as a class.

Questions:

1. What are the variables that control the amount of potential energy held by the car?

2. At what point(s) in the car's path is all its energy stored as potential energy?

3. At what point(s) in the car's path is all its energy stored as kinetic energy?

Data/Notes:

Trial	Ramp Height (m)	Speed (m/s)

Activity: Human Energy

Purpose

Our bodies can convert chemical energy (a form of potential energy) into kinetic energy. We will investigate how much energy you can produce by several different means.

Equipment

1. Meter stick
2. Timers
3. Rope
4. Mass

Procedure

You will have an opportunity to measure how much energy you produce lifting a mass with your hands, lifting a mass with your legs and powering a bicycle. A general formula for calculating the amount of energy produced is

$$Energy = force\ x\ distance = mass\ x\ 9.8\frac{m}{s^2}x\ distance$$

When the mass is measured in kilograms and the distance is measured in meters, the energy is expressed in a unit called the **joule**.

Often, energy is express as a function of time. For example, the amount energy produced per second. This is referred to as power.

$$Power = \frac{energy}{time}$$

When the energy is measured in joules and the time is measured in seconds, the power is expressed in a unit called the **watt**.

You will be asked to lift a weight with your hands and climb a set of stairs, then determine the amount of energy and power you produced.

Questions:

Why do you think the power produced by lifting is so much less than the power produced by climbing?

Data/Notes

Process	Mass (lbs)	Mass (kg)		Distance (m)	Energy (J)	Time (s)	Power (W)
Lifting water	4.41	2.0	$9.8\frac{m}{s^2}$				
Climbing stairs			$9.8\frac{m}{s^2}$				

Activity: Mousetrap Car

Purpose

You are to design and build a car powered by converting the elastic potential energy stored in a mousetrap spring into kinetic energy. While the car is provided as part of a kit, you may make any modifications you feel will improve the performance of the vehicle. You will be given 45 minutes to prepare your vehicle for a race. Two winners will be awarded small tokens of esteem—one for longest distance travelled, one for fastest vehicle at 2 meters distance.

Equipment

1. Mousetrap car kit
2. Anything else you can think of that we have on hand – just ask.

Procedure

Follow the kit guidelines provided to build your basic car. You can make any modifications you think will improve the performance of your car. SAFETY NOTE: Please be careful using the glue guns. If you need help from one of the instructors please ask!

Questions:

1. Aside from the conversion of potential into kinetic energy that provides the energy for the vehicle, are there other issues that could affect how well your car performs?

Data/Notes:

Activity: Steam Power

Purpose

You will be shown how to build a simple device which converts chemical potential energy into kinetic energy. You'll also be given a small toy that operates on the same principle.

Equipment

1. Pop cans
2. String
3. Hot plates
4. Bunsen burners
5. Ring stands
6. Putt putt boats

Procedure

After going outside, empty the can of diet cola by using a thumbtack to poke one hole halfway up the side of the can. Shake vigorously to remove as much of the cola as possible. Poke a second hole immediately opposite the first hole. Holding the top of the can in your left hand, use a thumbtack to gently bend each hole towards you. Bend the can's tab (without opening the top) and tie a thread to it. Fill the can with a small amount of water through either of the two holes and suspend it over a Bunsen burner. SAFETY NOTE: If you need help lighting a Bunsen burner please ask! Make sure long hair or sleeves are pulled back.

After you've gotten your can to spin, take one of the boats and fill the metal tube on its bottom with water. Light a candle in the metal spoon provided and put the spoon with burning candle inside the boat. Float the boat in a water-filled gutter and see what happens.

Questions:

1. How does the can convert chemical potential energy into kinetic energy?

2. How are the putt putt boat and pop can similar?

Data/Notes:

TUESDAY

Engineering is the science of economy, of conserving the energy, kinetic and potential provided and stored up by nature for the use of man. It is the business of engineering to utilize this energy to the best advantage, so that there may be the least possible waste.

~ William A. Smith, (1908).

The best way to make a fire with two sticks is to make sure that one of them is a match.

~ Will Rogers, an American humorist (1925).

Activity: Electricity and Magnetism: Electromagnets

Purpose

You will be shown how to build a simple device that converts chemical potential energy into kinetic energy using the principle of electromagnetism. Your task is to investigate the variables involved to determine how to build the strongest magnet using the materials provided. The strongest electromagnet will be determined by the number of paper clips each magnet is able to pick up.

Equipment

1. Bolts
2. Wires
3. Batteries
4. Paper clips
5. Compasses

Procedure

Coil the wire around the bolt. Attach the ends of the wire to opposite battery terminals. Bring either end of the bolt near a compass or magnetic field viewer.

Questions:

1. How does the number of wire coils affect the magnet's strength?

2. How does the kind of battery (9V vs. D-cell) affect the magnet's strength?

3. How does the number of batteries affect the magnet's strength?

4. How does the way the batteries are connected to each other affect the magnet's strength?

Data/Notes:

Activity: Electricity and Magnetism: Motors

Purpose

You will be shown how to build three devices, called motors, which convert chemical potential energy into kinetic energy using the principle of electromagnetism. All three devices share certain critical features. First, they each use an electric current to generate a magnetic field. Second, the generated magnetic field interacts with a second magnetic field to produce attractive or repulsive forces.

Equipment

1. World's simplest motor kit
2. Monopolar motor kit
3. Advanced motor kit
4. Batteries
5. Wires

Procedure

Using the kits and instructions provided, build each of the two motors.

Questions:

1. How is the idea of an electromagnet central to building an electric motor?

2. For the advanced motor, investigate any one of the suggested problems in the instruction guide.

Data/Notes:

Activity: Electricity and Magnetism: Motors and Generators

Purpose

Motors convert electrical potential energy into kinetic energy. Generators convert kinetic energy into electrical potential energy. Any motor can act as a generator and vice versa. You will be given a motor asked to familiarize yourself with its behavior as a motor, then asked to think about ways to make it act as a generator.

Equipment

1. Hobby motors
2. Batteries
3. Multimeter

Procedure

There are three properties of the electricity produced by a generator that we need to consider. The first is the ***voltage,*** the force that the charge being moved by the generator is producing. This force is measured in a unit called ***volts.*** The second is the ***amperage,*** the amount of charge that the generator is moving in a certain amount of time. This flow, or current, is measured in a unit called amps. The third property is whether the charge is moving continuously in one direction, called ***direct current (DC)*** electricity; or, if the charge is alternating directions, called ***alternating current (AC)*** electricity. The motors (and generators) we are working with involve DC electricity.

The amount of energy involved in an electrical system can be evaluated by knowing the voltage and the current. If the voltage is measured using volts and the current is measured using amps, multiplying the two values gives you the power in watts (or joules per second). For example, a vacuum cleaner drawing 10 amps at 120 volts is consuming 1200 watts or 1200 joules per second.

Try hooking your hobby motor up to various combinations of batteries. Then try hooking your motor up to a multimeter to measure millivolts (mV). Spin the axle and measure the voltage. Repeat, but instead measure the current in milliamps (mA).

Questions:

1. How does the number of batteries affect the motor's behavior?

2. How does the way the batteries are connected to each other affect the motor's behavior?

3. Name three ways that you could use to turn the motor's axle?

4. What was the maximum voltage you observed? What was the maximum current?

Activity: Human Power – Hand and Bicycle Generators

Purpose

Generators (and motors) come in all different shapes and sizes, depending on the application for which they are used. You will use both hand and bicycle powered generators to investigate the conversion of chemical potential energy (your movement) into electrical energy.

Equipment

1. Hand generators
2. Bicycle generator
3. Assorted light bulbs
4. Multimeter

Procedure

Use the hand generator to try powering several types of lights and other devices. Test to see if the speed or direction you crank the generator has an effect.

Using the bicycle generator provided try powering each of the available lights. Try powering the available motor.

Use a multimeter to the voltage produced by both the hand and bicycle generators. If you have time ask your instructor to help you measure the current produced as you power various devices.

Questions:

1. What are some other ways you could turn the axles of these generators?

Data/Notes:

Conditions	Voltage (V)	Amperage (A)	Power (W)

We've embarked on the beginning of the last days of the age of oil. Embrace the future and recognize the growing demand for a wide range of fuels or ignore reality and slowly-but surely-be left behind.

~ Michael Bowlin, an American businessman, chairman and CEO of ARCO (now BP), from speech in Houston (1999).

Coal is a portable climate.

It carries the heat of the tropics to Labrador and the polar circle; and it is the means of transporting itself whithersoever it is wanted. Watt and Stephenson whispered in the ear of mankind their secret, that a half-ounce of coal will draw two tons a mile, and coal carries coal, by rail and by boat, to make Canada as warm as Calcutta.

~ Ralph Waldo Emerson, an American author and philosopher (1860).

Some recent work by E. Fermi and L. Szilard…

leads me to expect that the element uranium may be turned into a new and important source of energy in the immediate future.

~ Albert Einstein, a German physicist, in a letter to President Franklin D. Roosevelt urging him to provide government support for Fermi and colleagues in their work on chain reactions (1939).

Activity: Solar Power – Cooking and Heating

Purpose

The sun delivers enough energy to the surface of the Earth to meet all of humanity's energy needs. Our food, in particular, is entirely dependent (either directly or indirectly) on photosynthesis. Our major sources of energy (oil, coal, natural gas) are all the result of accumulated photosynthetic products. Unfortunately, solar energy doesn't come directly in a form that is useful for all of our needs. You will be given a box and aluminum foil and a container filled with water. Your job is to use sunlight to heat the water to the highest temperature possible in a 15 minute period

Equipment

1. Cardboard box
2. Aluminum foil
3. Tape
4. Thermometer

Procedure

Secure the aluminum foil to the cardboard in such a way that the sunlight reflects into a concentrated region. Place the water in that region. You may do anything to your solar cooker that you feel will increase its ability to focus the sun's energy.

Questions:

1. What choices did you make in designing your solar cooker? Why?

2. To what temperature were you able to heat the water?

3. Aside from cooking, for what other uses could concentrating solar energy be useful?

Data/Notes:

Activity: Solar Power – Electrical Energy

Purpose

There are devices called photovoltaic cells that allow light to move charge and generate an electrical current. The PV cell is made of a carefully manufactured semiconducting material whose electrons are excited by light. Unfortunately, the current generation of PV cells converts only about 10% of the light's energy into electrical energy. Your job is to try and measure the maximum amount of energy and power available from the electrical energy produced by your PV cell.

Equipment

1. PV cell
2. Wires
3. Hobby motor
4. Super solar racing car

Procedure

Connect your PV cell to the multimeter. Using the data table on the next page, record the voltage and amperage under various conditions of your choosing. Calculate the energy produced by your solar cell. Repeat using a second or third solar cell connected to the first one. Record the voltage and amperage.

Connect your PV cell to your hobby motor. Using a string attach a weight to the axle and see how long it takes you to lift the weight.

Assemble your super solar racing car.

Questions:

1. What percent of the PV cell must be exposed for the car to move?

2. Your Super Solar Racer weighs 8 g (0.008 kg). Its solar cell area is 6 cm^2. Approximately what solar cell area would be needed for an average American car weighing 2000 kg?

Data/Notes:

Conditions	Voltage (V)	Amperage (A)	Power (W)

Activity: Wind Power – Electrical Energy

Purpose

Wind energy is another potential source of energy—a means of turning the axle of our generator. The challenge is harnessing that energy.

Equipment

1. Hobby motor
2. Styrofoam
3. Multimeter

Procedure

Design blades and a way to secure them to the axle of the hobby motor, making a fan. Test your fan to make sure when wind blows on it that it spins. Use the multimeter to measure the voltage and amperage your wind turbine produces. Attach your generator to a second motor and see how fast you can make that motor spin.

Questions:

1. What choices did you make in designing your wind turbine?

2. What voltage and amperage were you able to generate?

3. How does generating electrical energy from wind compare to generating it from flowing water?

Data/Notes:

I wanted be at my parents' house when the electricity came. It was in 1940. I remember my mother smiling. When the lights came on full, tears started to run down her cheeks… From there I went to my grandmother's house. It was a day of celebration. They had all kinds of parties-mountain people getting light for the first time.

~ Congressman Clyde T. Ellis, an American politician, as quoted by author Studs Terkel; Ellis served as director of the New Deal program that brought electricity to rural homes previously without it (1940).

If it weren't for electricity, we'd all be watching television by candlelight.

~ George Leslie Gobel, an American comedian (1982).

Activity: Finding Your Way – Global Positioning Systems

Purpose
Global Positioning System (GPS) technology can be incredibly powerful and useful. It can also be confusing because you have so much information available at the touch of a button. This activity will give you some time to play around with one kind of GPS unit.

Equipment
1. GPS Units

Procedure & Questions
GPS Basics
You will be given a separate set of instructions for how to use your GPS units.

GPS Scavenger Hunt
Often times, the best way to learn about something is to try it out. Using your GPS unit, you'll have to find three locations on campus. Each team will receive the coordinates for four locations on campus. At each location is a cup with a stamp that must be collected by your team. When your team has collected three stamps on your workbook come home. The two teams with the fastest times will receive small tokens of esteem.

Your stamps go here:

Activity: Energy Perspectives

Purpose

It is often helpful when trying to understand something to collect and display data to look for trends. In this activity you will be analyzing data from the Energy Information Agency using an analysis tool called a spreadsheet.

Procedure

Each group will choose to create one of the following graphs. Most graphs (bar and line graphs in particular) will require you to identify the independent variable (to be displayed on the x-axis) and the dependent variable (to be displayed on the y-axis). Pie graphs imply the independent variable is the value being graphed and the label is the dependent variable. Any graph should have a title and each axis should have a label along with units.

1. Energy Imports and Exports

Prepare a line graph that shows energy imports and energy exports over time. You may use a different color for each energy source, or you may choose to just plot the total imports and total exports.

2. Energy Production and Energy Consumption

Prepare a line graph that shows total energy production and energy consumption in the U.S. over time.

3. Residential Energy Consumption, by Source and User

Prepare a graph (or a few graphs) to show the amount of energy used by each source in the average US household. Would you use a bar or a PIE chart? Why?

4. Household Energy Consumption, by End-Use

Prepare a graph that shows the ways we use energy in our homes, both in the U.S. and in New York State.

5. Household Electricity Consumption, by End-Use

Prepare a graph that shows the ways we use electricity in our homes. Prepare a graph that shows the electricity use by kitchen appliances. What is the biggest electricity user in the kitchen?

6. Oil Importers and Exporters

Prepare two bar graphs that show the major oil exporters and importers. Where does the U.S. stand on each graph?

7. Oil Producers and Consumers

Prepare two bar graphs that show the major oil producers and consumers. Where does the U.S. stand on each graph?

Discussion Questions:

1. Which energy use sector is increasing the fastest? What energy resource does this sector primarily use? Where does most of this energy resource come from?

2. Which type of fuel is used most in the U.S.? Which is used the least?

3. Which country consumes the most oil? The least oil?

4. Compare how much oil the U.S. consumes with the amount we produce.

5. How much oil does the U.S. need per day? How much do we produce? Where does the rest come from?

6. What uses the most energy in the average U.S. household? What energy resource does this activity typically use?

7. How does energy consumption, by source, compare between New York State and the U.S. average? What are some reasons for the differences?

8. What portion of our household energy use is provided by electricity? How do the New York values compare with average U.S. values?

9. And what uses most of that electricity? Do you think this is comparable to your household? How can we use this information to save energy?

10. Notice the difference between the "primary electric energy" (generated at the utility plant) and the electricity consumed in the household. Why such a big difference?

Activity: Energy Sources Research

Purpose

You are part of a television news team reporting on a major wildfire which has destroyed a large electrical power plant. The fire has been dealt with but now discussions are beginning on how to provide power to a large population center.

Procedure

1. Working in groups of 2 to 3, develop a script for a 5 minute video that addresses all aspects of the rubric provided below.

2. Use one of the video cameras to record your presentation.

3. If additional information is required, try:

   http://www.eia.doe.gov/kids/energyfacts/index.html

   http://en.wikipedia.org/wiki/Energy_in_the_United_States

   http://needtoknow.nas.edu/energy/

   http://www.eere.energy.gov

   http://www.nrel.gov

   http://www.howstuffworks.com/

Descriptor	Advanced	Proficient	Basic	Below Basic	Research Questions
Incorporates Energy Questions	Elaborates on three or more research questions and develops accurate answers from various viewpoints.	Elaborates on one to two research questions and develops answers from various viewpoints.	Presents one or more research questions but answers are not fully developed.	Fails to present a research question or answers it incorrectly.	1. How do we harness the energy source? 2. What are the environmental impacts of your energy source? 3. What are the economic impacts of your energy source? How much does it cost per kWh? 4. What countries currently use this source? What percentage is used in the United States? 5. How is this energy source currently used? For example: At farms, in industry, etc. Could this source be used in a family home?
Responds to questions from point of view of character/s	Asks more than one relevant question or responds appropriately several times from the character's point of view	Asks at least one relevant question or responds to a question from the character's point of view	Character/s provides a response.	Character/s does not provide feedback.	Characters *might* be: News Reporter Energy Expert Local Wildlife Conservation Group Opposed to Energy Plan Local Coal Mine Representative Opposed/In Favor Company Representative Promoting Project
Exhibits understanding of Energy Issues	Questions and discussion explain the *pros* and *cons* of the use of *different energy* sources.	Questions and discussion show understanding that there are *pros* and *cons* to the use of *different energy* sources.	Questions and discussion suggest there are pros and cons to the use of different energy sources	Only one opinion is addressed	Issues *might* include: Sustainability Pollution Wildlife Economics Aesthetics Renewability
Incorporates Energy Vocabulary	More than four words used correctly in context and developed to show subtle understanding	Up to four words used correctly in context and developed to show subtle understanding	Several words used in correct context	Use of words is incorrect or does not expound enough to define	Vocabulary List: Biomass, Fossil Fuels, Geothermal, Hydropower, Uranium, Solar, Wind, Kinetic Energy, Potential Energy, Conversion, Chemical Energy, Joule, Watt, Electromagnetism, Generators, Motors, Photosynthesis, Photovoltaic cells, Harnessing Energy, Wind Turbine

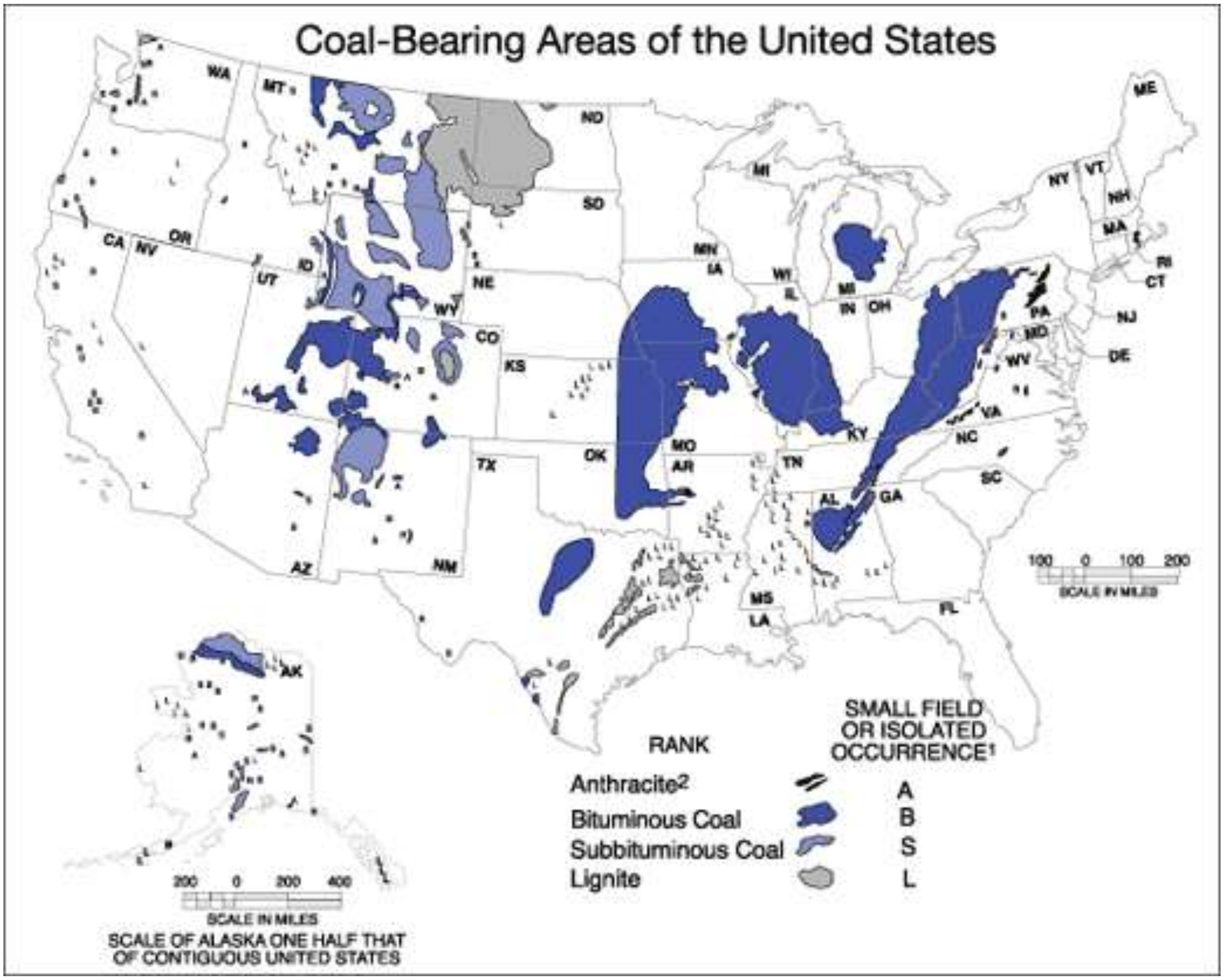
Fossil Fuels Fact Sheet

- Coal, Oil and Gas are called "fossil fuels" because they have been formed from the fossilized remains of prehistoric plants and animals.
- Fossil fuels are a nonrenewable energy source since they take millions of years to form.
- Fossil fuels ultimately get their energy from the sun. The plants that are converted into fossil fuels stored energy from the sun by photosynthesis.
- 85.6% of all energy consumed in the U.S. comes from fossil fuels.
- The average U.S. Household pays about 8 1/2 cents per kWh and uses 10,000 KWH per year.
- **How does it work? – Making power from fossil fuels**

Burn Fuel → heat water to make steam → steam turns turbines → turbines turn generators → electrical power sent around country

Coal

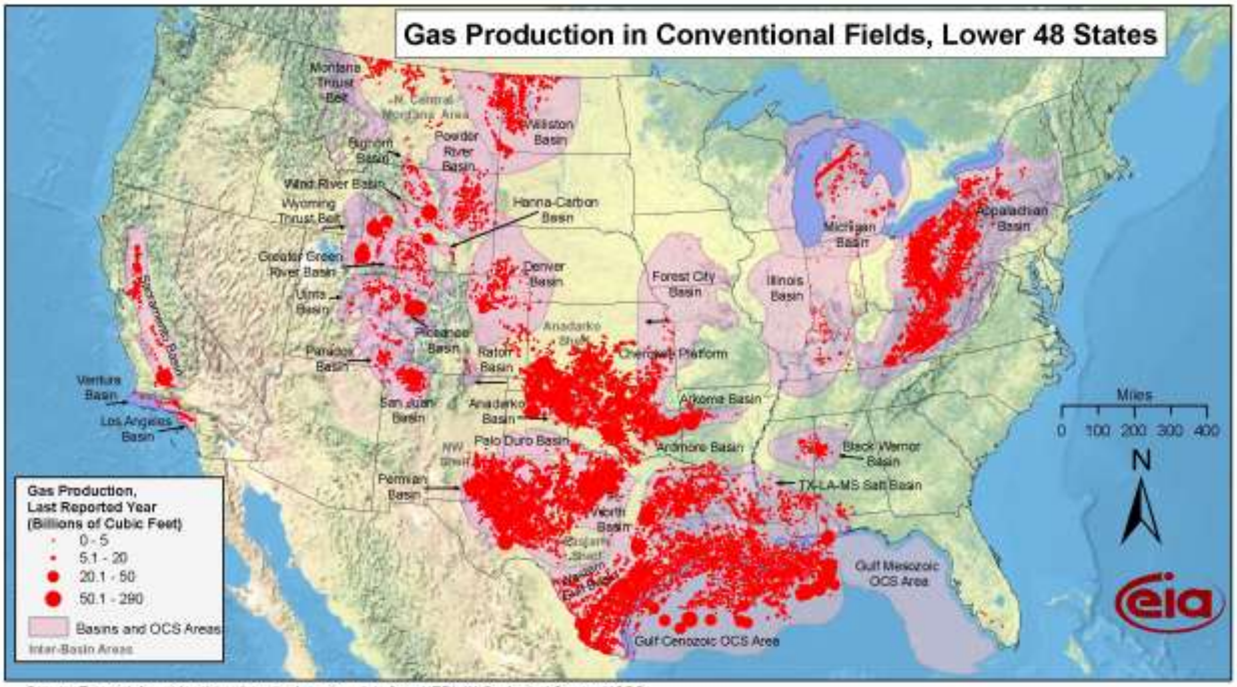
- Coal is the most abundant fossil fuel in the United States.
- Coal-generated electricity costs approximately 9 to 14 cents per kWh.
- Coal is a hard, black colored rock-like substance formed when dead plants were subjected to extreme heat and pressure for millions of years. It is made up of carbon, hydrogen, oxygen, nitrogen and varying amounts of sulfur.
- There are two ways to mine coal: Surface mining and underground mining
- Coal often costs more to transport than other fuels.
- There are several grades of coal depending on the geological conditions present when the coal formed. The different grades contain different amounts of energy.
- Coal deposits can be found in 38 states. Montana, Illinois, and Wyoming are the top coal states.
- Coal from the west has less sulfur content which means it produces fewer pollutants.
- The federal government owns a majority of the nation's coal reserves.
- Coal generates 50.2% of the electricity used in this country.
- Coal industries are required to monitor the amount of pollutants they release into the air, and to reclaim land damaged by surface mining. Burning coal presents the most potential for pollution of all the fossil fuels.
- Advanced coal technologies that reduce the impact of coal on the environment are currently being researched by scientists and engineers.



Coal-Bearing Areas of the United States
RANK
Anthracite2
Bituminous Coal
Subbituminous Coal
Lignite
SMALL FIELD OR ISOLATED OCCURRENCE1
A
B
S
L
SCALE IN MILES
SCALE OF ALASKA ONE HALF THAT OF CONTIGUOUS UNITED STATES

Natural Gas

- Natural gas was formed from the remains of tiny sea animals and plants that died millions of years ago. The gas then became trapped in layers of rock like water in a wet sponge.
- Raw natural gas is a mixture of different gases. Its main ingredient is methane.
- The strange smell of natural gas (like rotten eggs) comes from a chemical natural gas companies add called mercaptan. This is added so leaks are easily detected.
- Natural gas was first used in America in 1816 to light the streets of Baltimore.
- Natural gas accounts for 23.7% of the energy in the U.S.
- Natural gas is found more than 6,000 ft. under the earth's surface. Drilling can cost up to $100/ft so sites must be chosen carefully. Only 48% of the sites we drill actually produce natural gas.
- Natural gas is produced in 32 states. The top 3 are Texas, Oklahoma, and New Mexico.
- Natural gas is transported by pipeline. More than one millions miles of pipelines link natural gas fields to major cities in the U.S.
- Industry is the biggest consumer of natural gas, using it as a heating source and often as an ingredient in the products they produce.
- 60% of homes use natural gas for heating.
- Natural gas can be used in any vehicle with a regular internal combustion engine, although the vehicle must have a special carburetor and fuel tank.
- If we continue to use natural gas at the current rate, current US reserves will last approximately 50 years.
- Electricity generated from the combustion of natural gas costs approximately 7 to 12 cents per kWh.
- Natural gas is the most environmentally friendly fossil fuel.



Source: Energy Information Administration based on data from HPDI, IN Geological Survey, USGS
Updated: April 8, 2009

Oil (Petroleum)

- Oil was formed from the remains of tiny sea animals and plants that died millions of years ago. The organic material was then broken down into hydrogen and carbon atoms and a sponge-like rock was formed, full of oil.
- Only 44% of wells that are drilled for oil actually produce it.
- The average oil well produces 11 barrels of oil per day.
- State and federal governments regulate oil drilling and production.
- Texas, Alaska, and California are the top three oil producing states.
- Oil cannot be used as it is when it is taken from the ground. Oil refineries clean and separate the oil into various fuels and by-products. The most important of these is gasoline.
- Gasoline and other petroleum products are transported through pipelines. There are about 230,000 miles of pipelines in the U.S.
- Petroleum supplies 37.2% of the energy used in the U.S.
- Americans use about 18 million barrels of oil every day.
- 67% of oil is used for transportation, most of the rest is used as industrial feedstock to make polymers (especially plastics) and other specialized chemical substances.
- Petroleum's importance to transportation and industry means it is not used as a fuel to generate electricity.
- The U.S. is becoming increasingly dependent on other countries for oil. We import about 2/3 of the oil that we consume in the U.S. from other countries. Some of these countries include: Iran, Russia, Mexico and, Canada. The biggest imports of crude oil to the U.S. come from Canada.
- The outer continental shelf (off the coasts of California and Alaska and in the Gulf of Mexico), contain rich deposits of petroleum and natural gas but offshore production is very costly.
- Petroleum production, distribution, and consumption can contribute to air and water pollution.
- Drilling for oil can disturb fragile ecosystems, especially when there is a spill. Leaking underground storage tanks pollute the groundwater and create toxic fumes. Even burning fuel in our cars emits pollutants.
- The Clean Air Act of 1970 helped us make advances in protecting our environment. Oil refineries had to reduce emissions and new technologies have been developed.
- World economies are very sensitive to the cost of petroleum. Higher petroleum costs often result in economic slowdowns.

Geothermal Fact Sheet

- Geothermal energy comes from the heat within the earth. The word geothermal comes from the Greek words *geo*, meaning earth and *therme*, meaning heat.
- The outermost layer of the earth, the insulating crust, is broken into pieces called plates. These plates drift apart and push against each other in a process called plate tectonics. This process can cause the crust to become cracked or thinned, allowing plumes of magma to rise up into the crust. The magma can reach the surface (volcanoes) but most stays under the surface as geothermal heat.
- The underground heat can take 1000 to 1 million years to cool.
- In areas where there is underground water, the magma heats the water and creates either hot springs or underground reservoirs.
- Geothermal energy is renewable because water is replenished with rainfall and heat is continuously produced within the earth.
- Geothermal energy is harnessed by drilling wells into the underground geothermal reservoirs. The steam and heat is used to drive turbines in electric power plants.
- The water and steam from these reservoirs range in temperature from 250 to 700 degrees Fahrenheit.
- The hottest geothermal regions are found along major plate boundaries where earthquakes and volcanoes are concentrated. Most of the world's geothermal activity occurs in an area known as the Ring of Fire, which rims the Pacific Ocean bounded by Indonesia, the Philippines, Japan, the Aleutian Islands, North, Central and South America.
- Geothermal energy accounts for 0.3% of the energy in the U.S. That is enough to provide power to 3 million households.
- It costs approximately 10 cents per kWh to produce electricity from a geothermal system.
- Geothermal plants release only 1% of the carbon dioxide emitted by comparable fossil fuel plants.
- The earth has no shortage of geothermal activity, but not all geothermal resources are easy or economical to use.
- Today there are geothermal power plants in 21 countries, providing electricity to 15 million people.
- There are four types of geothermal power plants.
  - Flashed Steam Plants
    - Most geothermal power plants are flashed steam plants.
    - Hot water from production wells explosively boils, or flashes, into steam when it is released from the underground pressure of the reservoir. The force of that steam is then used to spin the turbine-generator.

  Dry Steam Plants
    - The steam from the geothermal reservoir shoots directly through a rock-catcher into the turbine-generator.
    - The rock-catcher protects the turbine from small rocks that may be carried along with the steam from the reservoir.
    - The Geysers dry steam reservoir in California has been producing electricity since 1960 and produces enough electricity to supply a city the size of San Francisco.

Binary Power Plants

- Binary power plants transfer heat from geothermal hot water to other liquids to produce electricity.
- Geothermal water is passed through a heat exchanger, which transfers the heat to a working fluid (isobutane or isopentane) which boils at a lower temperature than water. The vapor is then used to spin a turbine-generator. This way electricity can be produces from lower temperature reservoirs.

Hybrid Power Plants

- Flash and binary systems are combined to use both the steam and the hot water from a reservoir.
- A hybrid system provides about 25% of the electricity to the island of Hawaii.
- Water from geothermal reservoirs is used in many places to warm greenhouses that grow flowers, vegetables, and other crops.
- In Klamath Falls, Oregon, hot water is piped under sidewalks and roads to keep them from freezing in the winter.

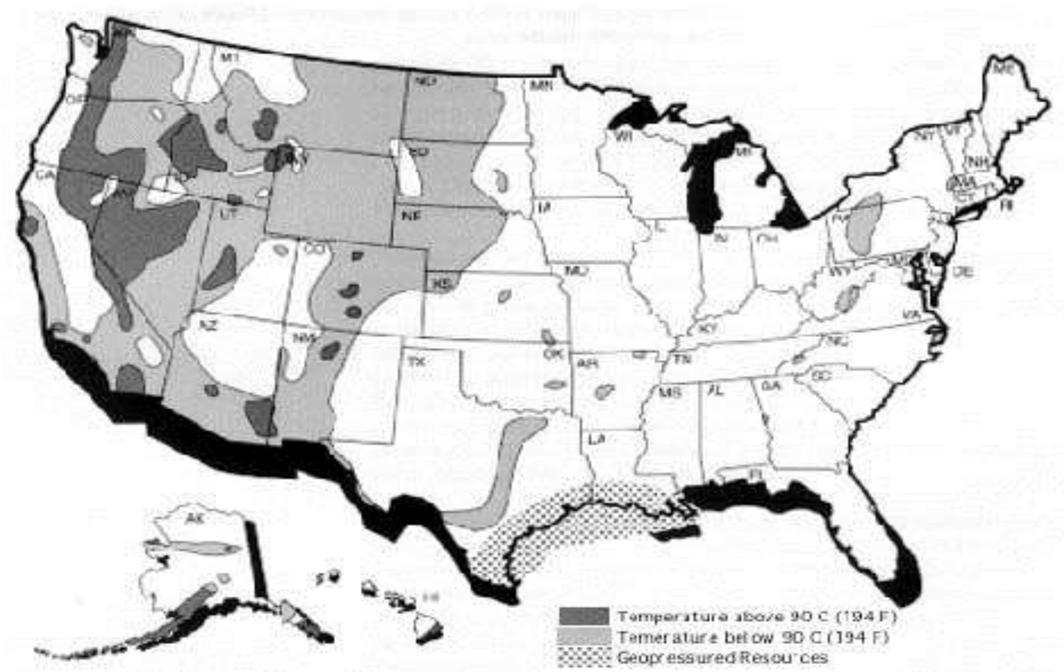
Geothermal Energy for heating and cooling

- The most widespread use of geothermal resources is to heat buildings.
- In the capital of Iceland, 95% of the buildings use geothermal heat.

Geothermal systems at home

- Use the Earth's constant temperatures to heat and cool buildings. These heat pumps transfer heat from the ground to buildings in the winter and vice versa in the summer.
- Geothermal systems cost more to install than conventional heating and cooling systems but they can reduce heating costs by 50-70%. Over the lifetime of the system, the average homeowner can anticipate saving about $20,000.
- Today more than 300,000 homes and building in the U.S use geothermal heat exchange systems
- The U.S. Environmental Protection Agency has rated geothermal heat pump systems among the most efficient heating and cooling technologies.

- The most important economic aspect of geothermal energy use is that it's homegrown — using geothermal energy reduces our dependence on foreign oil, creates jobs here in the U.S., and more favorably balances our global trading position.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Geopressured Resou ces

Hydropower Fact Sheet

- Hydropower is energy that comes from the force of moving water. It is an indirect form of solar energy.
- Hydropower can be found anywhere water moves from high ground to low ground. The force of moving water can be extremely powerful.
- There are 3 major ways in which we can capture hydropower for our use:
  - An impoundment facility uses a dam on a river to store water in a reservoir. Water is released from the reservoir through a turbine which activates a generator and produces electricity.
  - A diversion facility channels a section of a river through a canal which also goes through a turbine generator in order to produce electricity.
  - Micro-Hydroelectric Systems- Small turbine generators can be placed in a stream in order to generate electricity.

A diversion facility at Idaho Falls.

- Hydropower plants cause no air pollution because they don't burn fuel. However, damming rivers may disrupt wildlife and natural resources. Hydropower plants may also affect water quality by churning up dissolved metals that may have deposited in the water by industry long ago.
- Hydropower is the cheapest way to generate electricity today because, once a dam has been built and the equipment installed, the energy source (water) is free. This can help to reduce our dependence on foreign oil and strengthen our economy.
- The first hydroelectric plant was built at Niagara Falls in 1879.
- The top country using hydropower is Canada, generating around 325 billion kilowatt-hours per year. Other countries that use hydropower are the United States, Brazil, China, Russia, Norway, Japan, India, Sweden, and France.
- Today, hydroelectric power provides 2.7% of the energy used in the U.S.
- It costs about 8 cents per kWh to produce electricity at a typical hydro plant.
- People who have streams or waterfalls flowing on or near their property can use a micro-hydroelectric system to either power their house or sell back to the electric company

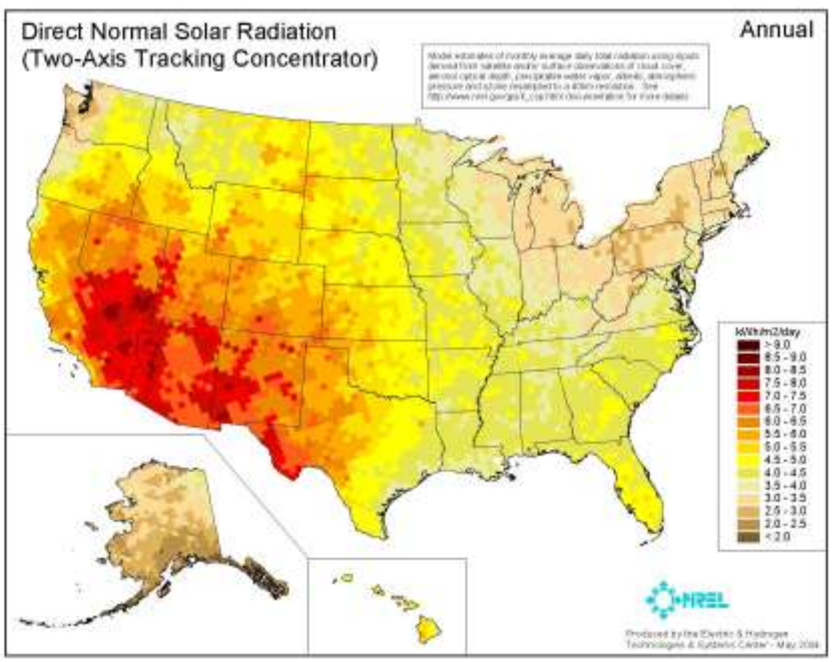
Solar Energy Fact Sheet

- Solar energy is the light and heat provided by the sun. The energy comes from the center of the sun where hydrogen atoms combine to form helium in a process called nuclear “fusion” (in nuclear “fission” atoms split instead of combining).
- Solar energy can be found in many places.
  - You can find solar energy provided as heat in the hot seat belt when you return to a parked car in a sunny parking lot.
  - A plant uses the solar energy provided as light during photosynthesis.
  - We use the solar energy provided as heat to warm our water and homes.
  - We use the solar energy provided as light by turning it into electricity.
- There are 3 major ways in which we can capture solar energy for our use:
  - Photovoltaic- A solar cell collects the light from the sun. The light may be reflected, absorbed, or may pass through the cell. Some of the energy absorbed can move electrons in the solar cell material which creates electricity. Solar cells are connected together to create solar panels.
  - Concentrating Solar Power Technologies- Curved reflectors are used to direct the sun’s energy to a single point in a tower. The heat produced at this point is used to heat a fluid. The steam produced turns a turbine which produces electricity.

  - Solar Heating can be as simple as using a window facing the sun to heat your bedroom. Solar collectors can be used to heat hot water pipes.
- Solar energy is one of the cleanest forms of energy as it produces no air or water pollution. However, the manufacturing and disposing of solar cells produces some waste products.
- The Solar cell industry can help to reduce our trade deficit and create new jobs which will strengthen the U.S. economy. Solar energy can protect the economy by keeping businesses open during power outages.
- Solar energy has been in use since 212 B.C. when the Greeks used mirrors to reflect the sun’s energy to light torches. The first Solar cells were invented in United States in 1883. They are now used in the U.S, Japan, France, Great Britain, parts of Africa, Antarctica, and even outer space.
- Today, solar energy in the form of electricity provides 0.1% of the energy used in the U.S.
- In general, electricity generated using solar energy costs about 30 cents per kWh.

- Today, solar energy is used to provide heating and electricity for homes and businesses. In the last decade, solar energy has also been used to power earth-orbiting satellites, cars, and even planes.

The Helios prototype flying wing is shown near the Hawaiian Islands during its first test flight on solar power. (Credit: NASA, Dryden Flight Research Center Photo Collection)



Wind Power Fact Sheet:

- Wind power is an indirect form of solar energy, caused by the uneven heating, terrain, and bodies of water of the earth.
- Wind power is used for grinding grain, pumping water, or generating electricity.
- Historically windmills were used for propelling boats across the Nile, pumping water, and producing food.
- Wind starts as kinetic energy and is converted to the mechanical energy form (grinding grain, pumping water, etc…), or to the electromagnetic form (electricity).
- Countries such as Denmark and Northern Germany generates up to 20% of their electricity through wind power.
- India and many European countries are planning for major wind facilities.
- There are 3 sizes/types of wind turbines: small (residential), medium (average size homes), and large (commercial).
- Wind energy does not have any output pollutants which makes it a very favorable means of electricity.
- Some concerns of wind turbines are their blades because they can kill some birds as they turn.
- They are also seen as a visual and auditory nuisance, leading to the term “viewshed” when talking about the visual impact of an energy production facility.
- Wind farms require a lot of land; each turbine needs approximately 2 acres.
- The good part about wind farms is that crops can be grown around the mechanisms as soon as the installation is complete.
- There are 2 types of wind turbines: the traditional horizontal-axis turbine with the blades and the vertical-axis turbine called the Darrieus Design.
- The most common type used today is the horizontal-axis turbine because it is more stable at greater heights where the wind is more turbulent.
- Wind turbines are made up of a rotor, which includes the blades and the hubs they are attached to, a nacelle, which is the frame for the gearbox and generator, and a tower; this is usually a large steel tubular structure. *See figure 1*.
- The blades of the wind turbines are very often made of fiberglass or other high-strength materials.
- The gears inside the turbine are important because they allow the turbine to turn slowly while the electric motor turns extremely quickly.
- Commercial-scale Turbine:

  3 blades on a tubular tower, Hub height 164-262 ft, Blade diameter 154-262 ft,

  Power ratings in U.S. 660 KW-1.8 MW

- The best places for wind production in the U.S. include California, Alaska, Hawaii, the Great Plains, and mountainous regions.
- Average wind speed of 14 mph must be kept for wind energy to be converted to electricity economically.
- The average wind speed in the U.S. is 20 mph.
- Anemometers are used to measure how fast the wind is blowing at a particular site.

- Wind energy converts 30-40% of the wind's kinetic energy into electricity.
- The cost of electricity by wind power is 9 cents per kWh on land and 24 cents per kWh offshore.

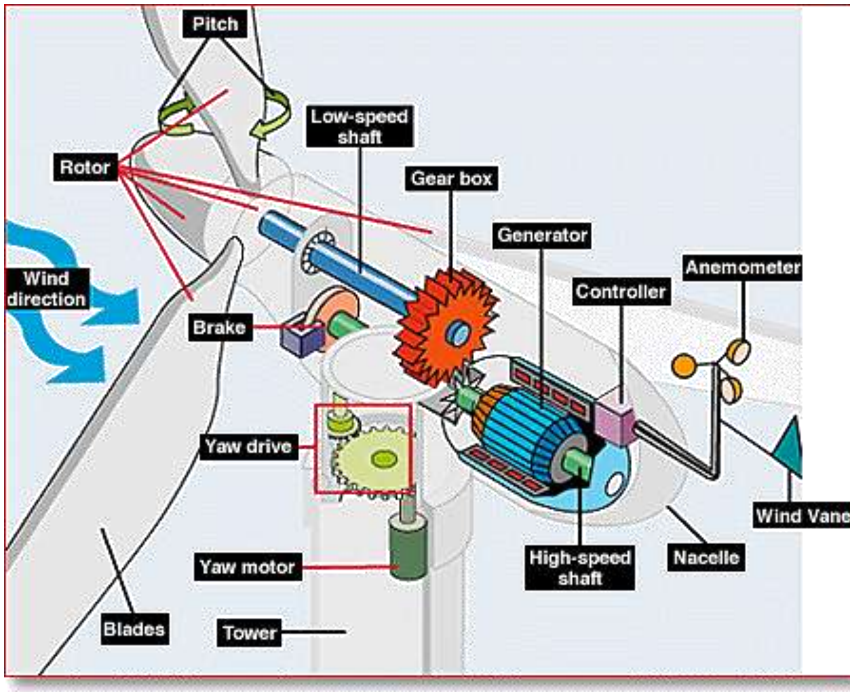
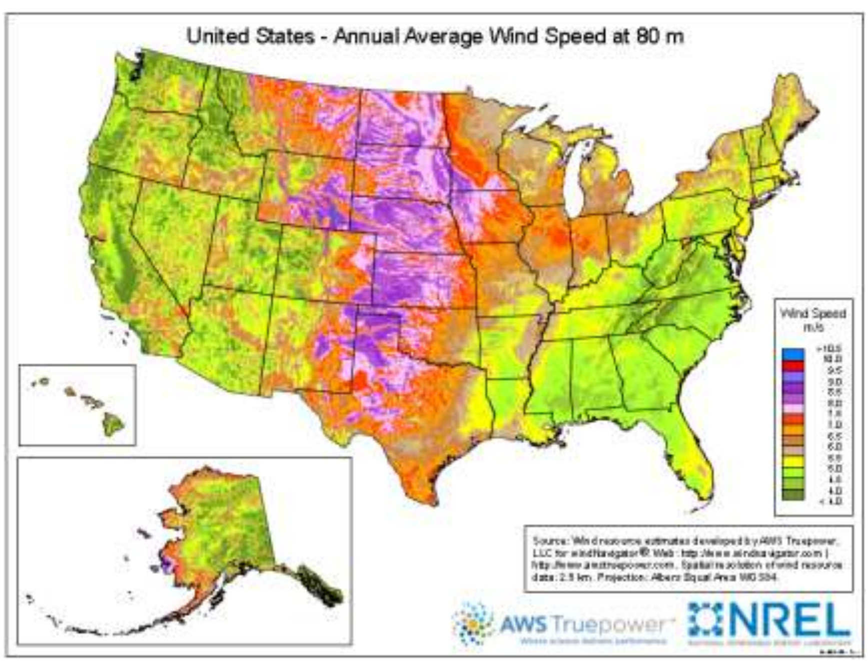


Fig. 1 The components of a common horizontal-axis turbine



Uranium Fact Sheet

- Uranium-238 has 238 protons and 238 neutrons in each atom. This type of uranium splits easily. When the atom splits, nuclear "fission" occurs and energy is produced (In nuclear "fusion", atoms combine instead of splitting).
- Uranium can be found in rocks all over the world. Rocks that contain a lot of uranium are called uranium ore.
- There is a process in which we can create nuclear energy from uranium:
  - Mining- Workers mine uranium ore much like coal miners mine coal, in deep underground mines or in open pits.
  - Milling- The uranium ore is crushed and mixed with an acid. The uranium dissolves and forms a yellow powder called a "yellow cake".
  - Conversion- The yellowcake is converted into the gas, uranium hexafluoride (UF6).
  - Enrichment- The UF6 gas contains a mix of different types of uranium. Some of the unwanted uranium is filtered out while the uranium-238 atoms are kept. After this is done, we have "enriched uranium".
  - Fuel Fabrication- The enriched uranium is made into "fuel pellets". A fuel pellet is about the size of your fingertip but can produce as much energy as 120 gallons of oil. The fuel pellets are sealed in 12-foot metal tubes called "fuel rods".
  - Nuclear Reactor- The fuel rods are hit with neutrons, causing a nuclear reaction. The nuclear reaction produces heat which boils water. The steam from the boiling water is used to turn a turbine which produces electricity.
- Nuclear power plants produce radioactive waste. The amount of waste produced is much less than fossil fuel waste, but it is far more dangerous. If the power plant isn't safe and the radioactive waste leaks, serious illness and death can occur. However, if the power plant is safe, there is very little impact on the environment. There is no air pollution, and the waste is recycled.
- The cost of uranium is cheap, but the power plants are expensive to build. Uranium is still an abundant natural resource and could provide us energy for many years – estimates range from 50 years to 500 years at current consumption rates. If we convert the uranium into plutonium (an even better fuel), we could have enough energy for millions of years.
- There are plenty of uranium mines in the United States. This can help to reduce our trade deficit and create new jobs which will strengthen the U.S. economy.
- Nuclear power plants can be found in the United States, France, Japan, and Germany. France generates 75% of its electricity with nuclear power.
- Today, energy produced from uranium provides 8.3% of the energy used in the U.S.
- Nuclear energy costs about 11 cents per kWh.
- No new power plants are planned in the U.S because of safety concerns and building costs.

U.S. Commercial Nuclear Power Reactors—Years of Operation

Years of Commercial Operation	Number of Reactors
△ 0-9	0
▲ 10-19	10
▲ 20-29	42
▲ 30-39	52

Source: U.S. Nuclear Regulatory Commission

Activity: Picturing Dinner (Again)

Purpose
Energy makes our world go round. We've looked at a number of energy transformations this week. Redraw a picture showing all the energy that goes into bringing your favorite meal to the table.

Equipment
1. Paper
2. Pencils
3. Markers

Procedure
Think of your favorite meal. Draw a picture that shows all the energy that went into bringing that meal to your table.

Questions:
How has your picture changed since the first time you drew it on Monday?

Activity:

Tour of Wyodak Mine and Power Station

Requirements and Expectations

- Please meet at the Science Center parking lot at 8:00 am.
- We will leave the college at 8:15 am.
- You should wear long pants (jeans are perfect), a long-sleeved cotton shirt and comfortable, sturdy closed-toed shoes.
- Do NOT wear sandals or flip flops.
- We will provide snacks, but be aware our tour schedule requires us to have a late lunch, approximately 12:45 pm.
- We will return to the college between 4:00 and 4:30 pm.