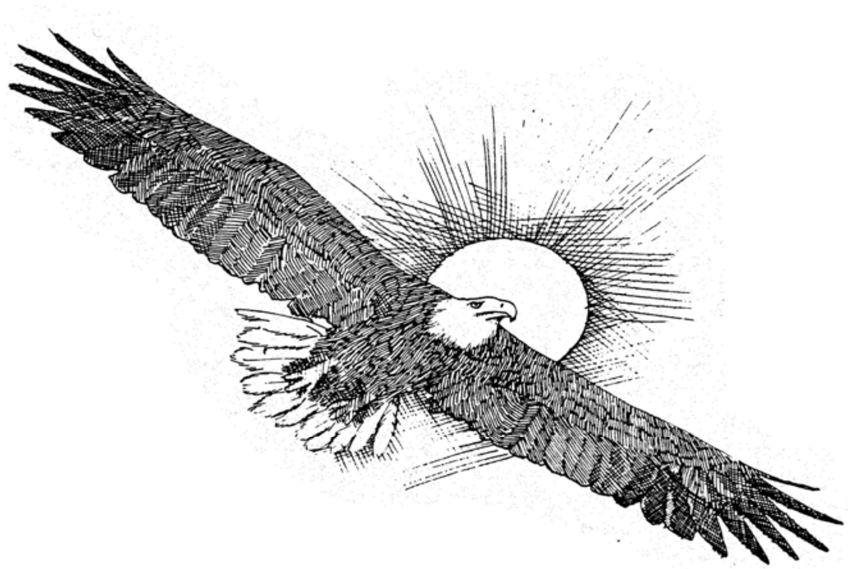
Energy



"The energy that sustains all living systems is solar energy, fixed in photosynthesis and held briefly in the biosphere before it is re-radiated into space as heat. It is solar energy that moves the rabbit, the deer, the whale, the child on the bicycle, and the human eye as it reads these words."
—George M. Woodwell

Introduction

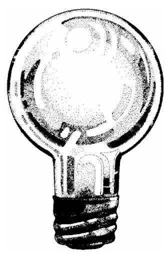
Energy is a central concept of the physical sciences. It pervades biological and geological sciences because the flow of energy underlies any system of interactions. All physical phenomena and interactions involve energy—from the building of mountains to the erupting of volcanoes, from earthquakes to weather patterns, and from mouse to man.

Because energy is a part of everything, there are many ways you can interpret it in a program. You could learn what a nearby power plant does, or find out what people did before they had electricity and running water. You could emphasize food chains and the transfer of energy, or you could look at all the fuel alternatives we have and their potential ramifications for the park and the environment.

Whatever the emphasis, energy is an important topic. California's use and choice of energy sources will dramatically affect our environment, our economy, and our future. If we explore our energy options and our efficiency opportunities, we will reap great benefits as a state, including slowing of the accumulation of atmospheric carbon dioxide (which may cause or aggravate global warming), and reducing air pollution and traffic congestion.

There is a great diversity of energy sources available; new energy technology has already begun to reduce our dependency on fossil fuels. California has 50 percent of the world's geothermal plants, 82 percent of the installed wind capacity, and 99 percent of the utility-sized solar plants. Helping Junior Rangers understand the energy choices of today while preparing them to become active participants in making those choices tomorrow is an important goal of this program.[1]

Interesting Energy Facts



In your lifetime, you will use:

- 26 million gallons of water
- 1,200 barrels of petroleum
- 13,000 pounds of paper
- 21,000 gallons of gasoline
- 50 tons of food[2]

- Automobiles, motorcycles, trucks, and buses drove over 2.8 trillion miles in 2002. That's almost one-twelfth the distance to the nearest star beyond the solar system. It's like driving to the sun and back 13,440 times.
- Recycling a pound of steel saves enough energy to light a 60-watt light bulb for 26 hours. Recycling a ton of glass saves the equivalent of nine gallons of fuel oil. Recycling aluminum cans saves 95 percent of the energy required to produce aluminum from bauxite. Recycling paper cuts energy usage in half.

Sample Program: Energy

I. Introduction
Introduce yourself to the group.
Introduce the Junior Ranger Program.

II. Focus
Are you a plant? Let's do an experiment to find out. Did everybody have something to drink today? Good. Now plant your feet firmly in the ground, take a deep breath, and stretch your hands up toward the sunlight. Do you feel full? No? I guess we're not plants, then.

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[1] *Compendium for Energy Resources*. Presented by the California Department of Education, The California Energy Extension Service in the Governor's Office of Planning and Research, and Sonoma State University. March 1992.
[2] G. Tyler Miller, Jr. *Living in the Environment*. Belmont, CA: Wadsworth Publishing Co, 1998.

III. Objectives

Plants can turn sunshine into food. Today we're going to find out not only how plants can do this, but also how animals (including people) get energy. We'll also find out the amazing ways that energy is transformed from one form to another form, and which energy sources are healthiest for people and for the environment.

IV. Inquiry/Discussion

A. Photosynthesis
1. Explain how plants turn the sun's energy into food.
2. Activity: Photosynthesis Relay Race (see activity section below)

B. Animal Energy
1. Unlike plants, people can't get energy from the sun.
2. Why does your body need energy? What does it use energy to do?
   To move, talk, exercise, think, pump blood, breathe, etc.
3. What happens by about 10:30 a.m. if you go to school without eating breakfast?
   You get hungry and run low on energy.
4. Humans get energy for their bodies by eating food—oatmeal, fruit, hamburgers, or pizza, for example.
5. Where do animals get their energy?
   Animals also get energy from food sources:
   Herbivores get energy from eating leaves, grass, plants, berries, nuts, and acorns (give examples from your park, showing the kinds of plants some herbivores in your park eat).
   Carnivores get energy from eating other animals (give examples from your park).

C. Food Chains
1. If a plant gets its energy from the sun, what happens to that energy when an herbivore like a rabbit eats the plant?
   The plant gives the herbivore energy to live: first the plant gets energy from the sun, then when the rabbit eats the plant, the sun's energy is transferred from the plant to the rabbit.
2. What happens if a carnivore like a hawk eats the rabbit?
   The hawk gets energy from the rabbit, who got its energy from the plant, who got its energy from the sun.
3. Hawks don't have many predators (animals who want to eat them). What do you think happens to all the energy the hawk has stored inside it when it dies?
   Some animals (scavengers) might eat the hawk after it dies. If they don't, bacteria and other tiny living things go to work on the bird's body. These decomposers, using the hawk's stored energy, release its nutrients back into the soil. These nutrients in turn are used by plants to grow. When the sun shines on the plant, the food chain and transfer of energy starts all over again.
4. Activity: Sing “There Once Was a Daisy” (see Appendix B)

5. Why are there fewer mountain lions than mice? Fewer mice than blades of grass?
   Explain energy loss: how energy is dissipated (used) in life functions such as movement, metabolism, growth, reproduction, and maintaining body heat. Plants and animals are temporary energy "vessels"—but very "leaky" ones.

D. Sources of Energy
1. So far, we've been talking about the energy that living things need. But people need energy for more than just moving around. We also need energy to turn on lights, to run our television, to fuel cars, and for many other things, as well. What kinds of energy do we use every day at home?
   Mostly electricity, natural gas, and gasoline.
2. We know we're using electricity when we turn on a light or drive a car. But a lot of the energy we use is hidden. For example, here's the energy involved in getting the carrots you eat for dinner:
   a. A farmer grows carrots. He uses fertilizer which is produced from fossil fuels.
   b. A truck takes the carrots to a processing factory. The truck uses energy from gasoline to move.
   c. At the factory, machines wash, slice, package, and freeze the carrots. The machines use energy from electricity to work.
   d. A refrigerated truck takes the carrots to the grocery store. Energy from gasoline is used to power the truck to keep the inside of the truck cold.
   e. At the grocery store the carrots are kept frozen in a freezer. Energy from electricity keeps the freezer cold.
   f. You drive to the grocery store to buy carrots. Energy from gasoline makes your car move.
   g. You drive home with the carrots.
   h. You cook the carrots. Energy from electricity (or gas) makes your stove hot.
   i. You eat the carrots. This gives you energy to play!

E. Other Sources of Energy
1. Besides electricity and gasoline, we use other kinds of energy, including solar energy, nuclear energy, wind energy, oil, coal, and other fossil fuels. Some of these energy sources are renewable, which means we won't run out of them. No matter how much energy from a renewable source we use, we will never use it all up unless the source (a forest, for example) is destroyed. Can you think of an example of a renewable energy source?
   Solar (sun) energy, wind energy, food energy, electricity, tidal energy, geothermal energy.
2. Other energy sources are non-renewable sources. This means that we can—and probably will—use these sources up. Can you think of an example of a non-renewable energy source?
   Fossil fuels like oil and coal, nuclear energy.
3. Why do you think we might run out of these kinds of energy someday?

There is a limited amount of these kinds of fuel, and it takes hundreds and hundreds of years for nature to make them. We're using them up faster than they can be renewed.

4. Activity: Energy Detective (see activity section below)

V. Application/Conclusion
   A. From being "energy detectives," did you discover that some kinds of energy are safer and better for the environment?
   B. How can we save energy?
      1. Walk or ride your bike instead of taking a car.
      2. Turn off lights, radio, television, etc. when leaving a room.
      3. Put on more clothing instead of turning up the thermostat.
   C. Announce the topic and time of the next Junior Ranger program.
   D. Stamp logbooks.

Activities

Photosynthesis Relay Race

Number of Children: 8 or more
Environment: Open area, approximately 40' x 40'
Equipment needed: Any objects that can be used to mark boundaries
Purpose: To learn about plants as producers, and about the elements necessary in photosynthesis
Activity:

1. Introduce plants as producers—making their own food through photosynthesis. Introduce the elements needed in photosynthesis (sun, carbon dioxide, and water).
2. Divide the group into 2 teams. Each team is divided into two groups. One group becomes "water molecules," and the other becomes "carbon dioxide molecules." One person (possibly the instructor) is the sun. One person from each team is the "producer." The producer starts at the sun.
3. On "go," each producer runs to and holds hands with one "carbon dioxide," and brings him/her to the sun. The producer then runs and gets a "water molecule" and brings her to and connects her with the carbon dioxide that is connected to the sun. Once connected, the producer must start at the sun and alternately weave through each member, then go back and pick up another molecule. This progresses until one team has all its molecules connected, when they shout "Photosynthesis!"

Energy Detective

Number of Children: One or more
Environment: Any
Equipment needed: None

Purpose: To identify different sources of energy in order to develop an ethic to use them wisely

Activity:

1. This is a sequential clue guessing game, in which Junior Rangers try to guess which kind of energy is being described.
2. Read clues aloud. Once the Junior Rangers know the answer, have them place a finger on their noses instead of raising their hands. When enough "noses have it," have them call the answer aloud in unison.

Adapted from <u>Science Alive!</u>, Unit 1 Energy Flow.

Mystery #1—Answer: Plant/Food Energy

1. I am a renewable source of energy (you won't run out of me).
2. You can make more and more of me.
3. You have to plant me, water me, and take care of me.
4. I am solid, but often I will bend in the wind.
5. I capture sunlight energy.
6. I need air, water, sun, and soil to grow.
7. You harvest me to eat me.
8. I am the source of energy for the human body.
9. I do not pollute.
10. I am not expensive.
11. Different types grow in different countries.

Mystery #2—Answer: Electricity

1. I am a renewable source of energy.
2. You can use a machine powered by water, gas, oil, wind, or the sun to make me.
3. I power your T.V., radio and lamps.
4. The machine most often used to make me is a turbine.
5. If you build a dam and let out water to roll over the round turbine, it spins so fast it produces me.
6. You can only see me at night. During the day I am invisible.
7. I look like gold or silver sparks at night.
8. I can shock you.
9. Scientists discovered a way to produce me that uses renewable solar energy called photovoltaics.
10. Photo=light, Voltaics=electricity.
11. Because you must use another source of energy to make me, I am expensive.

Mystery #3—Answer: Petroleum Oil

1. I am a non-renewable source of energy.
2. There is only a little bit of me on Earth.
3. I am thick, black, and gray.
4. I am a liquid found deep underground.
5. It's hard to get me off your skin, fur, or feathers.

6. I am expensive to buy.
7. I am as old as the dinosaurs.
8. I am actually an ancient package of captured sunlight energy.
9. You use me in cars, buses, planes, ships, and factories.
10. When you burn me, I turn into black smoke that causes air pollution, can make it hard to breathe, and can make you sick.

Mystery #4—Answer: Nuclear Energy
1. I am a non-renewable source of energy.
2. There is only a little of me on Earth.
3. I am made from a rare solid rock (uranium) that produces me when it explodes.
4. Once I'm made I am poisonous and stick around for a long time (hundreds of thousands of years).
5. Scientists have yet to find a safe place for the waste I create.
6. I am the most dangerous of all the energy sources.
7. I am very expensive to make.
8. If I wind up in the wrong hands, watch out—I could destroy life and property.
9. You use me to make electricity.
10. More and more scientists believe that I cause cancer.
11. You can build bombs out of me.

Mystery #5—Answer: Coal
1. I am ancient, captured sunlight energy.
2. I am a non-renewable source of energy.
3. There is more of me than oil, but still my days are limited on Earth.
4. I am black, red, or brown.
5. I am a rock.
6. I am as old as the dinosaurs. In fact, I may have dinosaurs buried inside me.
7. I am not very expensive to buy.
8. You burn me to heat your house, to make old trains run, or to make factories work.
9. When you burn me, I turn into thick, black smoke that pollutes the air. This makes it hard to breathe and can sometimes make you sick.
10. Scientists are inventing ways to use me wisely.

Mystery #6—Answer: Solar Energy
1. I am a renewable energy source.
2. You can use me to make electricity.
3. You can use me to heat your water.
4. You might see big panels that collect me on the tops of houses.
5. I am free, but the cells that are needed to turn me into energy can be expensive.
6. I am more abundant on a clear day.
7. You can't use me at night unless you store me.
8. Some people have calculators that are powered by me instead of batteries.
9. There are no bad effects to people or the environment from using me.

10. I work more efficiently in the light than in the shade.

Mystery #7—Answer: Wind Energy

1. I am a renewable energy source.
2. On some days there is more of me than on other days.
3. I make things turn, and the motion is turned into usable energy.
4. In Holland, and in some parts of California, you can see many of the things that turn me into usable energy.
5. I am the kind of energy that makes some kinds of boats go.
6. On some days, I make the trees sway.

Background Information: Energy

Energy is the capacity to do work or the ability to make things move. Energy comes in several forms—sound, light, heat, active (kinetic energy), and stored (potential energy)—and can be converted from one form to another.

Energy is an important part of our lives. It makes us live and grow, runs our lights, refrigerators, and televisions, provides hot water for our homes, and makes our cars and buses go. We need energy for everything we do!

Photosynthesis

Most plants have in common the unique ability to convert the sun's radiant energy to food. No other living kind of organism on earth can transform the sun's energy to support life. This process is called photosynthesis.

Leaves are like tiny sun-powered factories. In these factories, plants make food from water, carbon dioxide, and minerals from the soil. They do this by using a substance in the leaves called chlorophyll. Combining the sun's radiant energy with carbon (from the carbon dioxide), hydrogen (from water), and minerals from the soil, plants use the sun's rays to feed themselves.

This energy is stored in the plant's structure as sugar and starch, which possess chemical energy. As a byproduct of this process, plants produce the oxygen we breathe. Plants therefore help support human and animal life as they try to support their own.

Food Chains and Webs

Energy relationships between organisms are called food chains. Food chains begin with the sun, since the main source from which living things receive energy is sunlight. Animals can't convert the sun's energy to food, so they can get this energy only by eating plants (or other animals who have eaten plants).

There are two major food chains: grazing food chains and detritus (decomposer) food chains. Grazing chains begin when plants, the producers, convert the sun's energy to sugar and starch. Then the consumers take over: plant-eating animals (herbivores) receive the stored chemical energy when they feed, using some for immediate energy. Meat-eating animals (carnivores) get their energy when they consume the herbivores, again using some of the energy and storing some. In turn, carnivores are preyed upon by other predators. In some cases, if these carnivores do not have many predators themselves, they become the last step in the food chain. Omnivores, including humans, eat both plants and animals.

Detritus (or decomposer) food chains include insects and microscopic forms of life that break down matter. This chain completes a cycle by reclaiming the elements stored in once-living tissue and returning them to the soil, where they again nourish plants. The decomposers make it possible for the energy and nutrients stored in the body of a dead animal to support new life, rather than remaining unavailable and therefore being wasted.

Food chains are an overly simplistic way to describe the energy transfer between organisms. Most animals are part of more than one food chain and eat more than one kind of food in order to meet their food and energy requirements. These interconnected food chains form a food web. Food webs show how plants and animals are connected in many ways to ensure their survival.

Energy Loss

Each time an animal eats plants or another animal, some of the sun's energy is passed along the food web. However, at each link of that web, some of this energy is lost. When an herbivore eats a plant, it is eating only a small portion of the original “sunlight” energy. When a carnivore eats the herbivore, it gets an even smaller fraction of the original energy.

A food web can also be thought of as a pyramid. For example, a marsh full of cattails can provide enough food for a group of mice. But most of those mice might be needed to provide food for only one weasel. Because of this energy loss, there are relatively few carnivores, more herbivores, and lots of plants! It takes a lot of plants to support just one carnivore.

Carnivores are large and depend on meat, so there must be fewer carnivores in an area than the number of animals they eat. In general, carnivores have a population density of approximately one per square mile, whereas omnivorous mammals average about 20 per square mile and herbivorous rodents may attain densities of up to 100,000 per square mile.

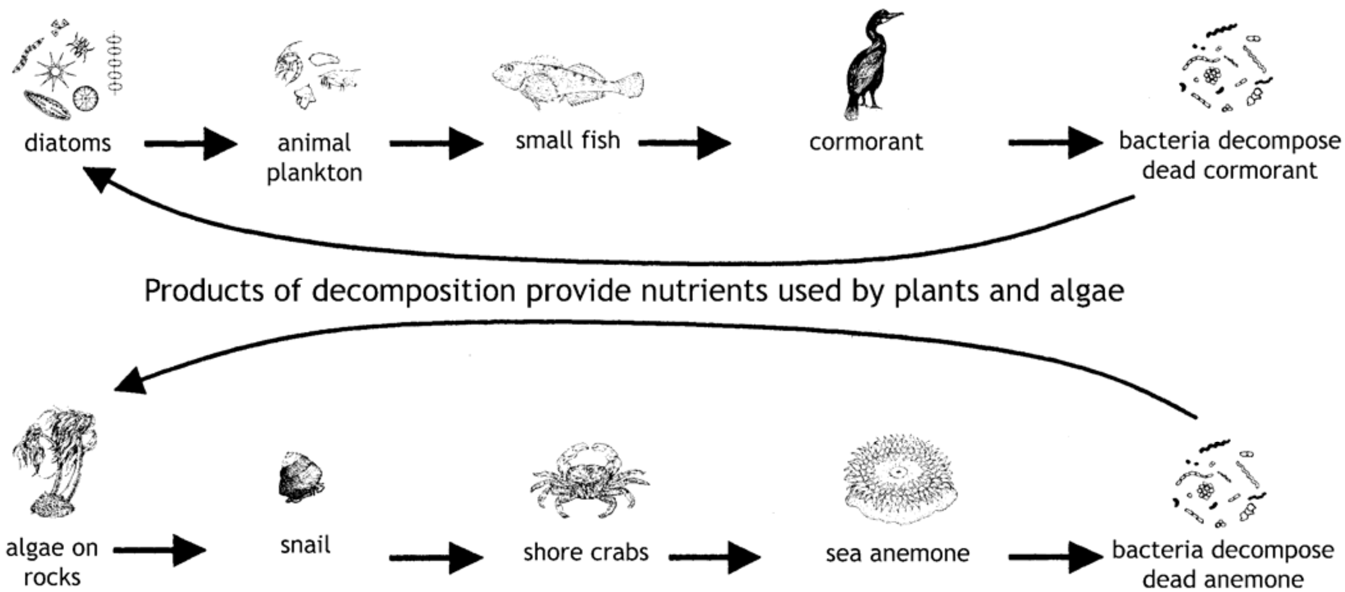
Humans are members of many food chains. For example, when we eat an ear of corn, we are part of a simple two-link chain: plant to human. When we eat a hamburger or drink milk, we are part of a three-link chain: grass to cow to human.

Since it takes so much more energy to support a carnivore, it's a good thing humans are omnivores! If humans ate only meat, the average person would consume about 1100 pounds of beef per year (or the equivalent of three calves). The three calves would eat 20 million alfalfa plants, which would require ten acres of land to grow. Each person would need ten acres of land to provide the meat needed for one year!

Following a Food Chain . . .

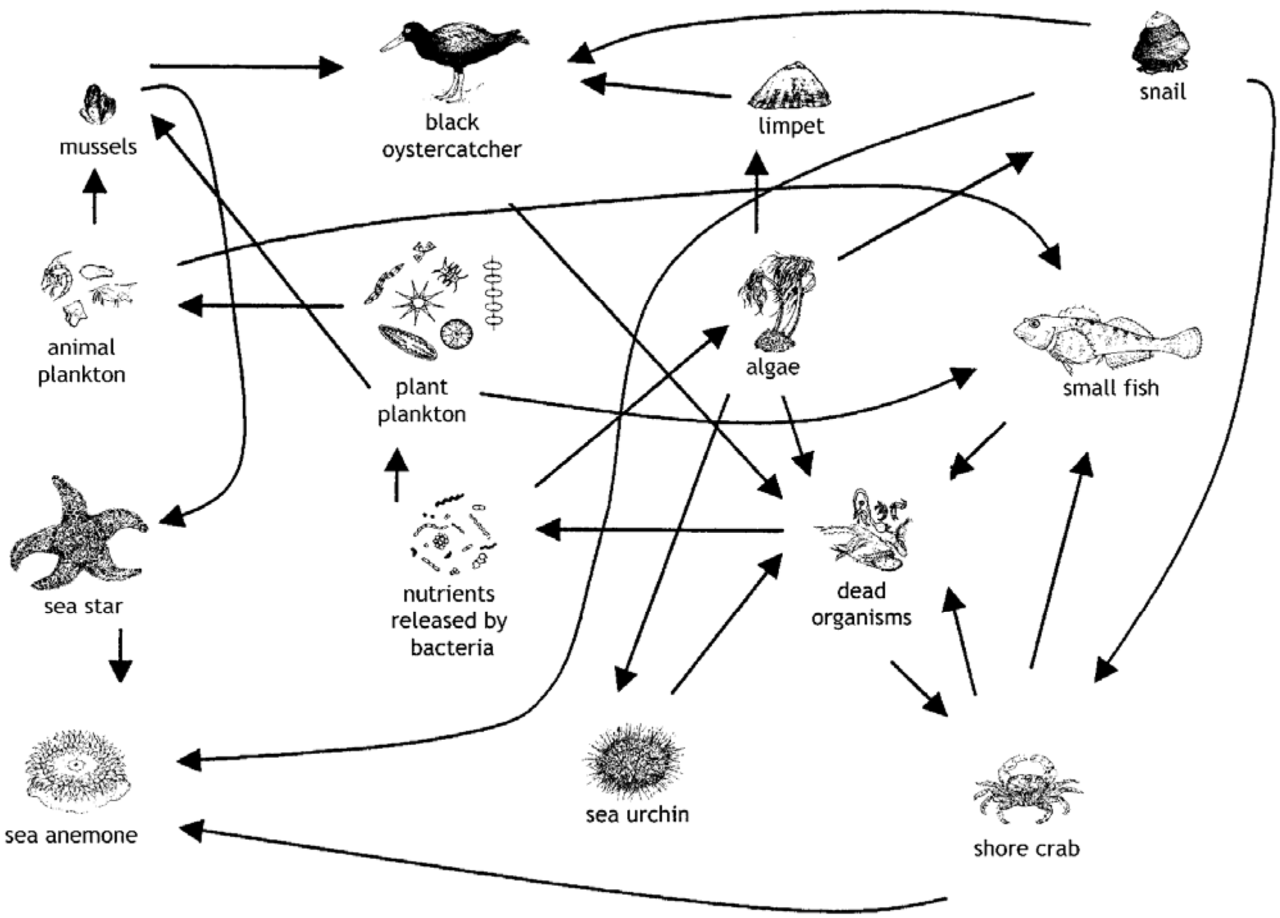
Intertidal Food Chains

An arrow indicates that an organism is eaten by another.
For example, sea urchin ⟶ an otter
(is eaten by)



A Simplified Intertidal Food Web

Remember that the organisms depend on light (energy) from the sun, and minerals and water from the sea. Even in this simplified web, to make it readable, not all connections are drawn.



Energy Sources

There are six primary sources of energy that are naturally available to us on earth: solar, chemical, nuclear, geothermal, tidal, and wind. Two of these, chemical and nuclear, are stored (potential) forms of energy. The other four (solar, geothermal, tidal, and wind energy) are kinetic forms of energy—energy that is active and always in motion. While we can use stored types of energy whenever we need them, we can only use kinetic forms when nature makes them accessible. (For example, solar energy is most readily available during sunlight hours, although some solar energy, stored as heat, can be released after dark).

Solar Energy

Solar energy (or sunlight) falls on the earth and provides heat and light for plant and animal life. A small fraction of the sun's energy interacts with plants and fuels the photosynthesis process, and is thus indirectly responsible for the food energy that we depend on.

Solar energy is also the source of the chemical energy that was stored hundreds of millions of years ago in the plant life of the swampy jungles on earth. We are using stored solar energy when we burn the fossil fuels: coal, petroleum, and natural gas.

The sun's energy also heats the land and the oceans and thus provides the energy for the great air and ocean currents—the winds and the waves. Scientists and engineers have found practical ways to use solar energy to heat and cool individual homes. Solar energy is the most abundant and continuous form of energy available to people, and has no adverse effects on human, animal, or plant life.

Fossil Fuels

Fossil fuels are sources of chemical energy. Energy is released through a chemical reaction. Most of the electricity produced in the world comes from the chemical energy released from the burning of wood, coal and oil.

Fossil fuels are used extensively because they are relatively easy to find, collect, store, transport, and use. Once discovered, the fuels can be removed from the ground by mining or drilling, and are transported by pipes, truck, rail, etc. to any destination.

Although we currently have enough fossil fuels available, at some point we are likely to deplete the earth's supply of fossil fuels, because the earth creates these fossil fuels very slowly. It would take 300 million years for the earth to replace the fossil fuels we have used in the past century. Since we use fossil fuels so much more quickly than the supply can be replenished, we cannot continue to use these fuels at current consumption rates for much longer. For this reason, fossil fuels are non-renewable sources of energy. Natural gas is a fossil fuel which is extracted by drilling wells. Geologists investigate land formations to look for likely spots. A drill breaks up the rock, and a pipe is lowered into the ground. Generally, the gas is found at least 5000 feet below the surface. Because geologists can only guess where gas is likely to be, these exploratory drillings sometimes fail to discover any natural gas.

Natural gas is used in heaters and air conditioners, or is turned into electricity. Natural gas is relatively harmless to people and the environment. However, it is a limited resource and cannot be considered a long-term energy solution.

Petroleum is also a fossil fuel. It is found by exploratory drilling in areas where geologists think it might be. The rock is broken up and a pipe is inserted into the ground which transports the oily substance to the surface. An average oil well is 4500 feet deep.

We use oil in our cars, buses, airplanes, ships and factories. Oil is not without its problems, however. It can harm the environment when it is produced, shipped, or burned; dumped into the water, it can kill marine life.

Coal, like oil and natural gas, is a fossil fuel formed from the remains of vegetation. Coal can be mined either on the surface or underground. In underground mining, a hole is dug to the coal bed and gradually a tunnel large enough for men and machines to enter is cleared. Coal is cut from the surrounding rock by machines, and transported to the surface on conveyors, where it is processed, loaded on trucks, and delivered to its destination. Surface mining is used when the coal is near the surface. Power shovels and bulldozers remove the earth, rock, and vegetation above the coal, then smaller machinery retrieves the coal. Strip mining digs up all overlying vegetation, so soil erosion occurs more quickly. All states now require that the mined land be restored. Dust levels in underground mines often cause the miners to have respiratory (breathing) problems.

Coal also causes problems when it is burned. Most coal contains a chemical called sulphur that creates pollution. Coal is also dirty, and leaves soot and grime. Coal is most often used today in the generation of electricity.

Nuclear Energy

Nuclear energy is produced when the splitting or fusing of atomic nuclei occurs. These reactions are called fission or fusion, respectively. Although we can currently use only fission to produce usable energy, physicists will eventually have the technology to use fusion for energy as well.

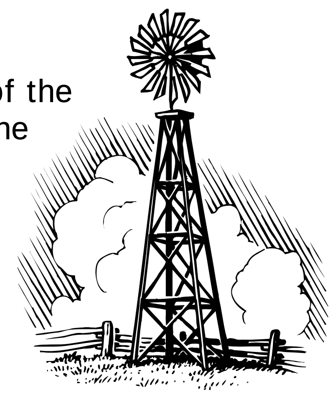
The use of fission has been controversial. Proponents of nuclear energy argue that it does not pollute the air, add to the greenhouse effect by adding carbon dioxide to the atmosphere (as in the burning of coal and oil), or contribute to acid rain. It is also an important energy source for countries such as France, who do not have adequate coal, oil, or hydro-electric power to meet energy needs. Although fission was once considered inexpensive, the costs of storing or reprocessing the spent fuel and dismantling the plant when its lifetime is over have proved very expensive.

The problems of mining the uranium required for the fission reaction are similar to those of other types of mining. The miners are exposed to dust, accidents, fumes, and intense noise. Moreover, breathing radioactive gas has been linked to lung cancer. Waste materials from uranium mining are also dangerous and must be kept contained. The reactors themselves are highly radioactive, and must be kept out of contact with living material. Nuclear plant discharge (or waste) must be stored for hundreds of thousands of years before it is safe.

There is a safer, less expensive future for nuclear power, however. Plasma physicists are currently working on a fusion power plant, which would use an inexpensive fuel, deuterium, which can be found in ocean water. Deuterium is a naturally occurring isotope of hydrogen which can be fused to produce helium. In the process, under conditions of very high temperature and pressure (such as occur on the sun), energy is released. The byproducts of this process have a relatively short-lived radioactivity and decay quickly, as opposed to the hundreds of thousands of years for fission waste products. Although this technology is being studied by many nations, including the U.S., Europe, and Russia, it has not yet been realized as a source of power.[3]

Geothermal Energy

There is a tremendous amount of energy in the earth from the heat of molten rock and radioactive decay. Although heat energy is an active or "kinetic" form of energy, the heat of the earth is effectively stored and insulated by the solid, thin crust on which we live.



When heat from the molten interior of the earth meets underground water, steam results. When this steam pushes through the surface of the earth, it creates geysers. Geologists study these geysers to determine whether they are usable; if so, the steam is channeled to a nearby electric plant for conversion to electric power. Geothermal energy can be used directly and does not require a processing plant. It does not create major land disturbances (as with mining) or waste disposal problems (as do nuclear energy or fossil fuels). When available, it is considered a desirable source of energy.

The drawbacks to geothermal energy are the sulfur and other noxious fumes produced, and the corrosive qualities of this water, which results in high maintenance costs for machinery. In addition, geothermal energy is available to us only in those regions where magma (molten rock inside the earth) is close to the surface and the energy can leak out through cracks in the crust. Since these sources are not numerous, geothermal energy is not widely used. In California, we have a geothermal plant in the Sonoma area.

Tidal Energy

Like geothermal energy, tidal energy is a form of continuous energy from the sea. To use this energy, the water is used to turn a turbine and create electricity. Tidal generation of electricity is only practical in places near an ocean where there are high tides. Tidal energy is the least used of the six energy sources.

[3] Information on fusion is from theoretical physicist Dr. Philip F. Meads, Jr.

Wind and Water Energy

Wind and water energy are used extensively in areas where they are available. The kinetic—or moving—energy of water and wind can be converted to electricity through the use of windmills and turbines.

Windmills are turned by the blowing wind, and this motion produces electricity. In some areas of California, you can see groups of these windmills turning as they generate electricity.

Water energy (or hydroelectric energy) works as water in a dam is released, rolling over a round turbine. The turbine spins very quickly, and this motion produces electricity. Wind and water are renewable sources of energy.

Electricity

We call electricity an intermediate form of energy. It is not stored energy, like fossil fuels, and it is not in the form in which it finally appears as light, motion, or heat. Electricity can be generated by water, sun, or wind. Otherwise, electric energy depends on fossil fuels to be created, and the adverse effects of fossil fuel usage become the adverse effects of electricity production.

Suggested Resources: Energy

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