



# CK-12 FlexBook



# Environmental Science

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Printed: December 24, 2013

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## CHAPTER

## 1

# Introduction to Energy Resources

- Define energy.
- Describe energy's forms of storage and release.
- Explain the law of conservation of energy.



**Where does this young basketball player get his energy?**

He gets his energy from the Sun. Not directly, of course. He eats food, which used sunlight to grow, or he eats something that ate something that used sunlight to grow. When he shoots the ball, some of the energy goes into the ball and hopefully the ball goes into the hoop. Three points!

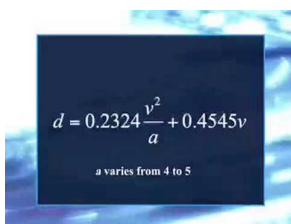
## Energy Basics

**Energy** is the ability to do work or produce change. Every living thing needs energy to perform its daily functions and even more energy to grow. Plants get energy from the “food” they make by photosynthesis, and animals get energy directly or indirectly from that food. People also use energy for many things, such as cooking food, keeping ice cream cold in the freezer, heating a house, constructing a skyscraper, or lighting their homes. Because billions of people all around the world use energy, there is a huge need for energy resources. Energy conservation is something everyone can do now to help reduce the strain on energy resources.

## Conservation of Energy

The law of conservation of energy says that energy cannot be created or destroyed. This means that even though energy changes form, the total amount of energy always stays the same. How does energy get converted from one type to another when you kick a soccer ball? When your body breaks down the food you eat, it stores the energy from the food as **chemical energy**. But some of this stored energy has to be released to make your leg muscles move. The chemical energy is converted to another form of energy called **kinetic energy**. Kinetic energy is the energy of anything in motion. Your muscles move your leg, your foot kicks the ball, and the ball gains kinetic energy from the kick. So you can think of the action of kicking the ball as a story of energy changing forms.

To learn the quadratic equations related to getting a rapidly moving car to overcome its kinetic energy and come to a stop, watch this video (**IE 1e**): <http://www.youtube.com/watch?v=v-Z2-jxCqVw&feature=related> (6:01).



$$d = 0.2324 \frac{v^2}{a} + 0.4545v$$

*a varies from 4 to 5*

### MEDIA

Click image to the left for more content.

**Potential energy** is energy that is stored. Potential energy has the potential to do work or the potential to be converted into other forms of energy. If a ball is sitting on the very edge at the top of the hill, it is not moving, but it has a lot of potential energy.

Animations showing the conversion of potential energy to kinetic energy can be seen at the following sites:

- <http://www.physicsclassroom.com/mmedia/energy/se.cfm>
- <http://www.physicsclassroom.com/mmedia/energy/ce.cfm>
- <http://www.physicsclassroom.com/mmedia/energy/dg.cfm>

## Fuel

If you read a book beneath a lit lamp, that lamp has energy from electricity. The energy to make the electricity comes from **fuel**. Fuel has energy that it releases. A fuel is any material that can release energy in a chemical change.

What are some examples of fuel, and what are they used for?

1. Food is fuel for your body.
2. Sunlight is the energy plants need to make food by photosynthesis.
3. Gasoline is fuel for cars.
4. Hydrogen is fuel for the Sun.

For a fuel to be useful, its energy must be released in a way that can be controlled. Controlling the release of energy makes it possible for the energy to be used to do work.

## Heat

When fuel is used for its energy, it is usually burned, and most of the energy is released as **heat** (**Figure 1.1**). The heat may then be used to do work. Think of a person striking a match to set some small twigs on fire. After the twigs burn for a while, they get hot enough to make some larger sticks burn. The fire keeps getting hotter, and soon it is hot enough to burn whole logs. Pretty soon the fire is roaring, and a pot of water placed on the fire starts to boil. Some of the liquid water evaporates.



**FIGURE 1.1**

A controlled fire.

What is the source of energy for boiling and evaporating the water? Although some chemical energy from the match was put into starting the fire, the heat to boil and evaporate the water comes from the energy that was stored in the wood. The wood is the fuel for the fire.

## Summary

- Energy is the ability to do work. Energy cannot be created or destroyed; it can only change form.
- Fuel stores energy that can be released during use.
- Heat is the motion of atoms due to the use of energy.

## Making Connections



### MEDIA

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## Practice

Use this resource to answer the questions that follow.

Forms of Energy

<http://bit.ly/nlcOxb>

1. What is energy?
2. What is chemical energy used for?
3. What produces electrical energy?
4. What is the source of light energy?
5. List examples of mechanical energy.
6. What produces thermal energy?
7. What is nuclear energy?

## Review

1. Give an example of how the law of conservation of energy works.
2. Compare and contrast chemical energy, kinetic energy, and potential energy.
3. Think about a candle flame and a bathtub full of hot water. Which has the highest temperature and which has the highest heat? What's the difference?

---

## References

1. Awesomoman. Fire. Public Domain

## CHAPTER

## 2

# Energy Conservation

- Describe forms of energy conservation.
- Explain why energy conservation is important



## How much energy can you save?

By turning off the lights, keeping rooms at a reasonable temperature in summer and winter, driving a fuel-efficient car or taking the bus, and many other things, society can save a lot of energy. By saving energy we reduce the financial and environmental costs of collecting that energy, and the pollution and greenhouse gases that come from using that energy. In all, it's a win-win situation!

## Energy Conservation

What benefits are there from energy conservation? Conserving energy means that less energy is needed, which reduces costs, ensures that non-renewable energy sources will last longer, and reduces political and environmental impacts.

What are the two ways that energy can be conserved? (1) Use less energy, and (2) use energy more efficiently.

The pie chart (**Figure 2.1**) shows how energy is used in the United States.

**Table 2.1** shows some ways that people can decrease energy use and use energy more efficiently in transportation, residences, industries, and office settings.

**TABLE 2.1: Ways to Use Energy More Efficiently**

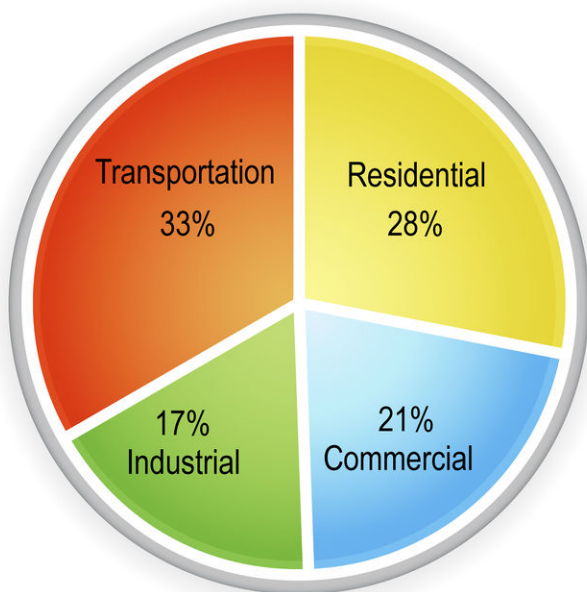
Where Energy is Used	How We Can Use Less Energy	How We Can Use Energy More Efficiently
Transportation	Ride a bike or walk instead of taking a car.	Increase fuel efficiency in cars.

**TABLE 2.1:** (continued)

Where Energy is Used	How We Can Use Less Energy	How We Can Use Energy More Efficiently
	Reduce the number of trips you make.	Buy and drive smaller cars.
	Use public transportation.	Build cars from lighter and stronger materials.
		Drive at speeds at or below 90 kilometers per hour (55 miles per hour).
Residential	Turn off lights when not in a room.	Replace old appliances with newer more efficient models.
	Only run appliances when necessary.	Insulate your home.
	Unplug appliances when not in use.	Make sure windows and doors are well sealed.
	Wear a sweater instead of turning up heat.	Use LED bulbs if available, or compact fluorescent light bulbs (and dispose of properly!).
	Use fans instead of turning down air conditioner.	
	Engage in activities that do not involve electronics.	
	Rely on sunlight instead of artificial light.	
Industrial	Recycle materials like soda cans and steel.	Practice conservation in factories.
	Reduce use of plastic, paper, and metal materials.	Reuse materials.
		Design equipment to be more efficient.
Commercial (businesses, shopping areas, etc.)	Turn off appliances and equipment when not in use.	Use fluorescent lighting.
		Set thermostats to automatically turn off heat or air conditioning when buildings are closed.

---

## U.S. Energy Usage, by Sector (2004)

**FIGURE 2.1**

Almost one-half of the energy used in the United States is for transportation and home use. This means individual choices can make a big impact on energy conservation.

Using less energy, or using energy more efficiently, will help conserve our energy resources. Since many of the energy resources we depend upon are non-renewable, we need to make sure that we waste them as little as possible.

Energy saving tips from the U.S. Department of Energy: <http://www.energy.gov/energytips.htm>.

The U.S. Department of Energy has a video to let you know how a home energy audit will help you to make your home more energy efficient. Be sure to follow links to the "Do it yourself" page. [http://www.energysavers.gov/your\\_home/energy\\_audits/index.cfm/mytopic=11160](http://www.energysavers.gov/your_home/energy_audits/index.cfm/mytopic=11160)

### Summary

- Conserving energy is cleaner and cheaper than finding new energy.
- To conserve energy, use less energy and be more efficient about the energy you use.
- There are many ways to conserve energy in your own life, such as walking or taking the bus, wearing a sweater instead of turning up the heat, etc.

### Practice

Use this resource to answer the questions that follow.

<http://www.youtube.com/watch?v=QG3HNQiEaTM>



### MEDIA

Click image to the left for more content.

1. What will the population be in 2030?
2. How much will our energy demands increase by 2030?
3. What is energy efficiency?
4. How can industries optimize their energy efficiency?
5. What can be done to make vehicles more efficient?
6. How effective can using energy efficiently be?

### Review

1. Why is conservation the best way to stretch our energy resources?
2. List some ways that society can conserve energy.
3. List some ways that you and the other members of your household can conserve energy.

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### References

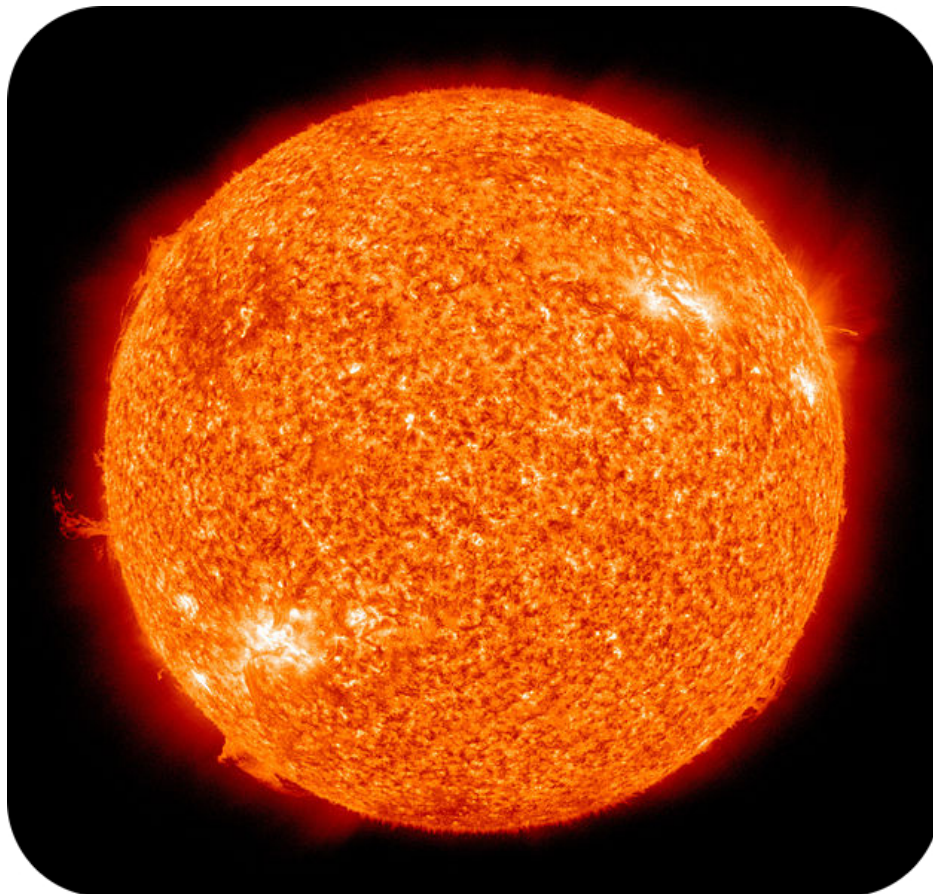
1. CK-12 Foundation. . CC-BY-NC-SA 3.0

## CHAPTER

## 3

# Renewable vs Non-Renewable Energy Resources

- Define renewable resource and nonrenewable resource.
- Compare and contrast renewable and nonrenewable resources.
- Identify renewable and nonrenewable resources.



## What is the source of nearly all of Earth's energy?

The source of nearly all energy on Earth is our star, the Sun. Solar energy feeds almost all life on Earth, is trapped in fossil fuels, and is the reason wind blows and water flows. Earth's other big source of energy is the planet's internal heat.

## Types of Energy Resources

Energy resources are either renewable or nonrenewable. **Nonrenewable resources** are used faster than they can be replaced, so the supply available to society is limited. **Renewable resources** will not run out because they are replaced as quickly as they are used (see example in **Figure 3.1**). Can you think of some renewable and nonrenewable energy sources?

**FIGURE 3.1**

An old windmill in Big Sur, California.

## Nonrenewable Resources

**Fossil fuels** —coal, oil, and natural gas —are the most common example of nonrenewable energy resources. Fossil fuels are formed from fossils, the partially decomposed remains of once living plants and animals. These fossils took millions of years to form. When fossil fuels are burned for energy, they release pollutants into the atmosphere. Fossil fuels also release carbon dioxide and other greenhouse gases, which are causing global temperatures to rise.

## Renewable Resources

Renewable energy resources include solar, water, wind, biomass, and geothermal. These resources are either virtually limitless like the Sun, which will continue to shine for billions of years, or will be replaced faster than we can use them. Amounts of falling water or wind will change over the course of time, but they are quite abundant. Biomass energy, like wood for fire, can be replaced quickly.

The use of renewable resources may also cause problems. Some are expensive, while some, such as trees, have other uses. Some cause environmental problems. As the technology improves and more people use renewable energy, the prices may come down. At the same time, as we use up fossil fuels such as coal, oil, and natural gas, these nonrenewable resources will become more expensive. At some point, even if renewable energy costs are high, nonrenewable energy will be even more expensive. Ultimately, we will have to use renewable sources.

## Important Things to Consider about Energy Resources

With both renewable and nonrenewable resources, there are at least two important things to consider. One is that we have to have a practical way to turn the resource into a useful form of energy. The other is that we have to consider what happens when we turn the resource into energy.

For example, if we get much less energy from burning a fuel than we put into making it, then that fuel is probably not a practical energy resource. On the other hand, if another fuel gives us large amounts of energy but creates large amounts of pollution, that fuel also may not be the best choice for an energy resource.

## Electrical Grids

No matter what the source, once it is generated electricity has to move from place to place. It does so by an electrical grid. Many communities have electrical grids that were built decades ago. These grids are inefficient and have high failure rates.

The electrical grids of the future are likely to be **smart grids**. Smart grids start with electricity production from one or more power generation sources. The electricity is streamed through multiple networks out to millions of consumers. Smart meters are placed with the consumers. They supply information on the state of the electrical system. Operators know within minutes if the power goes out, rather than having to wait for phone calls from consumers. Smart meters measure consumption and assist consumers in using power when it is more economical, even turning on or off appliances in homes or workplaces to smooth demand. Smart grids are essential for integrating renewable energy sources, such as solar and wind, into the network because they have highs and lows in their supply.

Today we rely on electricity more than ever, but the resources that currently supply our power are finite. The race is on to harness more renewable resources, but getting all that clean energy from production sites to homes and businesses is proving to be a major challenge.

Find out more at <http://www.kqed.org/quest/television/climate-watch-unlocking-the-grid>.



### MEDIA

Click image to the left for more content.

## Summary

- Non-renewable resources are used faster than they can be replaced. Once they're gone, they are, for all practical purposes, gone. Renewable resources are so abundant or are replaced so rapidly that, for all practical purposes, they can't run out.
- Fossil fuels are the most commonly used non-renewable resources. Renewable resources include solar, wind, hydro, and (possibly) biomass.
- A resource may take so much energy to harness that it doesn't provide much net energy.

## Making Connections



### MEDIA

Click image to the left for more content.

## Practice

Use this resource to answer the questions that follow.

<http://www.hippocampus.org/Earth%20Science> → Environmental Science → Search: **Renewable and Nonrenewable Energy**

1. What is nonrenewable energy?

2. What are fossil fuels?
3. What are the forms of renewable energy?
4. How does hydroelectric energy work?
5. What is the concern with hydroelectric energy?
6. What problem has been caused by the use of fossil fuels?
7. What are oil companies expecting to occur by 2050?

### Review

1. What does it mean that a form of energy might take more energy to harness than it provides?
2. Are renewable resources always renewable, or can they become nonrenewable?
3. Why aren't renewable resources used for everything that we use energy for?

---

### References

1. Image copyright Chee-Onn Leong, 2012. . Used under license from Shutterstock.com

## CHAPTER

## 4

## Energy Use

- Describe energy use in the U.S.
- Compare oil use in the U.S. and other top oil-using nations.



This woman in India uses a simple wood fire for cooking. For many people in the world, wood is their main energy resource. They burn it to stay warm as well as to cook their food. Other energy resources, such as oil or gas, are simply not available to them or are far too expensive for most people to use. However, if you live in the U.S. or another of the richer nations of the world, you probably depend almost totally on these more expensive energy resources, especially oil.

### Use of Energy Resources

Look at the circle graph in the **Figure 4.1**. It shows that oil is the single most commonly used energy resource in the U.S., followed by natural gas, and then by coal. All of these energy resources are nonrenewable. Nonrenewable resources are resources that are limited in supply and cannot be replaced as quickly as they are used up. Renewable resources, in contrast, provide only 8 percent of all energy used in the U.S. Renewable resources are natural resources that can be replaced in a relatively short period of time or are virtually limitless in supply. They include solar energy from sunlight, geothermal energy from under Earth's surface, wind, biomass (from once-living things or their wastes), and hydropower (from running water).

### Oil Use by Nation

People in the U.S. use far more energy from oil than people in any other nation. The bar graph in the **Figure 4.2** compares the amount of oil used by the top ten oil-using nations. The U.S. uses more oil than several other top-ten countries combined. If you also consider the population size in these countries, the differences are even more stunning. The average person in the U.S. uses a whopping 23 barrels of oil a year! In comparison, the average person in India or China uses just 1 or 2 barrels of oil a year. At the following URL, you can explore energy use per person in the U.S. and other countries or regions of the world over the past 50 years.

## U.S. Energy Consumption by Energy Source, 2011

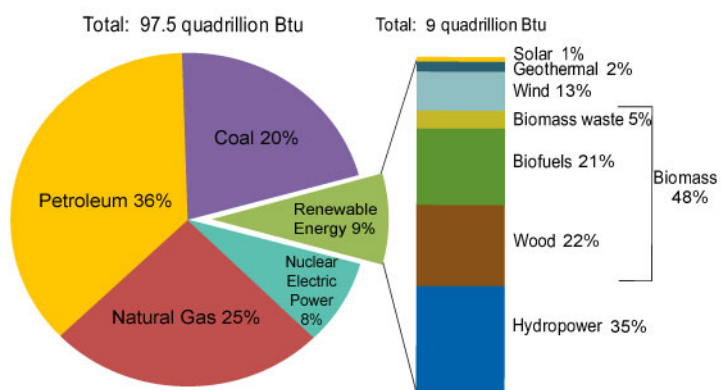


FIGURE 4.1

Source: U.S. Energy Information Administration, *Monthly Energy Review*, Table 10.1 (March 2012), preliminary 2011 data.

[http://www.google.com/publicdata/explore?ds=d5bncppjof8f9\\_&met\\_y=eg\\_use\\_pcap\\_kg\\_oe&idim=country:USA&dl=en&hl=en&q=energy+use](http://www.google.com/publicdata/explore?ds=d5bncppjof8f9_&met_y=eg_use_pcap_kg_oe&idim=country:USA&dl=en&hl=en&q=energy+use)

### Oil Use (Barrels per Day) in the Top Ten Oil-Consuming Nations

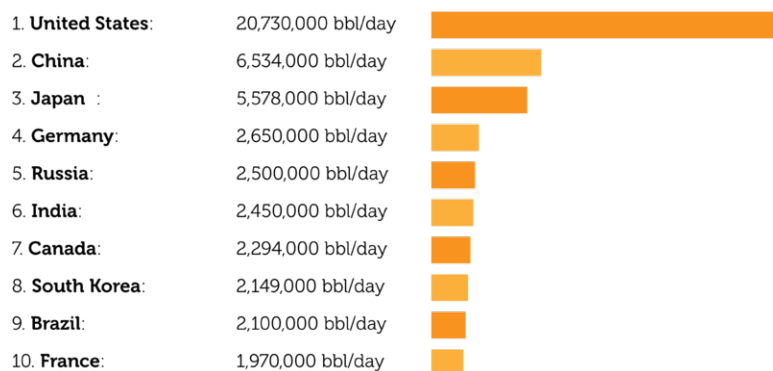


FIGURE 4.2

**Q:** How does the use of oil and other fossil fuels relate to pollution?

**A:** Greater use of oil and other fossil fuels causes more pollution.

**Q:** How do people in the U.S. use all that energy?

**A:** You can find out at the following URL. <http://needtoknow.nas.edu/energy/energy-use/>

## Summary

- Oil is the single most commonly used energy resource in the U.S., followed by natural gas, and then by coal. These are all nonrenewable energy resources. Only 8 percent of all energy used in the U.S. comes from renewable energy resources, such as solar, wind, and biomass energy.
- People in the U.S. use far more energy per personenergy from oilpeople in any other nation.

## Vocabulary

- **nonrenewable resource:** Anything people can use that comes from nature.
- **renewable resource:** Natural resource that can be replaced in a relatively short period of time or is virtually limitless in supply.

## Practice

At the following URL, find the ranking of the U.S. in total energy use and in the use of each of the major energy resources. Make a table to summarize the information.

<http://yearbook.enerdata.net/#/2010-energy-consumption-data.html>

## Review

1. Outline the use of energy resources in the U.S.
2. Compare the use of oil in the U.S. with oil use in other nations.

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## References

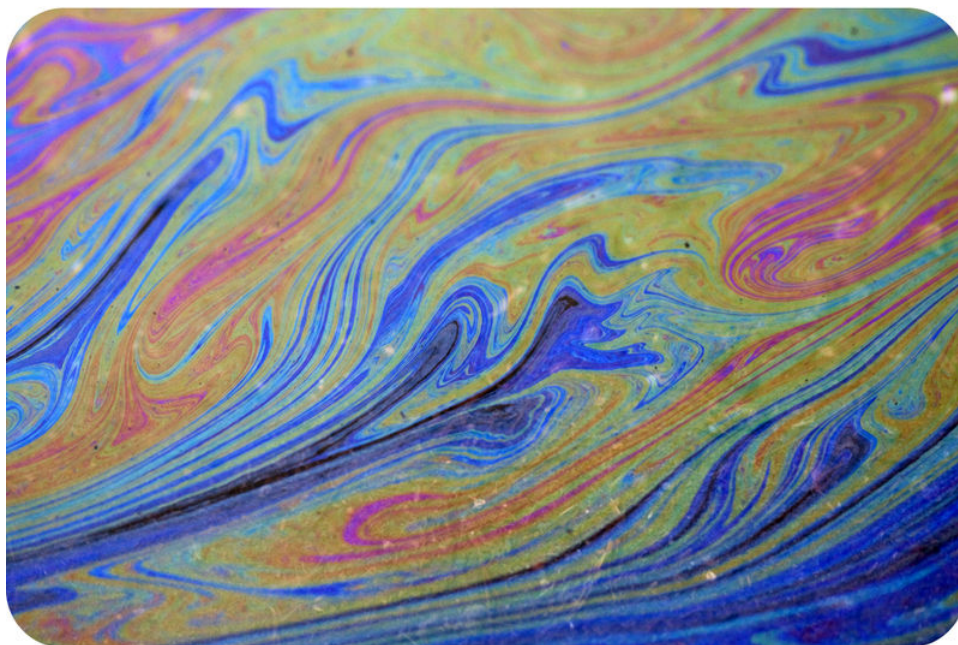
1. . . public domain
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## CHAPTER

## 5

# Non-Renewable Energy Resources

- Define nonrenewable resource.
- Identify nonrenewable energy resources.
- State drawbacks of using nonrenewable energy resources.



It may look beautiful, but this oil slick threatens the environment and living things. Unfortunately, oil spills are common because we rely heavily on oil as an energy resource. Oil is an example of a nonrenewable resource.

## What Are Nonrenewable Resources?

**Nonrenewable resources** are natural resources that are limited in supply and cannot be replaced as quickly as they are used up. A natural resource is anything people can use that comes from nature. Energy resources are some of the most important natural resources because everything we do requires energy. Nonrenewable energy resources include fossil fuels such as oil and the radioactive element uranium.

## Types of Fossil Fuels

Oil, or petroleum, is one of several **fossil fuels**. Fossil fuels are mixtures of hydrocarbons (compounds containing only hydrogen and carbon) that formed over millions of years from the remains of dead organisms. In addition to oil, they include coal and natural gas. Fossil fuels provide most of the energy used in the world today. They are burned in power plants to produce electrical energy, and they also fuel cars, heat homes, and supply energy for many other purposes. You can see some ways they are used in the **Figure 5.1**. For a more detailed introduction to fossil fuels, go to this URL: [http://www.ecokids.ca/pub/eco\\_info/topics/energy/ecostats/index.cfm](http://www.ecokids.ca/pub/eco_info/topics/energy/ecostats/index.cfm)

**Q:** Why do fossil fuels have energy?

**A:** Fossil fuels contain stored chemical energy that came originally from the sun.

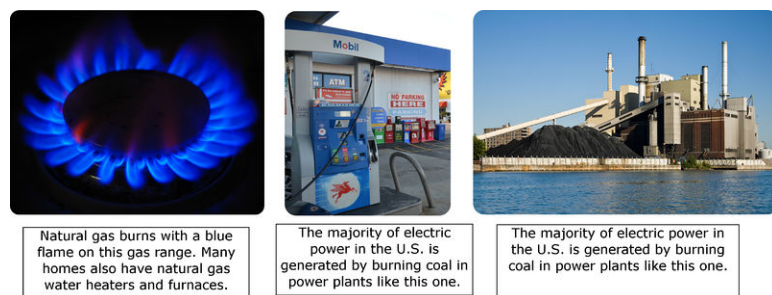


FIGURE 5.1

## How Fossil Fuels Formed

When ancient plants underwent photosynthesis, they changed energy in sunlight to stored chemical energy in food. The plants used the food and so did the organisms that ate the plants. After the plants and other organisms died, their remains gradually changed to fossil fuels as they were covered and compressed by layers of sediments. Petroleum and natural gas formed from ocean organisms and are found together. Coal formed from giant tree ferns and other swamp plants.

## Fossil Fuels and the Environment

When fossil fuels burn, they release thermal energy, water vapor, and carbon dioxide. The thermal energy can be used to generate electricity or do other work. The carbon dioxide is released into the atmosphere and is a major cause of global climate change. The burning of fossil fuels also releases many pollutants into the air. Pollutants such as sulfur dioxide form acid rain, which kills living things and damages metals, stonework, and other materials. Pollutants such as nitrogen oxides cause smog, which is harmful to human health. Tiny particles, or particulates, released when fossil fuels burn also harm human health.

The **Table 5.2** shows the amounts of pollutants released by different fossil fuels. Natural gas releases the least pollution; coal releases the most. Petroleum has the additional risk of oil spills, which may seriously damage ecosystems. To learn about other ways that our dependence on fossil fuels damages the environment and threatens human life, watch the video at this URL: <http://coal.wiki.lovett.org/Home>

**Q:** Some newer models of cars and other motor vehicles can run on natural gas. Why would a natural gas vehicle be better for the environment than a vehicle that burns gasoline, which is made from oil?

**A:** Natural gas produces much less pollution and carbon dioxide when it burns than gasoline does. So a natural gas vehicle would contribute less to global climate change, acid rain, and air pollution that harms health. Besides being better for the environment, burning natural gas instead of gasoline results in less engine wear and provides more energy for a given amount of fuel.

## Nuclear Energy

Like fossil fuels, the radioactive element uranium can be used to generate electrical energy in power plants. This source of energy is known as **nuclear energy**. In a nuclear power plant, the nuclei of uranium atoms are split apart into smaller nuclei in the process of nuclear fission. This process releases a tremendous amount of energy from just a small amount of uranium. The total supply of uranium in the world is quite limited, however, and cannot be replaced once it is used up. That's why nuclear energy is a nonrenewable resource. The use of nuclear energy also produces dangerous radioactive wastes. In addition, accidents at nuclear power plants have the potential to release large amounts of harmful radiation into the environment.

## Fossil Fuel Pollution Levels

Pounds per Billion Units of Energy

Pollutant	Natural Gas	Oil	Coal
Carbon Dioxide	117,000	164,000	208,000
Carbon Monoxide	40	33	208
Nitrogen Oxides	92	448	457
Sulfur Dioxide	1	1,122	2,591
Particulates	7	84	2,744
Mercury	0	0.007	0.016

FIGURE 5.2

**Q:** Why is nuclear energy often considered to be “greener” than energy from fossil fuels?

**A:** Unlike energy from fossil fuels, nuclear energy doesn’t produce air pollution or carbon dioxide that contributes to global climate change.

### Summary

- Nonrenewable resources are natural resources that are limited in supply and cannot be replaced as quickly as they are used up. Nonrenewable energy resources include fossil fuels and uranium.
- Fossil fuel, oil, natural gas, and coal most of the energy used in the world today. Burning fossil fuels produces air pollution as well as carbon dioxide that causes global climate change.
- Nuclear energy is produced by splitting the nuclei of radioactive uranium. This doesn’t release air pollution or carbon dioxide, but it does produce dangerous radioactive wastes.

### Vocabulary

- **fossil fuel:** Mixture of hydrocarbons that formed over millions of years from the remains of dead organisms (petroleum, natural gas, or coal).
- **natural resource:** Anything people can use that comes from nature.
- **nonrenewable resource:** Natural resource that is limited in supply and cannot be replaced except over millions of years.
- **nuclear energy:** Energy released in a nuclear reaction (nuclear fission or nuclear fusion).

### Practice

At the following URL, do the word search puzzle for nonrenewable energy resources. [http://www.softschools.com/science/words/games/word\\_search888.html](http://www.softschools.com/science/words/games/word_search888.html)

## Review

1. Define natural resource. What are nonrenewable natural resources?
2. List four commonly used nonrenewable energy resources.
3. Explain how fossil fuels formed.
4. Compare and contrast the three types of fossil fuels in terms of the pollution they produce.
5. Present the pros and cons of nuclear energy use.

---

## References

1. Left: C.A. Muller; Center: Joe Shlabotnik; Right: James M Phelps, Jr. . Left: CC-BY-NC-SA 2.0; Center: CC-BY-NC-SA 2.0; Right: Used under license from Shutterstock.com
2. . . CC-BY-NC-SA

## CHAPTER

## 6

# Fossil Fuel Formation

- Describe the formation of fossil fuels.



## What exactly is powering this car?

There was an old ad suggesting that you put a tiger in your tank was referring to the strength and speed of these wild cats. But it might also have been referring to the use of organic material to power an engine. When your tank is full of gas, it doesn't have a tiger in it, but it does have ancient plants, plankton, and other formerly living creatures. Not a pegasus though!

## Formation of Fossil Fuels

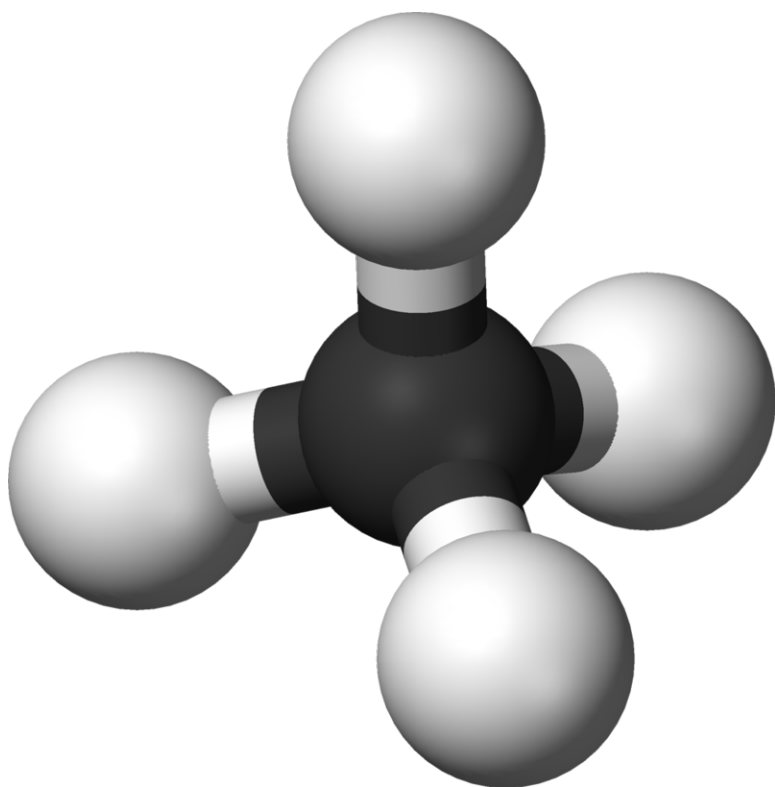
Can you name some fossils? How about dinosaur bones or dinosaur footprints? Animal skeletons, teeth, shells, coprolites (otherwise known as feces), or any other remains or traces from a living creature that becomes rock is a **fossil**.

The same processes that formed these fossils also created some of our most important energy resources, **fossil fuels**. Coal, oil, and natural gas are fossil fuels. Fossil fuels come from living matter starting about 500 million years ago. Millions of years ago, plants used energy from the Sun to form sugars, carbohydrates, and other energy-rich carbon compounds. As plants and animals died, their remains settled on the ground on land and in swamps, lakes, and seas (**Figure 6.1**).

Over time, layer upon layer of these remains accumulated. Eventually, the layers were buried so deeply that they were crushed by an enormous mass of earth. The weight of this earth pressing down on these plant and animal remains created intense heat and pressure. After millions of years of heat and pressure, the material in these layers turned into chemicals called **hydrocarbons** (**Figure 6.2**). An animated view of a hydrocarbon is seen here: [http://www.nature.nps.gov/GEOLOGY/usgsnps/oilgas/CH4\\_3.MPG](http://www.nature.nps.gov/GEOLOGY/usgsnps/oilgas/CH4_3.MPG).

**FIGURE 6.1**

This wetland may look something like an ancient coal-forming swamp.

**FIGURE 6.2**

Hydrocarbons are made of carbon and hydrogen atoms. This molecule with one carbon and four hydrogen atoms is methane.

Hydrocarbons can be solid, liquid, or gaseous. The solid form is what we know as coal. The liquid form is petroleum, or crude oil. Natural gas is the gaseous form.

The solar energy stored in fossil fuels is a rich source of energy. Although fossil fuels provide very high quality energy, they are non-renewable.

## Summary

- Hydrocarbons are molecules made of one carbon and four hydrogen atoms.
- Ancient living organisms are buried quickly and altered by intense heat and pressure to form fossil fuels.
- Fossil fuels include solid coal, liquid petroleum, and liquid natural gas.

## Practice

Use this resource to answer the questions that follow.

<http://www.youtube.com/watch?v=XoyqQgmwY9E>



### MEDIA

Click image to the left for more content.

1. What is natural gas and crude oil made from?
2. Why are these products called fossil fuels?
3. What type of environment did the microorganisms live in?
4. What covered the organisms?
5. What is bio-genesis?
6. How were the biotic materials cooked?

## Review

1. Why are coal, petroleum, and natural gas called fossil fuels?
2. How do fossil fuels form?
3. What is the actual source of energy in a fossil fuel?

---

## References

1. Image copyright Ramunas Bruzas, 2010. . Used under license from Shutterstock.com
2. Benjah-bmm27. Ball and stick model of methane. Public Domain

# CHAPTER 7

## Coal Power

- Explain how coal forms and is used.
- Describe the environmental consequences of burning coal.



### What was the foundation of the Industrial Revolution?

The Industrial Revolution was the change in society that resulted from people learning to use fossil fuels. By harnessing fossil fuels, work could be done more rapidly and more cheaply, allowing people to manufacture goods cheaply and efficiently.

### Coal

**Coal**, a solid fossil fuel formed from the partially decomposed remains of ancient forests, is burned primarily to produce electricity. Coal use is undergoing enormous growth as the availability of oil and natural gas decreases and cost increases. This increase in coal use is happening particularly in developing nations, such as China, where coal is cheap and plentiful.

Coal is black or brownish-black. The most common form of coal is bituminous, a sedimentary rock that contains impurities such as sulfur (**Figure 7.1**). Anthracite coal has been metamorphosed and is nearly all carbon. For this reason, anthracite coal burns more cleanly than bituminous coal.

**FIGURE 7.1**

Bituminous coal is a sedimentary rock.

## Coal Formation

Coal forms from dead plants that settled at the bottom of ancient swamps. Lush coal swamps were common in the tropics during the Carboniferous period, which took place more than 300 million years ago (**Figure 7.2**). The climate was warmer then.

Mud and other dead plants buried the organic material in the swamp, and burial kept oxygen away. When plants are buried without oxygen, the organic material can be preserved or fossilized. Sand and clay settling on top of the decaying plants squeezed out the water and other substances. Millions of years later, what remains is a carbon-containing rock that we know as coal.

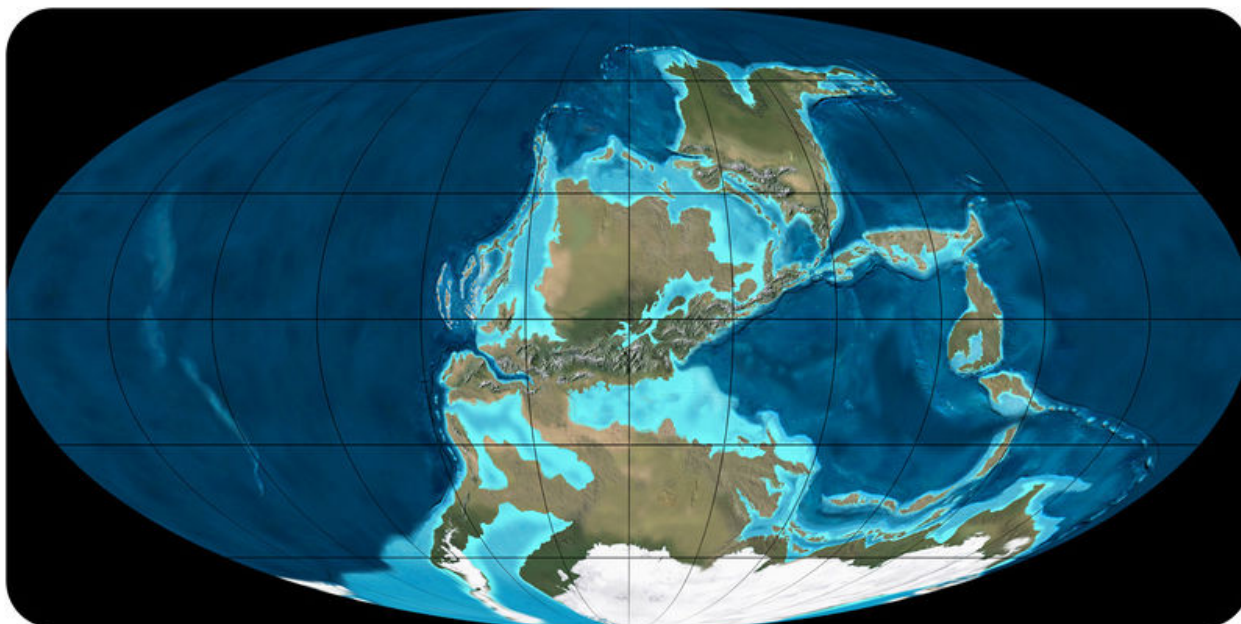
## Coal Use

Around the world, coal is the largest source of energy for electricity. The United States is rich in coal (**Figure 7.3**). California once had a number of small coal mines, but the state no longer produces coal. To turn coal into electricity, the rock is crushed into powder, which is then burned in a furnace that has a boiler. Like other fuels, coal releases its energy as heat when it burns. Heat from the burning coal boils the water in the boiler to make steam. The steam spins turbines, which turn generators to create electricity. In this way, the energy stored in the coal is converted to useful energy like electricity.

## Consequences of Coal Use

For coal to be used as an energy source, it must first be mined. Coal mining occurs at the surface or underground by methods that are described in the “Concept Materials of Earth’s Crust” (**Figure 7.4**). Mining, especially underground mining, can be dangerous. In April 2010, 29 miners were killed at a West Virginia coal mine when gas that had accumulated in the mine tunnels exploded and started a fire.

Coal mining exposes minerals and rocks from underground to air and water at the surface. Many of these minerals contain the element sulfur, which mixes with air and water to make sulfuric acid, a highly corrosive chemical. If the

**FIGURE 7.2**

The location of the continents during the Carboniferous period. Notice that quite a lot of land area is in the region of the tropics.

sulfuric acid gets into streams, it can kill fish, plants, and animals that live in or near the water.

### Summary

- Coal is solid fossil fuels formed primarily from ancient swamp plants, especially during the Carboniferous.
- Coal is the source of most electricity.
- Coal mining may bring dangerous materials into the air and coal burning is sometimes quite dirty.

### Practice

Use this resource to answer the questions that follow.

<http://science.discovery.com/videos/how-do-they-do-it-coal-mining.html>

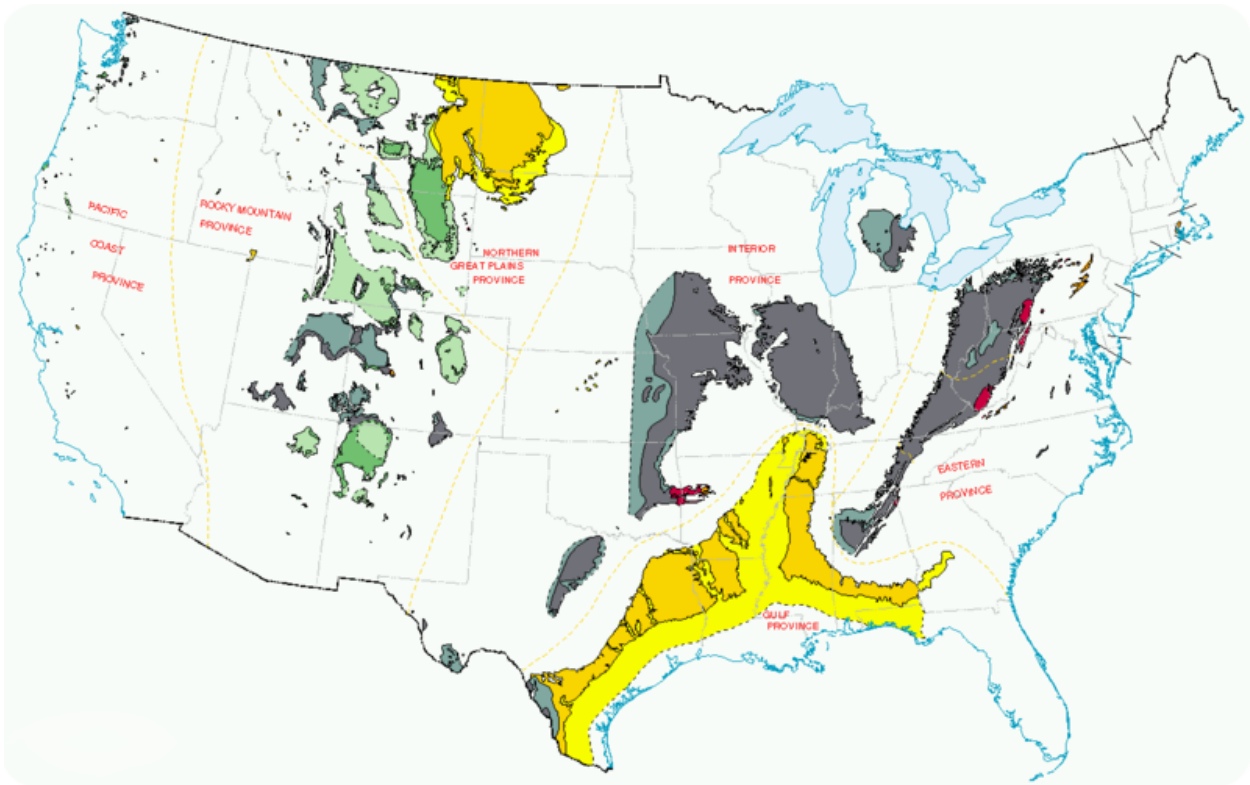


Multimedia

#### MEDIA

Click image to the left for more content.

1. How much electricity is produced from coal?
2. Where is the largest underground coal mining complex?



**FIGURE 7.3**

United States coal-producing regions in 1996. Orange is highest grade anthracite; red is low volatile bituminous; gray and gray-green is medium to high-volatile bituminous; green is subbituminous; and yellow is the lowest grade lignite.

3. How much coal does it produce?
4. How long have they been mining at this site?
5. What is a continuous miner?
6. How is the coal processed?
7. What waste is produced?
8. How quickly is the coal processed?

## Review

1. How does coal form?
2. There are swamps today. Why is coal not a renewable resource?
3. What are some of the environmental consequences of coal use?



Coal being mined by mountaintop removal.



A small coal-fired power plant in Utah.

---

**FIGURE 7.4**

The coal used in power plants must be mined. One method to mine coal is by mountaintop removal.

---

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## References

1. Courtesy of the US Geological Survey and the Mineral Information Institute. Bituminous coal. Public Domain
2. Dr. Ron Blakey. Map showing the continents during the Carboniferous period. CC-BY-SA 3.0
3. Courtesy of the US Geological Survey. US coal producing regions in 1996. Public Domain
4. (a) JW Randolph; (b) David Jolley (Staplegunther). Coal being mined by mountaintop removal. (a) Public Domain; (b) GNU-FDL 1.2

## CHAPTER

## 8

# Petroleum Power

- Explain how petroleum forms and is used.
- Describe the environmental consequences of petroleum use.



## What is the connection between ancient swamps and the Indy 500?

Many forms of fun and transportation are made possible by liquid petroleum. Petroleum is the result of plants dying in ancient swamps.

## Oil

**Oil** is a liquid fossil fuel that is extremely useful because it can be transported easily and can be used in cars and other vehicles. Oil is currently the single largest source of energy in the world.

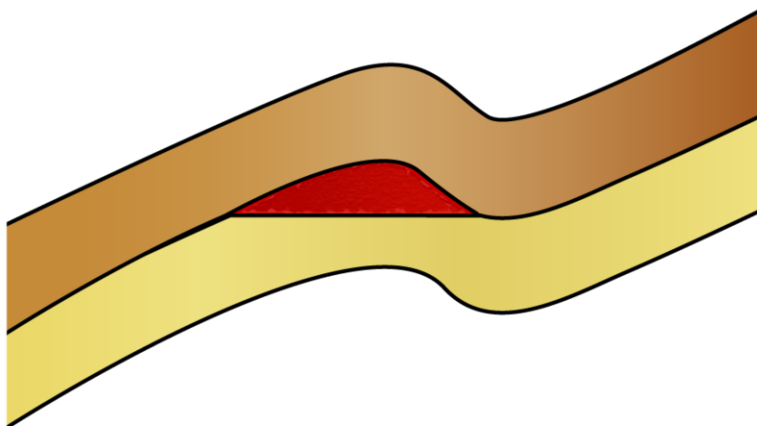
## Oil Formation

Oil from the ground is called **crude oil**, which is a mixture of many different hydrocarbons. Crude oil is a thick dark brown or black liquid hydrocarbon. Oil also forms from buried dead organisms, but these are tiny organisms that live on the sea surface and then sink to the seafloor when they die. The dead organisms are kept away from oxygen by layers of other dead creatures and sediments. As the layers pile up, heat and pressure increase. Over millions of years, the dead organisms turn into liquid oil.

## Oil Production

In order to be collected, the oil must be located between a porous rock layer and an impermeable layer (**Figure 8.1**). Trapped above the porous rock layer and beneath the impermeable layer, the oil will remain between these layers until it is extracted from the rock.

- An animation of an oil deposit forming is shown here: [http://www.nature.nps.gov/GEOLOGY/usgsnps/oilgas/ENTRAP\\_3.MPG](http://www.nature.nps.gov/GEOLOGY/usgsnps/oilgas/ENTRAP_3.MPG).

**FIGURE 8.1**

Oil (red) is found in the porous rock layer (yellow) and trapped by the impermeable layer (brown). The folded structure has allowed the oil to pool so a well can be drilled into the reservoir.

- The oil pocket is then drilled into from the surface. An animation of an oil deposit being drilled is shown here: [http://www.nature.nps.gov/GEOLOGY/usgsnps/oilgas/DRILL\\_3.MPG](http://www.nature.nps.gov/GEOLOGY/usgsnps/oilgas/DRILL_3.MPG).
- Sideways drilling allows a deposit that lies beneath land that cannot be drilled to be mined for oil: [http://www.nature.nps.gov/GEOLOGY/usgsnps/oilgas/HORDRI\\_3.MPG](http://www.nature.nps.gov/GEOLOGY/usgsnps/oilgas/HORDRI_3.MPG).

To separate the different types of hydrocarbons in crude oil for different uses, the crude oil must be refined in refineries like the one shown in **Figure 8.2**. Refining is possible because each hydrocarbon in crude oil boils at a different temperature. When the oil is boiled in the refinery, separate equipment collects the different compounds.

**FIGURE 8.2**

Refineries like this one separate crude oil into many useful fuels and other chemicals.

## Oil Use

Most of the compounds that come out of the refining process are fuels, such as gasoline, diesel, and heating oil. Because these fuels are rich sources of energy and can be easily transported, oil provides about 90% of the energy used for transportation around the world. The rest of the compounds from crude oil are used for waxes, plastics, fertilizers, and other products.

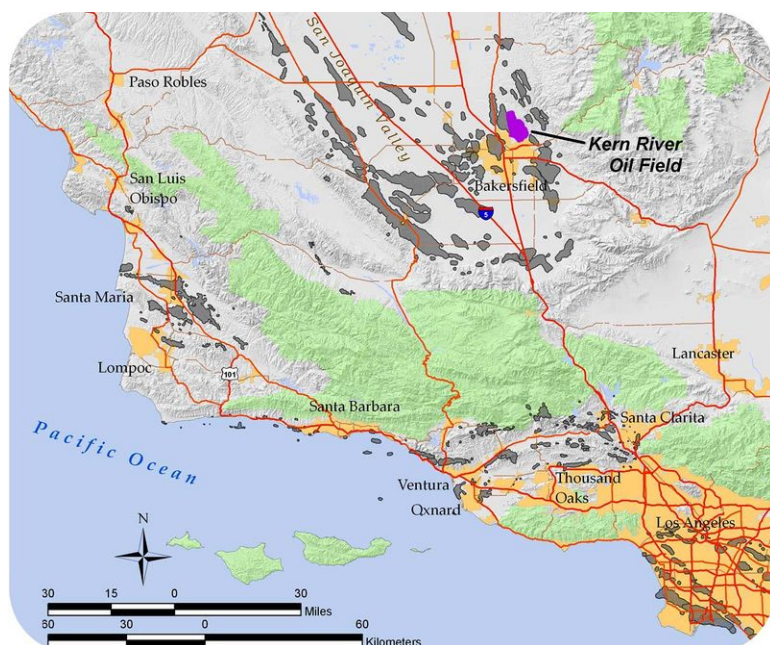
Gasoline is in a convenient form for use in cars and other transportation vehicles. In a car engine, the burned gasoline mostly turns into carbon dioxide and water vapor. The fuel releases most of its energy as heat, which causes the

gases to expand. This creates enough force to move the pistons inside the engine and to power the car.

## Consequences of Oil Use

The United States does produce oil, but the amount produced is only about one-quarter as much as the nation uses. The United States has only about 1.5% of the world's proven oil reserves, so most of the oil used by Americans must be imported from other nations.

The main oil-producing regions in the United States are the Gulf of Mexico, Texas, Alaska, and California (**Figure 8.3**). An animation of the location of petroleum basins in the contiguous United States can be seen here: [http://www.nature.nps.gov/GEOLOGY/usgsnps/oilgas/BASINS\\_3.MPG](http://www.nature.nps.gov/GEOLOGY/usgsnps/oilgas/BASINS_3.MPG).



**FIGURE 8.3**

Most of California's oil fields, such as the Kern River, are in the southern San Joaquin Valley. Oil collects in permeable sedimentary rocks from the top of folds like the one shown above.

As in every type of mining, mining for oil has environmental consequences. Oil rigs are unsightly (**Figure 8.4**), and spills are too common (**Figure 8.5**).

## Summary

- Liquid fossil fuels include petroleum, which is useful for vehicles because it is easily stored and transported.
- Petroleum is also extremely important for materials like waxes, plastics, fertilizers, and other products.
- Extracting petroleum from the ground and transporting it can be damaging to the environment.

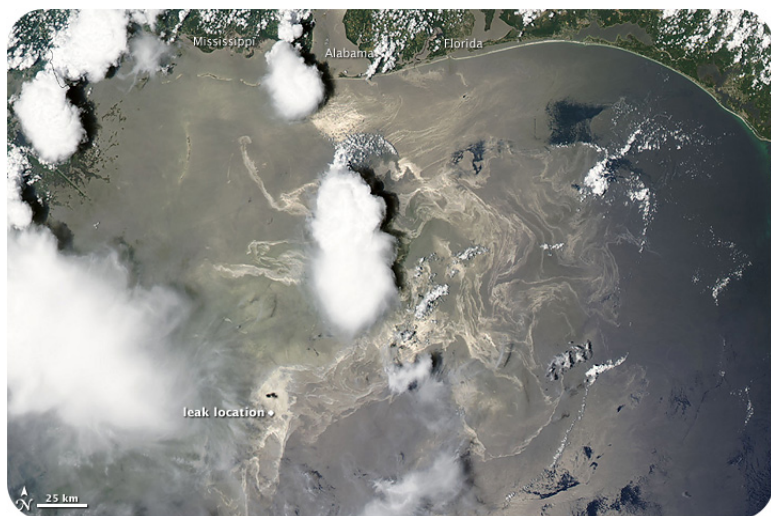
## Practice

Use this resource to answer the questions that follow.

<http://www.youtube.com/watch?v=rgrUwPWjj2Q>

**FIGURE 8.4**

Drill rigs at the Kern River Oil Field in California.

**FIGURE 8.5**

A deadly explosion on an oil rig in the Gulf of Mexico in April 2010 led to a massive oil spill. When this picture was taken in July 2010, oil was still spewing into the Gulf. The long-term consequences of the spill are being studied and are as yet unknown.



#### MEDIA

Click image to the left for more content.

1. What produced the fossil fuels?
2. What is sediment?

3. What is kerogen? How is it produced?
4. How do we find oil?
5. How do we get the oil out of the ground?
6. Why is drilling mud pumped down the pipe?
7. What are cuttings?
8. What does the pumping unit do?
9. What happens at the refinery?
10. What does fractional distillation produce?
11. What are petrochemicals used for?
12. What other products are made from oil?

## Review

1. Why is it harder to find a substitute for petroleum than it is for coal? Think about what these fuels are used for.
2. Why are there more likely to be hazardous consequences for deep oil drilling than for the shallow drilling that's been taking place for centuries?
3. How is crude oil formed?

---

## References

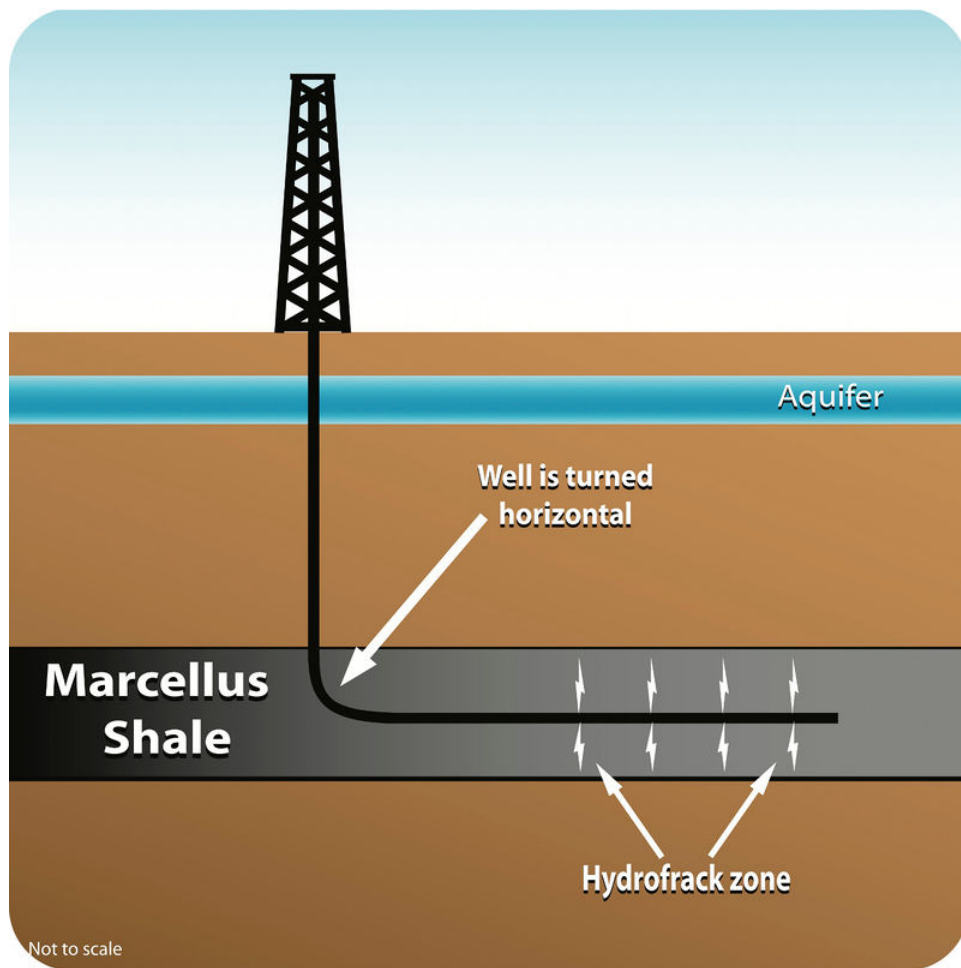
1. Oceanh, modified by CK-12 Foundation. Anticlinal structural trap - trapping oil between rock layers. CC-BY 3.0
2. Leonard G.. . CC-SA 1.0
3. Antandrus. . GNU-FDL 1.2
4. Antandrus. Drill rigs at Kern River Oil Field, California. GNU-FDL 1.2
5. Courtesy of MODIS Rapid Response Team/NASA's Earth Observatory. Gulf of Mexico oil spill in April 2010. Public Domain

## CHAPTER

## 9

# Natural Gas Power

- Explain how natural gas forms and is used.
- Describe the consequences of natural gas extraction.



### What caused the recent earthquakes in Ohio and Oklahoma?

The process of extracting natural gas, known as fracking, injects liquid waste into deep wells. Coincidentally, locations where seismic activity is virtually unknown have begun to experience earthquakes. Is fracking related to earthquake activity? Many geologists think the link is undeniable.

### Natural Gas

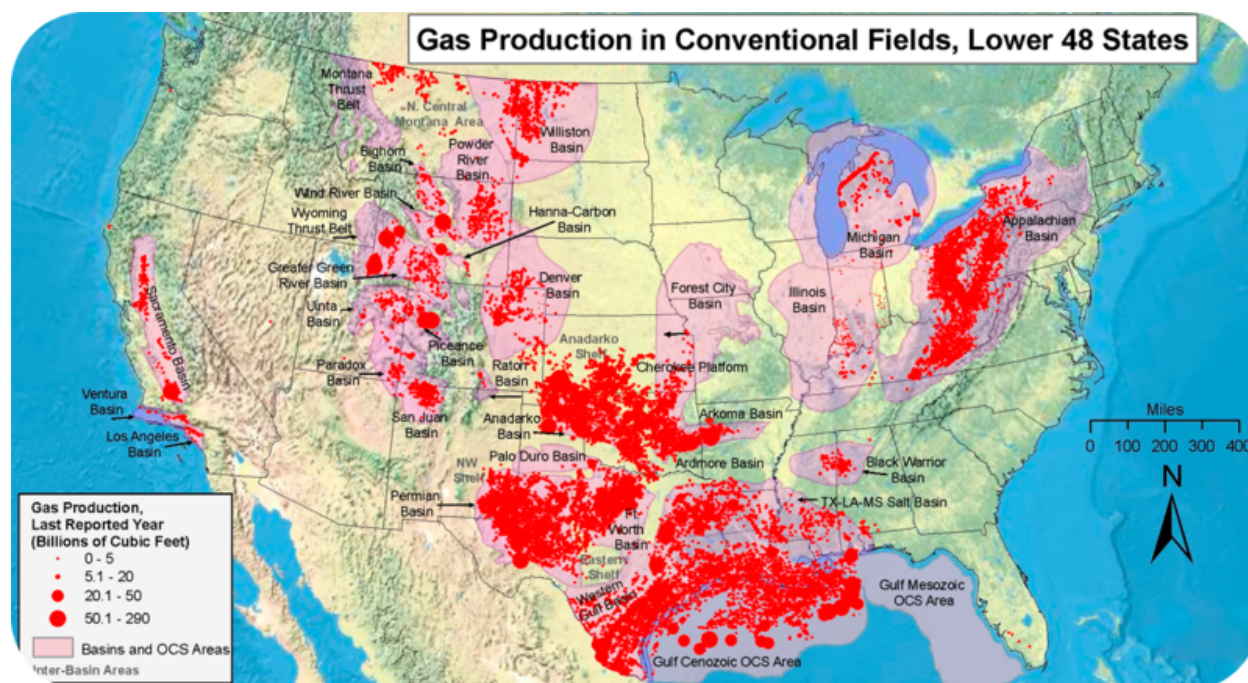
**Natural gas**, often known simply as gas, is composed mostly of the hydrocarbon methane. The amount of natural gas being extracted and used in the United States is increasing rapidly.

### Natural Gas Formation

Natural gas forms under the same conditions that create oil. Organic material buried in the sediments harden to become a shale formation that is the source of the gas. Although natural gas forms at higher temperatures than crude oil, the two are often found together.

The formation of an oil and gas deposit that can be mined is seen in this animation: [http://www.nature.nps.gov/GEOLOGY/usgsnps/oilgas/PETSYS\\_3.MPG](http://www.nature.nps.gov/GEOLOGY/usgsnps/oilgas/PETSYS_3.MPG).

The largest natural gas reserves in the United States are in the Appalachian Basin, Texas, and the Gulf of Mexico region (**Figure 9.1**). California also has natural gas, found mostly in the Central Valley. In the northern Sacramento Valley and the Sacramento Delta, a sediment-filled trough formed along a location where crust was pushed together (an ancient convergent margin).



**FIGURE 9.1**

Gas production in the lower 48 United States.

- An animation of global natural gas reserves is seen here: [http://www.nature.nps.gov/GEOLOGY/usgsnps/oilgas/GLOBE\\_3.MPG](http://www.nature.nps.gov/GEOLOGY/usgsnps/oilgas/GLOBE_3.MPG).

## Natural Gas Use

Like crude oil, natural gas must be processed before it can be used as a fuel. Some of the chemicals in unprocessed natural gas are poisonous to humans. Other chemicals, such as water, make the gas less useful as a fuel. Processing natural gas removes almost everything except the methane. Once the gas is processed, it is ready to be delivered and used. Natural gas is delivered to homes for uses such as cooking and heating. Like coal and oil, natural gas is also burned to generate heat for powering turbines. The spinning turbines turn generators, and the generators create electricity.

## Consequences of Natural Gas Use

Natural gas burns much cleaner than other fossil fuels, meaning that it causes less air pollution. Natural gas also produces less carbon dioxide than other fossil fuels do for the same amount of energy, so its global warming effects are less (**Figure 9.2**).



**FIGURE 9.2**

A natural gas drill rig in Texas.

- See the pollution created by a car burning gasoline and a car burning natural gas in this animation: [http://www.nature.nps.gov/GEOLOGY/usgsnps/oilgas/GASPOL\\_3.MPG](http://www.nature.nps.gov/GEOLOGY/usgsnps/oilgas/GASPOL_3.MPG).

Unfortunately, drilling for natural gas can be environmentally destructive. One technique used is hydraulic fracturing, also called **fracking**, which increases the rate of recovery of natural gas. Fluids are pumped through a borehole to create fractures in the reservoir rock that contains the natural gas. Material is added to the fluid to prevent the fractures from closing. The damage comes primarily from chemicals in the fracturing fluids. Chemicals that have been found in the fluids may be carcinogens (cancer-causing), radioactive materials, or endocrine disruptors, which interrupt hormones in the bodies of humans and animals. The fluids may get into groundwater or may runoff into streams and other surface waters. As noted above, fracking may cause earthquakes.

## Summary

- Natural gas forms with crude oil but at higher temperatures.
- Natural gas burns more cleanly than petroleum and produces fewer greenhouse gases.
- Hydraulic fracturing, known as fracking, is a relatively new method for extracting natural gas, which may be linked to groundwater contamination and the generation of small earthquakes in non-seismic regions.

## Practice

Use this resource to answer the questions that follow.

<http://www.youtube.com/watch?v=zmAwkYLEV80>



### MEDIA

Click image to the left for more content.

1. What is fracking?
2. Explain how natural gas is extracted.
3. What used to cause additional fracking?
4. What is the concern with fracking?
5. What law is the gas company exempted from?

## Review

1. You'll be hearing a lot about fracking in the coming years. What is it and how does it work?
2. How is natural gas different from crude oil and how does it form differently?
3. Why is natural gas considered more environmentally sound than other fossil fuels?

---

## References

1. Courtesy of the U.S. Energy Information Administration (April 2002). Map showing gas production in the Lower 48 United States. Public Domain
2. David R. Tribble (Loadmaster). Gas drill rig in Alvarado, Texas. CC-BY-SA 3.0

## CHAPTER

## 10

## Fossil Fuel Reserves

- Describe the limitations of traditional and alternative fossil fuels.

**How much is left?**

The answer to that question depends on what we as a society are willing to do to get fossil fuels. How much are we willing to damage the environment to extract and transport fossil fuels? How much are we willing to raise atmospheric greenhouse gas levels and further alter climate? The Keystone Pipeline would bring crude oil from tar sands to the U.S., but for the time being, that project is on hold.

**Fossil Fuel Reserves**

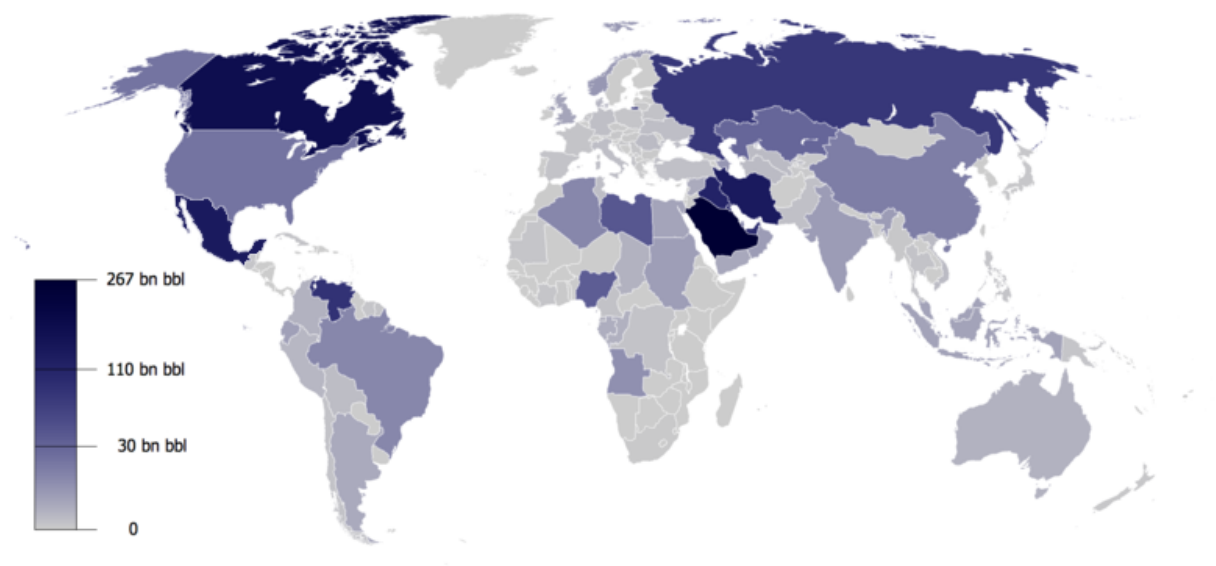
Fossil fuels provide about 85% of the world's energy at this time. Worldwide fossil fuel usage has increased many times over in the past half century (coal –2.6x, oil –8x, natural gas –14x) because of population increases, because of increases in the number of cars, televisions, and other fuel-consuming uses in the developed world, and because of lifestyle improvements in the developing world.

- Past and predicted use of different types of energy in the United States can be seen in this animation: [http://www.nature.nps.gov/GEOLOGY/usgsnps/oilgas/MAXGAS\\_3.MPG](http://www.nature.nps.gov/GEOLOGY/usgsnps/oilgas/MAXGAS_3.MPG).

The amount of fossil fuels that remain untapped is unknown, but can likely be measured in decades for oil and natural gas and in a few centuries for coal (**Figure 10.1**).

**Alternative Fossil Fuels**

As the easy-to-reach fossil fuel sources are depleted, alternative sources of fossil fuels are increasingly being exploited (**Figure 10.2**). These include oil shale and tar sands. **Oil shale** is rock that contains dispersed oil that has not collected in reservoirs. To extract the oil from the shale requires enormous amounts of hot water. **Tar sands**

**FIGURE 10.1**

Worldwide oil reserves.

**FIGURE 10.2**

A satellite image of an oil-sands mine in Canada.

are rocky materials mixed with very thick oil. The tar is too thick to pump and so tar sands are strip-mined. Hot water and caustic soda are used to separate the oil from the rock.

The environmental consequences of mining these fuels, and of fossil fuel use in general, along with the fact that these fuels do not have a limitless supply, are prompting the development of alternative energy sources in some regions.

## Summary

- Easy to get at fossil fuels are running out, but there are other sources that are harder to get at that are still available.
- Oil shales and tar sands are two of the alternative sources of fossil fuels that are much in the news.
- The need for fossil fuels continues to grow as people in the developed world use more and more people in the developing world want them.

## Practice

Use this resource to answer the questions that follow.

<http://www.youtube.com/watch?v=6MJQOyeRvBc>



### MEDIA

Click image to the left for more content.

1. How much oil shale is there in the United States?
2. How much oil can be produced from oil shale?
3. Where is the Green River Formation?
4. What is oil shale?
5. How many barrels does OSEC plan to produce each day?

## Review

1. What are oil shales and tar sands?
2. How do scientists and politicians determine how much fossil fuel is left? Why is this number undoubtedly inaccurate?
3. Why is the need for fossil fuels increasing?

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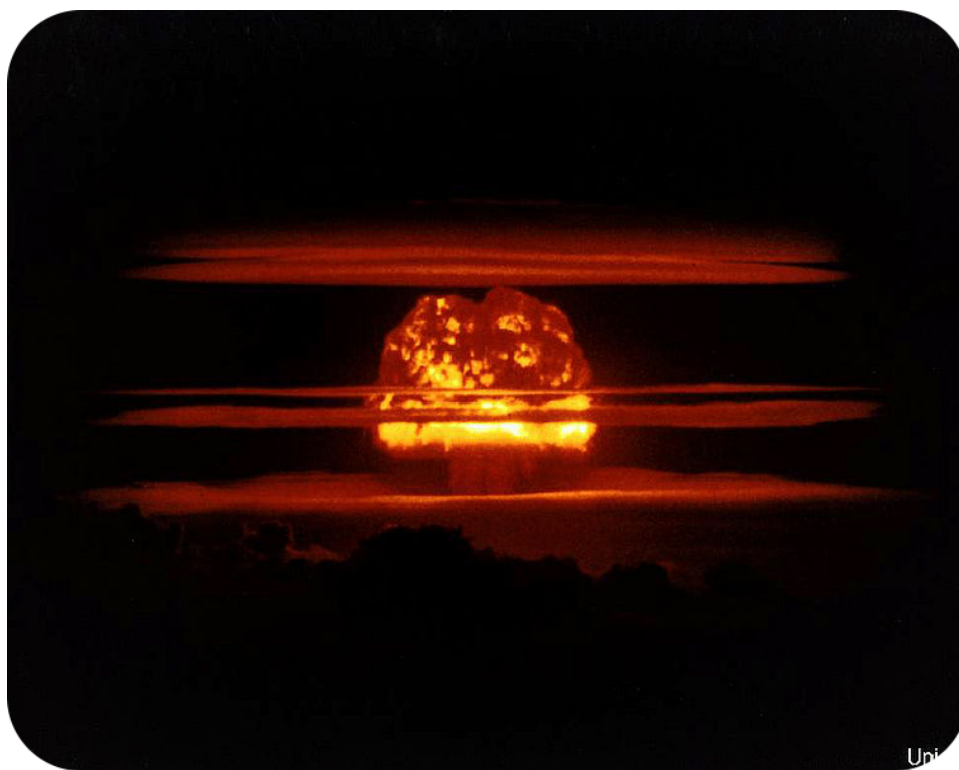
## References

1. H&R. Worldwide oil reserves. Public Domain
2. Courtesy of NASA's Earth Observatory. . Public Domain

# CHAPTER 11

## Nuclear Power

- Explain how nuclear energy is harnessed and used, and describe its consequences.



### What does an atomic bomb have to do with energy generation?

Splitting atoms releases enormous amounts of energy. To be useful rather than destructive, nuclear power plants must be safeguarded, but this attempt is not always successful.

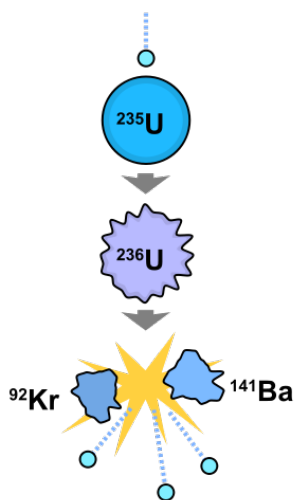
### Nuclear Energy

When the nucleus of an atom is split, it releases a huge amount of energy called **nuclear energy**. For nuclear energy to be used as a power source, scientists and engineers have learned to split nuclei and to control the release of energy (**Figure 11.1**).

### Nuclear Energy Use

Nuclear power plants, such as the one seen in **Figure 11.2**, use uranium, which is mined, processed, and then concentrated into fuel rods. When the uranium atoms in the fuel rods are hit by other extremely tiny particles, they split apart. The number of tiny particles allowed to hit the fuel rods needs to be controlled, or they would cause a dangerous explosion. The energy from a nuclear power plant heats water, which creates steam and causes a turbine to spin. The spinning turbine turns a generator, which in turn produces electricity.

Many countries around the world use nuclear energy as a source of electricity. In the United States, a little less than 20% of electricity comes from nuclear energy.

**FIGURE 11.1**

When struck by a tiny particle, Uranium-235 breaks apart and releases energy.

**FIGURE 11.2**

Nuclear power plants like this one provide France with almost 80% of its electricity.

## Consequences of Nuclear Power

Nuclear power is clean. It does not pollute the air. However, the use of nuclear energy does create other environmental problems. Uranium must be mined (**Figure 11.3**). The process of splitting atoms creates radioactive waste, which remains dangerous for thousands or hundreds of thousands of years. As yet, there is no long-term solution for storing this waste.

The development of nuclear power plants has been on hold for three decades. Accidents at Three Mile Island and Chernobyl, Ukraine verified people's worst fears about the dangers of harnessing nuclear power (**Figure 11.4**).

Recently, nuclear power appeared to be making a comeback as society looked for alternatives to fossil fuels. After all, nuclear power emits no pollutants, including no greenhouse gases. But the 2011 disaster at the Fukushima Daiichi Nuclear Power Plant in Japan may have resulted in a new fear of nuclear power. The cause of the disaster was a 9.0 magnitude earthquake and subsequent tsunami, which compromised the plant. Although a total meltdown was averted, the plant experienced multiple partial meltdowns, core breaches, radiation releases, and cooling failures. The plant is scheduled for a complete cold shutdown before the end of 2011.

Nuclear power is a controversial subject in California and most other places. Nuclear power has no pollutants



**FIGURE 11.3**

Uranium mine near Moab, Utah.



**FIGURE 11.4**

Damaged building near the site of the Chernobyl disaster.

including carbon emissions, but power plants are not always safe and the long-term disposal of wastes is a problem that has not yet been solved. The future of nuclear power is murky.

Find out more at <http://science.kqed.org/quest/audio/new-nuclear/>.



**MEDIA**

Click image to the left for more content.

## Summary

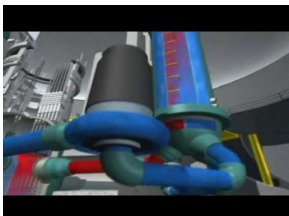
- Nuclear energy is released when the nucleus of an atom is split.
- Nuclear power plants use uranium in fuel rods, which later become nuclear waste. Nuclear waste can be dangerous for hundreds of thousands of years.

- Periodic accidents involving nuclear power plants seem to slow down the development of nuclear power in many countries.

## Practice

Use this resource to answer the questions that follow.

<http://www.youtube.com/watch?v=VJf1bBDR3e8>



### MEDIA

Click image to the left for more content.

1. How many countries use nuclear power?
2. What is used to produce the electricity in the power plant?
3. What releases the heat in nuclear plants?
4. What is used as the fuel?
5. What are the two types of reactors?
6. What is the function of the control rods?

## Review

1. How is nuclear energy generated?
2. Since the waste from nuclear power plants is dangerous for up to hundreds of thousands of years, how do you think it should be safeguarded?
3. Do you think that the nuclear disaster in Japan in 2011 should affect how nations develop or choose not to develop their nuclear resources? What about nations that are not near a subduction zone?

---

## References

1. Fastfission. Illustration of nuclear fission. Public Domain
2. Stefan Kühn. . CC-BY-SA 2.5
3. Qfl247. Uranium mine near Moab, Utah. CC-BY-SA 3.0
4. Image copyright Sergey Kamshylin, 2010. . Used under license from Shutterstock.com

# CHAPTER 12

## Renewable Energy Resources

- Define renewable resource.
- Describe several renewable energy resources.



Acre upon acre of wind turbines stretch over the landscape in this photo. The blades of the turbines spin in the wind like giant pinwheels. The energy of the moving blades is used to generate useful electrical energy. Wind is one of several renewable energy resources.

**Q:** What are some other renewable energy resources?

**A:** You can read about the major renewable energy resources in this article. But here's a hint in advance. Renewable energy resources include mechanical, electromagnetic, chemical, and thermal forms of energy.

### What Are Renewable Resources?

**Renewable resources** are natural resources that can be replaced in a relatively short period of time or are virtually limitless in supply. In addition to wind, renewable energy resources include sunlight, moving water, biomass, and geothermal energy. All of these resources are freely available and won't run out. Most of them also have the advantage of producing little if any pollution or carbon dioxide, which contributes to global climate change. Nonetheless, these energy resources are used far less than nonrenewable energy resources, especially fossil fuels. You can see where renewable energy resources are used in the U.S., as well as learn more about them, at this URL: [http://www.nationalatlas.gov/articles/people/a\\_energy.html](http://www.nationalatlas.gov/articles/people/a_energy.html)

### Wind

Wind is moving air, so it has mechanical energy that can do work. People have been using wind for energy for thousands of years. The old-fashioned windmill in the **Figure 12.1** is one way that wind energy can be used. The

wind turbines in the opening photo above are a much newer way of using wind energy. They change the kinetic energy of the wind to electrical energy. However, only certain areas of the world get enough steady wind to produce much electricity. Many people also think that wind turbines are noisy, dangerous to birds, and unattractive in the landscape. At the URL below, you can watch a video about the development of wind energy in China, which aims to become a world leader in renewable energy production.

<http://www.guardian.co.uk/world/2012/mar/19/china-windfarms-renewable-energy>



**FIGURE 12.1**

This old windmill uses wind energy to operate a mechanical pump that lifts water out of a well. Windmills like this one have been used for centuries.

**Q:** Where does the energy of the wind come from? Why does air move in the atmosphere?

**A:** Wind is caused by unequal heating of the atmosphere by the sun. In other words, differences in thermal energy cause air to move in the atmosphere.

## Sunlight

The sunlight that reaches Earth is the planet's most important source of energy. The energy in sunlight, called solar energy, is electromagnetic energy. This is a form of energy that travels through space in electric and magnetic waves. Solar energy can be used to heat homes and produce electricity in solar cells like those on the roof seen in the **Figure 12.2**. Sunny areas receive plenty of sunlight to generate electricity, but solar energy may not be practical in areas that are often cloudy.



**FIGURE 12.2**

Solar panels on the roof of this family home generate enough electricity to supply the family's needs.

**Q:** In addition to the roofs of homes and other buildings, where else can you find solar cells? **A:** Calculators often have solar cells. Solar-powered outdoor lights are very common as well.

## Moving Water

The mechanical energy of rapidly flowing water can turn a turbine and generate electricity. Electricity produced in this way is called hydroelectric power. The water may flow over a waterfall or through a dam. You can see a picture of a dam in the **Figure** below. A drawback of dams is that they flood land upstream from the dam and reduce water flow downstream from the dam, and this can destroy ecosystems. At the following URL, you can learn more about hydroelectric power and see an animation of a hydroelectric power plant.

<http://ga.water.usgs.gov/edu/hyhowworks.html>



**FIGURE 12.3**

This is Hoover dam on the Colorado River between Arizona and Nevada. Water flowing through the dam generates electricity for both of these states and southern California.

**Q:** Does a hydroelectric power plant release air pollution or carbon dioxide? Why or why not.

**A:** No, it doesn't. A hydroelectric plant doesn't burn fuel, which is what produces air pollution in power plants that generate electricity from fossil fuels or biomass.

## Biomass

The stored chemical energy in organic matter or wastes is called biomass energy. The organic matter may be trees or other plants, or it may be wastes from homes and industries. When biomass is burned, it produces thermal energy that can be used for heating homes, cooking, or generating electricity. Biomass is an important energy source in the poorer nations where most people can't afford fossil fuels. However, burning biomass releases air pollution and contributes to global climate change. Biomass can be used to make ethanol, a fuel that is added to gasoline. Although ethanol releases less pollution than gasoline, large areas of land are needed to grow the plants needed to make it (see **Figure 12.4**). This reduces the amount of land available for food production.



**FIGURE 12.4**

This large machine is harvesting and grinding plants to make ethanol.

## Geothermal Energy

Geothermal energy is thermal (“heat”) energy from below Earth’s surface. It can be used to heat homes or generate electricity. A geothermal system pumps water underground where it is heated and then pumps the warm water back to the home or power plant (see **Figure 12.5**). The thermal energy of the water can be used directly to heat the home. Or it can be used to produce steam and generate electricity. Installing a geothermal system can be expensive because of the need to drill through underground rocks, but the energy it uses is free.

## Summary

- Renewable resources are natural resources that can be replaced in a relatively short period of time or are virtually limitless in supply.
- Renewable energy resources include wind, sunlight, moving water, biomass, and geothermal energy. Except for biomass, which is burned, these renewable energy resources produce little if any pollution, although each has other drawbacks.

## Vocabulary

- **renewable resource:** Natural resource that can be replaced in a relatively short period of time or is virtually limitless in supply.

**FIGURE 12.5**

This power plant uses geothermal energy.

## Practice

At the following URL, play the renewable energy resources vocabulary game. Be sure to read the definition of each renewable energy resource.

## Review

1. What is a renewable resource?
2. List five renewable energy sources. What form of energy does each resource supply?
3. Choose one of the five renewable energy resources described in this article, and do a Web quest to learn more about it. Start your search at the URL below. Based on your research, make a list of main points about the energy source you chose.

<http://www.aresearchguide.com/energy.html>

---

## References

1. Brent Danley. . CC-BY-NC-SA 2.0
2. Mike Spasoff. . CC-BY 2.0
3. L. Richard Martin Jr.. . CC-BY 2.0
4. International Maize and Wheat Improvement Center. . CC-BY-NC-SA 2.0
5. ThinkGeoEnergy. . CC-BY 2.0

# CHAPTER 13

## Solar Power

- Explain how solar energy is collected and used.



Since so much of the energy we use came ultimately from the Sun, why don't we just get our power directly from the Sun?

That's a good question. Can you answer it?

### Solar Energy

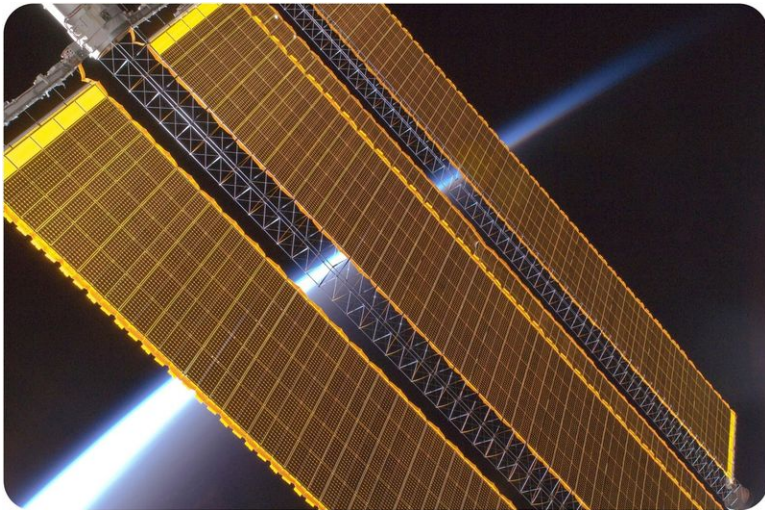
Energy from the Sun comes from the lightest element, hydrogen, fusing together to create the second lightest element, helium. Nuclear fusion on the Sun releases tremendous amounts of solar energy. The energy travels to the Earth, mostly as visible light. The light carries the energy through the empty space between the Sun and the Earth as **radiation**.

### Solar Power Use

Solar energy has been used for power on a small scale for hundreds of years, and plants have used it for billions of years. Unlike energy from fossil fuels, which almost always come from a central power plant or refinery, solar power can be harnessed locally (**Figure 13.1**). A set of solar panels on a home's rooftop can be used to heat water for a swimming pool or can provide electricity to the house.

Society's use of solar power on a larger scale is just starting to increase. Scientists and engineers have very active, ongoing research into new ways to harness energy from the Sun more efficiently. Because of the tremendous amount of incoming sunlight, solar power is being developed in the United States in southeastern California, Nevada, and Arizona.

Solar power plants turn sunlight into electricity using a large group of mirrors to focus sunlight on one place, called a receiver (**Figure 13.2**). A liquid, such as oil or water, flows through this receiver and is heated to a high temperature by the focused sunlight. The heated liquid transfers its heat to a nearby object that is at a lower temperature through a process called **conduction**. The energy conducted by the heated liquid is used to make electricity.

**FIGURE 13.1**

Solar panels supply power to the International Space Station.

**FIGURE 13.2**

This solar power plant uses mirrors to focus sunlight on the tower in the center. The sunlight heats a liquid inside the tower to a very high temperature, producing energy to make electricity.

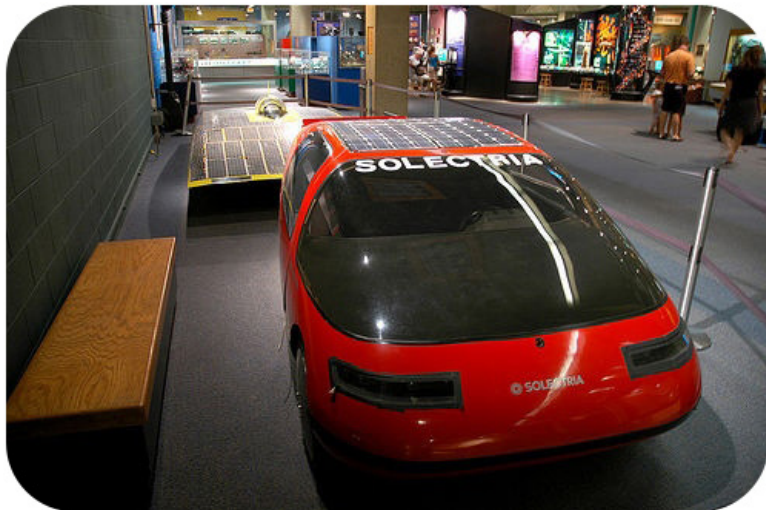
A video of how solar energy can be concentrated so that it can be used for power: [http://www1.eere.energy.gov/multimedia/video\\_csp.html](http://www1.eere.energy.gov/multimedia/video_csp.html).

### Consequences of Solar Power Use

Solar energy has many benefits. It is extremely abundant, widespread, and will never run out. But there are problems with the widespread use of solar power.

- Sunlight must be present. Solar power is not useful in locations that are often cloudy or dark. However, storage technology is being developed.

- The technology needed for solar power is still expensive. An increase in interested customers will provide incentive for companies to research and develop new technologies and to figure out how to mass-produce existing technologies (**Figure 13.3**).
- Solar panels require a lot of space. Fortunately, solar panels can be placed on any rooftop to supply at least some of the power required for a home or business.

**FIGURE 13.3**

This experimental car is one example of the many uses that engineers have found for solar energy.

## Summary

- Solar energy is the result of nuclear fusion in our nearest star.
- A liquid is heated and moves that energy by conduction.
- Solar power is expensive, but as demand increases technology improves and costs decrease.

## Practice

Use this resource to answer the questions that follow.

[https://www.eeremultimedia.energy.gov/solar/videos/solar\\_power\\_basics](https://www.eeremultimedia.energy.gov/solar/videos/solar_power_basics)

1. What does solar power do for the planet?
2. What is diffuse light?
3. Explain passive solar heating.
4. What is solar thermal energy used for?
5. Explain how concentrating solar power works.
6. How do photovoltaic panels work?
7. What are the advantages of photovoltaic panels?
8. List the advantages to using solar power.

## Review

1. How is solar power collected on a large scale?

2. What are some of the downsides of depending on solar energy?
3. What are some of the positive sides of using solar energy?

---

## References

1. Courtesy of NASA. Solar array panels on International Space Station. Public Domain
2. affloresm. . CC-BY 2.0
3. Daniel Borman (borman818). . CC-BY 2.0

# CHAPTER 14

## Hydroelectric Power

- Explain how energy from falling water is harnessed for hydroelectric power.
- Describe the consequences of hydroelectric power use.



### Did the idea for the first dam come from beavers?

Beavers have been building dams for a long time, for food, for a home, and for protection from predators. They probably haven't realized that they can use a dam for hydroelectric power, although are we sure there aren't little TVs in those lodges?

### Water Power

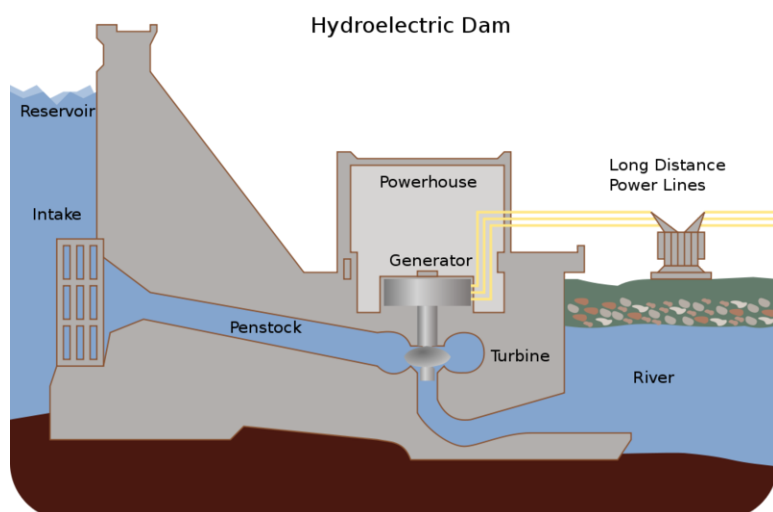
Water covers 70% of the planet's surface, and water power (hydroelectric power) is the most widely used form of renewable energy in the world. Hydroelectric power from streams provides almost one fifth of the world's electricity.

### Hydroelectric Power

Remember that potential energy is the energy of an object waiting to fall. Water held behind a dam has a lot of potential energy.

In a hydroelectric plant, a dam across a riverbed holds a stream to create a reservoir. Instead of flowing down its normal channel, the water is allowed to flow into a large turbine. As the water moves, it has kinetic energy, which makes the turbine spin. The turbine is connected to a generator, which makes electricity (**Figure 14.1**).

Most of the streams in the United States and elsewhere in the developed world that are suitable for hydroelectric power have already been dammed. In California, about 14.5% of the total electricity comes from hydropower. The state's nearly 400 hydropower plants are mostly located in the eastern mountain ranges, where large streams descend down a steep grade.

**FIGURE 14.1**

A cross-section of a hydroelectric plant.

## Consequences of Water Power Use

The major benefit of hydropower is that it generates power without releasing any pollution. Hydropower is also a renewable resource since the stream will keep on flowing. However, there are a limited number of suitable dam sites. Hydropower also has environmental problems. When a large dam disrupts a river's flow, it changes the ecosystem upstream. As the land is flooded by rising water, plants and animals are displaced or killed. Many beautiful landscapes, villages, and archeological sites have been drowned by the water in a reservoir (**Figure 14.2**).

**FIGURE 14.2**

Glen Canyon Dam in Arizona created Lake Powell. The dam was controversial because it flooded Glen Canyon, a beautiful desert canyon.

The dam and turbines also change the downstream environment for fish and other living things. Dams slow the release of silt so that downstream deltas retreat and seaside cities become dangerously exposed to storms and rising sea levels.

## Ocean Water Power

The energy of waves and tides can be used to produce water power. Tidal power stations may need to close off a narrow bay or estuary. Wave power applications have to be able to withstand coastal storms and the corrosion of seawater. Because of the many problems with them, tide and wave power plants are not very common.

Although not yet widely used, many believe tidal power has more potential than wind or solar power for meeting alternative energy needs. Quest radio looks at plans for harnessing power from the sea by San Francisco and along the northern California coast.

Find out more at <http://science.kqed.org/quest/audio/harnessing-power-from-the-sea/>.



### MEDIA

Click image to the left for more content.

## Summary

- Hydroelectric power is clean and is important in many regions of the world.
- Hydropower has downsides like the changes dams make to a river's ecosystem.
- Hydropower utilizes the energy of falling water.

## Practice

Use this resource to answer the questions that follow.

<http://www.hippocampus.org/Earth%20Science> → Environmental Science → Search: **Hydroelectric Power**

1. How is hydroelectric power generated?
2. What does the height of the water determine?
3. How is the turbine rotated?
4. What are the advantages of hydroelectric power?
5. What are the disadvantages of hydroelectric power?

## Review

1. How does energy transition from one form to another as water moves from behind a dam to downstream of a dam?
2. Describe how hydroelectric energy is harnessed.
3. What are some of the downsides of using hydroelectric power?

---

## References

1. Tomia. . CC-BY-SA 2.5

2. Image Copyright Manamana, 2011. Glen Canyon Dam in Arizona created Lake Powell. Used under license from Shutterstock.com

# CHAPTER 15

## Wind Power

- Explain how wind energy is harnessed and used, and describe its consequences.



### What does "NIMBY" stand for?

Not in my backyard. As much as any type of power source, wind power pits people who are concerned about the environment against, well, people who are concerned about the environment. Some people want the benefits of clean wind power but don't want the turbines in their vicinity.

### Wind Energy

Energy from the Sun also creates wind, which can be used as wind power. The Sun heats different locations on Earth by different amounts. Air that becomes warm rises and then sucks cooler air into that spot. The movement of air from one spot to another along the ground creates wind. Since wind is moving, it has kinetic energy.

Wind power is the fastest growing renewable energy source in the world. Windmills are now seen in many locations, either individually or, more commonly, in large fields.

"Wind Powering America" follows the development of wind power in the United States over the past several years: [http://www.windpoweringamerica.gov/wind\\_installed\\_capacity.asp](http://www.windpoweringamerica.gov/wind_installed_capacity.asp).

### Wind Power Use

Wind is the source of energy for wind power. Wind has been used for power for centuries. For example, windmills were used to grind grain and pump water. Sailing ships traveled by wind power long before ships were powered by fossil fuels. Wind can be used to generate electricity, as the moving air spins a turbine to create electricity (**Figure 15.1**).

This animation shows how wind power works: [http://www.energysavers.gov/your\\_home/electricity/index.cfm/mytopic=10501](http://www.energysavers.gov/your_home/electricity/index.cfm/mytopic=10501).

**FIGURE 15.1**

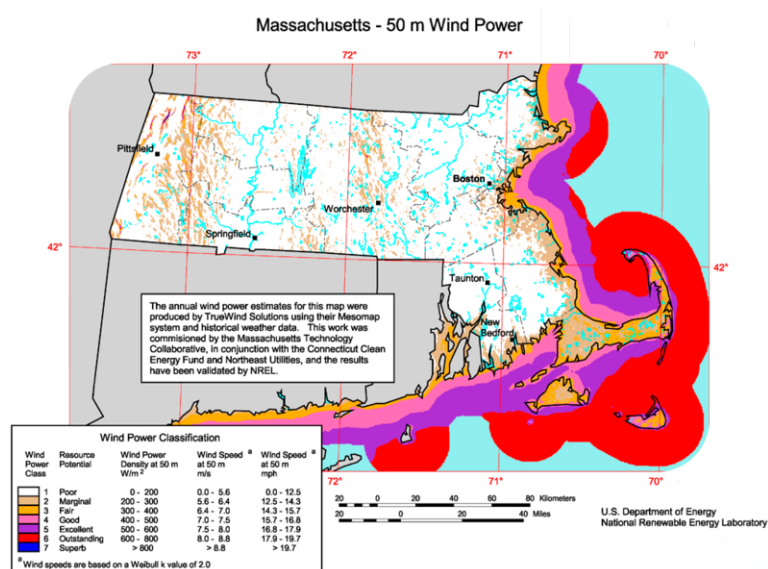
Wind turbines like the ones shown above turn wind into electricity without creating pollution.

## Consequences of Wind Power

Wind power has many advantages. It does not burn, so it does not release pollution or carbon dioxide. Also, wind is plentiful in many places. Wind, however, does not blow all of the time, even though power is needed all of the time. Just as with solar power, engineers are working on technologies that can store wind power for later use.

Windmills are expensive and wear out quickly. A lot of windmills are needed to power a region, so nearby residents may complain about the loss of a nice view if a wind farm is built. Coastlines typically receive a lot of wind, but wind farms built near beaches may cause unhappiness for local residents and tourists.

The Cape Wind project off of Cape Cod, Massachusetts has been approved but is generating much controversy. Opponents are in favor of green power but not at that location. Proponents say that clean energy is needed and the project would supply 75% of the electricity needed for Cape Cod and nearby islands (**Figure 15.2**).

**FIGURE 15.2**

Cape Wind off of Cape Cod in Massachusetts receives a great deal of wind (red color) but is also popular with tourists for its beauty.

California was an early adopter of wind power. Windmills are found in mountain passes, where the cooler Pacific Ocean air is sucked through on its way to warmer inland valleys. Large fields of windmills can be seen at Altamont Pass in the eastern San Francisco Bay Area, San Geronio Pass east of Los Angeles, and Tehachapi Pass at the

southern end of the San Joaquin Valley.

## Summary

- Wind contains energy, which can move a turbine and generate electricity.
- Wind power is clean and does not release greenhouse gases, but some people complain about the spread of windmills across certain locations.
- Wind has been used as a local energy source for centuries and is now being scaled up for use regionally.

## Practice

Use this resource to answer the questions that follow.

[http://www.energysavers.gov/your\\_home/electricity/index.cfm/mytopic=10501](http://www.energysavers.gov/your_home/electricity/index.cfm/mytopic=10501)

1. How much has wind power production increased in the United States?
2. How do wind turbines work?
3. What is the wind vane for?
4. What does an anemometer measure?
5. What is the yaw drive for?
6. What is the wind potential in your state?
7. What are the advantages of an off grid system?
8. What are the advantages of wind farms?

## Review

1. Describe what causes wind and how wind energy can be harnessed.
2. What are some of the downsides of using wind power?
3. Why do you think that wind is the fastest growing non-renewable energy source?

---

## References

1. Philipp Hertzog. . GNU-FDL 1.2
2. Courtesy of National Renewable Energy Laboratory/US Department of Energy. Cape Wind off of Cape Cod in Massachusetts. Public Domain

# CHAPTER 16

## Geothermal Power

- Explain how geothermal energy is harnessed and used.



### How could geothermal energy be used just about anywhere?

Geothermal energy comes from heat deep below the surface of the Earth. That heat may come to the surface naturally or it may be available through drilling. Nothing must be done to the geothermal energy. It is a resource that can be used without processing.

### Geothermal Energy

The heat that is used for geothermal power may come to the surface naturally as hot springs or geysers, like The Geysers in northern California. Where water does not naturally come to the surface, engineers may pump cool water into the ground. The water is heated by the hot rock and then pumped back to the surface for use. The hot water or steam from a geothermal well spins a turbine to make electricity.

Geothermal energy is clean and safe. The energy source is renewable since hot rock is found everywhere in the Earth, although in many parts of the world the hot rock is not close enough to the surface for building geothermal power plants. In some areas, geothermal power is common (**Figure 16.1**).

In the United States, California is a leader in producing geothermal energy. The largest geothermal power plant in the state is in the Geysers Geothermal Resource Area in Napa and Sonoma Counties. The source of heat is thought to be a large magma chamber lying beneath the area.

Where Earth's internal heat gets close to the surface, geothermal power is a clean source of energy. In California, The Geysers supplies energy for many nearby homes and businesses.

**FIGURE 16.1**

A geothermal energy plant in Iceland. Iceland gets about one fourth of its electricity from geothermal sources.

Find out more at <http://www.kqed.org/quest/television/geothermal-heats-up2>.

**MEDIA**

Click image to the left for more content.

## Summary

- Most geothermal energy being used now is in regions where hot material comes to the surface.
- Hot rocks are everywhere below Earth's surface so geothermal energy could be used anywhere with drilling.
- Geothermal energy is clean and does not release greenhouse gases.

## Practice

Use this resource to answer the questions that follow.

[http://www1.eere.energy.gov/geothermal/egs\\_animation.html](http://www1.eere.energy.gov/geothermal/egs_animation.html)

1. What is an enhanced geothermal system?
2. How is an appropriate site found?
3. What can occur where the fractures are created in the rock?
4. How is the heat extracted?
5. How can the system be expanded?
6. What is the future of geothermal energy?

## Review

1. How is geothermal energy harnessed?
2. How would it be possible for a geothermal plant to gather energy if the hot material was not located at the surface?
3. Why is geothermal energy becoming more popular?

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## References

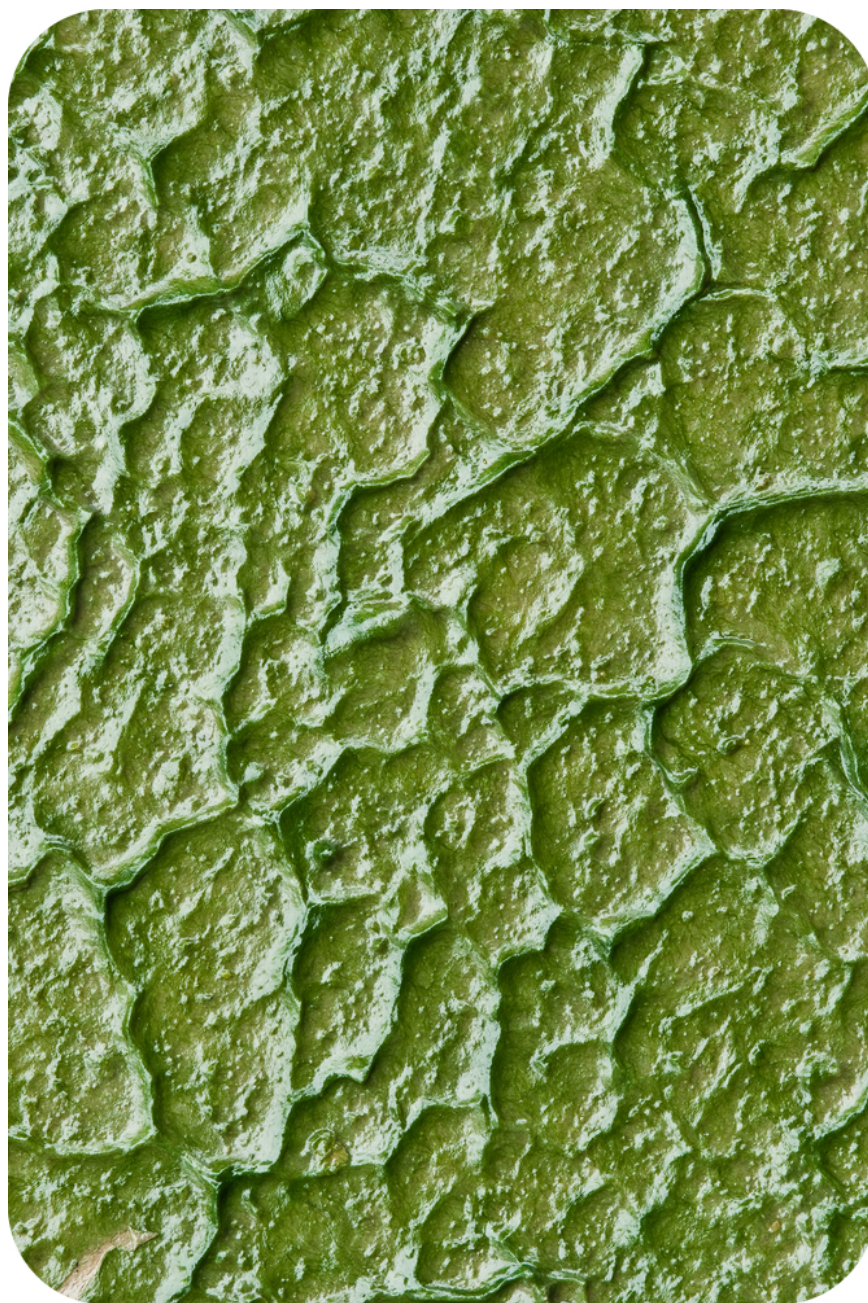
1. Gretar Ívarsson. A geothermal energy plant in Iceland. Public Domain

## CHAPTER

## 17

# Energy from Biomass

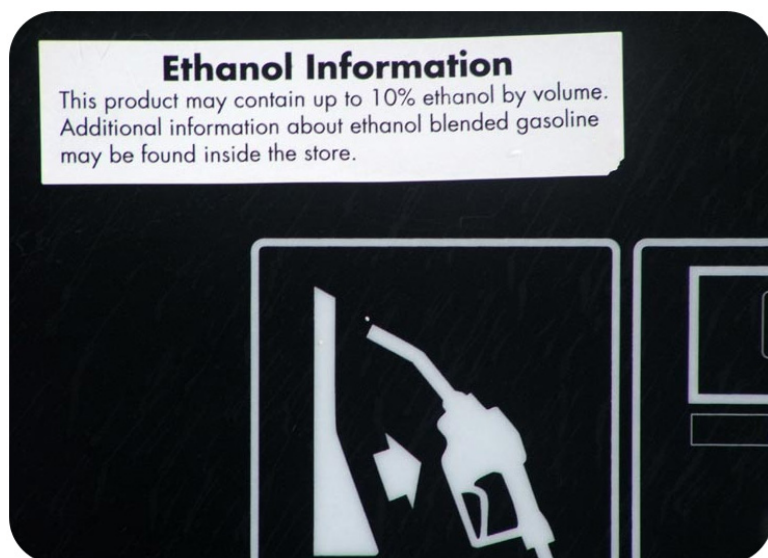
- Explain how biomass energy is harnessed and used, and describe its consequences.

**Why is algae better than corn for biofuel?**

Algae is a better alternative for producing biofuel than traditional crops because crops could be used for other things, like feeding people.

## Biomass

Biomass is the material that comes from plants and animals that were recently living. Biomass can be burned directly, such as setting fire to wood. For as long as humans have had fire, people have used biomass for heating and cooking. People can also process biomass to make fuel, called **biofuel**. Biofuel can be created from crops, such as corn or algae, and processed for use in a car (**Figure 17.1**). The advantage to biofuels is that they burn more cleanly than fossil fuels. As a result, they create less pollution and less carbon dioxide.



**FIGURE 17.1**

Biofuels, such as ethanol, are added to gasoline to cut down the amount of fossil fuels that are used.

Organic material, like almond shells, can be made into electricity. Biomass power is a great use of wastes and is more reliable than other renewable energy sources, but harvesting biomass energy uses energy and biomass plants produce pollutants including greenhouse gases.

Find out more at <http://science.kqed.org/quest/audio/how-green-is-biomass-energy/>.



### MEDIA

Click image to the left for more content.

Cow manure can have a second life as a source of methane gas, which can be converted to electricity. Not only that food scraps can also be converted into green energy.

Find out more at <http://science.kqed.org/quest/video/from-waste-to-watts-biofuel-bonanza/>.



### MEDIA

Click image to the left for more content.

Food that is tossed out produces methane, a potent greenhouse gas. But that methane from leftovers can be harnessed and used as fuel. Sounds like a win-win situation.

Find out more at <http://science.kqed.org/quest/audio/power-up-with-leftovers/>.

**MEDIA**

Click image to the left for more content.

## Consequences of Biomass Use

In many instances, the amount of energy, fertilizer, and land needed to produce the crops used make biofuels mean that they often produce very little more energy than they consume. The fertilizers and pesticides used to grow the crops run off and become damaging pollutants in nearby water bodies or in the oceans.

To generate biomass energy, break down the cell walls of plants to release the sugars and then ferment those sugars to create fuel. Corn is a very inefficient source; scientists are looking for much better sources of biomass energy.

See more at <http://www.kqed.org/quest/television/biofuels-beyond-ethanol>.

**MEDIA**

Click image to the left for more content.

## Algae Biofuels

Research is being done into alternative crops for biofuels. A very promising alternative is algae. Growing algae requires much less land and energy than crops. Algae can be grown in locations that are not used for other things, like in desert areas where other crops are not often grown. Algae can be fed agricultural and other waste so valuable resources are not used. Much research is being done to bring these alternative fuels to market. Many groups are researching the use of algae for fuel.

Many people think that the best source of biomass energy for the future is algae. Compared to corn, algae is not a food crop, it can grow in many places, it's much easier to convert to a usable fuel, and it's carbon neutral.

Find out more at <http://science.kqed.org/quest/video/algae-power/>.

**MEDIA**

Click image to the left for more content.

## Summary

- Biofuels are useful because they are liquid and can go into a gas tank unlike many other types of alternative energy.
- Algae is the focus of much research because it is a very promising alternative to traditional crops for biofuels.
- Biofuels have been used for as long as people have been burning wood for warmth or to cook their food.

## Practice

Use this resource to answer the questions that follow.



### MEDIA

Click image to the left for more content.

1. How much gas is produced from corn?
2. What was the Model T designed to run on?
3. Why are cell phones forbidden in the factory?
4. How much ethanol does the factory produce?
5. Is corn an efficient energy source? Explain your answer.

## Review

1. What are the advantages of algae over other sources of biofuels?
2. Why are some crops, like corn, not necessarily a good source of biofuels?
3. How can an energy source produce very little energy more than the energy it takes to produce it?

---

## References

1. Proximo.xv. Ethanol information sign in California. GNU-FDL 1.2

## CHAPTER

## 18

## Materials Humans Use

- Identify resources commonly consumed by human uses.

**What resources are in those electronics?**

Everyone may realize that we use resources like trees, copper, water, and gemstones, but how many of us realize the tremendous variety of elements we need to make a single electronic device? A tablet computer with a touch screen contains many common chemical elements and a variety of rare earth elements.

**Common Materials We Use from the Earth**

People depend on natural resources for just about everything that keeps us fed and sheltered, as well as for the things that keep us entertained. Every person in the United States uses about 20,000 kilograms (40,000 pounds) of minerals every year for a wide range of products, such as cell phones, TVs, jewelry, and cars. **Table 18.1** shows some common objects, the materials they are made from, and whether they are renewable or nonrenewable.

**TABLE 18.1: Common Objects We Use From the Earth**

Common Object	Natural Resources Used	Are These Resources Renewable or Nonrenewable?
Cars	15 different metals, such as iron, lead, and chromium to make the body.	Nonrenewable
Jewelry	Precious metals like gold, silver, and platinum. Gems like diamonds, rubies, emeralds, turquoise.	Nonrenewable
Electronic Appliances (TV's, computers, DVD players, cell phones, etc.)	Many different metals, like copper, mercury, gold.	Nonrenewable

**TABLE 18.1:** (continued)

Common Object	Natural Resources Used	Are These Resources Renewable or Nonrenewable?
Clothing	Soil to grow fibers such as cotton. Sunlight for the plants to grow. Animals for fur and leather.	Renewable
Food	Soil to grow plants. Wildlife and agricultural animals.	Renewable
Bottled Water	Water from streams or springs. Petroleum products to make plastic bottles.	Nonrenewable and Renewable
Gasoline	Petroleum drilled from wells.	Nonrenewable
Household Electricity	Coal, natural gas, solar power, wind power, hydroelectric power.	Nonrenewable and Renewable
Paper	Trees; Sunlight Soil.	Renewable
Houses	Trees for timber. Rocks and minerals for construction materials, for example, granite, gravel, sand.	Nonrenewable and Renewable

## Summary

- Many objects, such as a car, contain many types of resources.
- Resources may be renewable or nonrenewable, and an object may contain some of each.
- Rare earth elements and other unusual materials are used in some electronic devices.

## Practice

Use this resource to answer the questions that follow.

<http://www.bbc.co.uk/news/world-asia-pacific-13777439>

1. What products require rare earth elements?
2. What is neodymium used for?
3. What is lanthanum used for?
4. What is praseodymium used for?
5. What is cerium used to produce?
6. What is gadolinium used in?
7. What country controls 97% of the rare earth elements?
8. What is the largest rare earth mine in the world?
9. Why are rare earth elements difficult to extract?
10. What type of mines are used to extract rare earth elements?
11. How many tons of rare earth elements did China export in 2010?
12. Why is China now limiting their exports?

## Review

1. What resources are important to you that are renewable? Nonrenewable?
2. What resources do you use that you could use less or not use at all?
3. How might one of these resources go from being renewable to nonrenewable?

## CHAPTER

## 19

## Finding and Mining Ores

- Describe how ore deposits are located, mined, and refined to become useful materials.

**Why is the football team in San Francisco named the 49ers?**

Football team names sometimes reflect the history of a region. The San Francisco 49ers are a reference to the California Gold Rush, when immigrants from around the United States came to what would become The Golden State to mine placer deposits. What that has to do with football is anyone's guess!

**Ore Deposits**

Some minerals are very useful. An **ore** is a rock that contains minerals with useful elements. Aluminum in bauxite ore (**Figure 19.1**) is extracted from the ground and refined to be used in aluminum foil and many other products. The cost of creating a product from a mineral depends on how abundant the mineral is and how much the extraction and refining processes cost. Environmental damage from these processes is often not figured into a product's cost. It is important to use mineral resources wisely.

**Finding and Mining Minerals**

Geologic processes create and concentrate minerals that are valuable natural resources. Geologists study geological formations and then test the physical and chemical properties of soil and rocks to locate possible ores and determine their size and concentration.

A mineral deposit will only be mined if it is profitable. A concentration of minerals is only called an **ore deposit** if it is profitable to mine. There are many ways to mine ores.

**FIGURE 19.1**

Aluminum is made from the aluminum-bearing minerals in bauxite.

## Surface Mining

Surface mining allows extraction of ores that are close to Earth's surface. Overlying rock is blasted and the rock that contains the valuable minerals is placed in a truck and taken to a refinery. As pictured in **Figure 19.2**, surface mining includes open-pit mining and mountaintop removal. Other methods of surface mining include strip mining, placer mining, and dredging. Strip mining is like open pit mining but with material removed along a strip.



(a) The El Chino open-pit silver mine in New Mexico



(b) An aerial view of an open pit gold mine in Australia



(c) With mountaintop removal, everything lying above an ore deposit is just removed. This controversial mining technique is common in coal mining regions, such as Kentucky above.

**FIGURE 19.2**

These different forms of surface mining are methods of extracting ores close to Earth's surface.

**Placers** are valuable minerals found in stream gravels. California's nickname, the Golden State, can be traced back to the discovery of placer deposits of gold in 1848. The gold weathered out of hard metamorphic rock in the western Sierra Nevada, which also contains deposits of copper, lead, zinc, silver, chromite, and other valuable minerals. The

gold traveled down rivers and then settled in gravel deposits. Currently, California has active mines for gold and silver and for non-metal minerals such as sand and gravel, which are used for construction.

## Underground Mining

Underground mining is used to recover ores that are deeper into Earth's surface. Miners blast and tunnel into rock to gain access to the ores. How underground mining is approached—from above, below, or sideways—depends on the placement of the ore body, its depth, the concentration of ore, and the strength of the surrounding rock.

Underground mining is very expensive and dangerous. Fresh air and lights must also be brought into the tunnels for the miners, and accidents are far too common.



**FIGURE 19.3**  
Underground mine.

## Ore Extraction

The ore's journey to becoming a useable material is only just beginning when the ore leaves the mine (**Figure 19.4**). Rocks are crushed so that the valuable minerals can be separated from the waste rock. Then the minerals are separated out of the ore. A few methods for extracting ore are:

- heap leaching: the addition of chemicals, such as cyanide or acid, to remove ore.
- flotation: the addition of a compound that attaches to the valuable mineral and floats.
- smelting: roasting rock, causing it to segregate into layers so the mineral can be extracted.

To extract the metal from the ore, the rock is melted at a temperature greater than  $900^{\circ}\text{C}$ , which requires a lot of energy. Extracting metal from rock is so energy-intensive that if you recycle just 40 aluminum cans, you will save the energy equivalent of one gallon of gasoline.

## Summary

- An ore deposit must be profitable to mine by definition. If it is no longer profitable, it is no longer an ore deposit.

**FIGURE 19.4**

Enormous trucks haul rock containing ore from a mine site to where the rock is processed.

**FIGURE 19.5**

A steel mill.

- Surface mines are created for mineral deposits that are near the surface; underground mines are blasted into rock to get at deeper deposits.
- Ore is extracted from rock by heap leaching, flotation or smelting.

### Practice

Use this resource to answer the questions that follow.



## MEDIA

Click image to the left for more content.

1. What is the Superpit?
2. How large is the Superpit?
3. How is gold extracted from this mine?
4. What is Australia's rank in gold mining?
5. What minerals is Australia the leading country for?

## Review

1. What sorts of changes can transform a deposit that is an ore into a deposit that is not an ore?
2. Why is the production of the metal to create your aluminum soda can energy-intensive?
3. How is ore taken from a rock and made into a metal like a copper wire?

## References

1. Courtesy of US Geological Survey/Mineral Information Institute. . Public Domain
2. (a) Eric Guinther (Marshman); (b) Courtesy of Jesse Allen/NASA's Earth Observatory; (c) iLoveMountains.org; Composite created by CK-12 Foundation. Surface mining. (a) GNU-FDL 1.2; (b) Public Domain; (c) CC-BY 2.0
3. . . GNU-FDL 1.2
4. Nick Bonzey. . CC-BY-SA 2.0
5. Třinecké železářny. . The copyright holder of this file allows anyone to use it for any purpose provided that the copyright holder is properly attributed.

# CHAPTER 20

## Availability of Natural Resources

- Explain how factors such as abundance, price, and politics influence the availability and cost of resources.



### What is electronic waste?

We obtain resources of developing nations. We also dump waste on these nations. Many of our electronic wastes, which we think are being recycled, end up in developing countries. These are known as electronic waste or **e-waste**. People pick through the wastes looking for valuable materials that they can sell, but this exposes them to many toxic compounds that are hazardous to them and the environment.

### Resource Availability

#### Supply

From the table in the previous lesson you can see that many of the resources we depend on are nonrenewable. Nonrenewable resources vary in their availability; some are very abundant and others are rare. Materials, such as gravel or sand, are technically nonrenewable, but they are so abundant that running out is no issue. Some resources are truly limited in quantity: when they are gone, they are gone, and something must be found that will replace them. There are even resources, such as diamonds and rubies, that are valuable in part because they are so rare.

#### Price

Besides abundance, a resource's value is determined by how easy it is to locate and extract. If a resource is difficult to use, it will not be used until the price for that resource becomes so great that it is worth paying for. For example, the oceans are filled with an abundant supply of water, but desalination is costly, so it is used only where water is really limited (**Figure 20.1**). As the cost of desalination plants comes down, more will likely be built.

**FIGURE 20.1**

Tampa Bay, Florida, has one of the few desalination plants in the United States.

## Politics

Politics is also part of determining resource availability and cost. Nations that have a desired resource in abundance will often **export** that resource to other countries, while countries that need that resource must **import** it from one of the countries that produces it. This situation is a potential source of economic and political trouble.

Of course the greatest example of this is oil. 11 countries have nearly 80% of all of the world's oil (**Figure 20.2**). However, the biggest users of oil, the United States, China, and Japan, are all located outside this oil-rich region. This leads to a situation in which the availability and price of the oil is determined largely by one set of countries that have their own interests to look out for. The result has sometimes been war, which may have been attributed to all sorts of reasons, but at the bottom, the reason is oil.

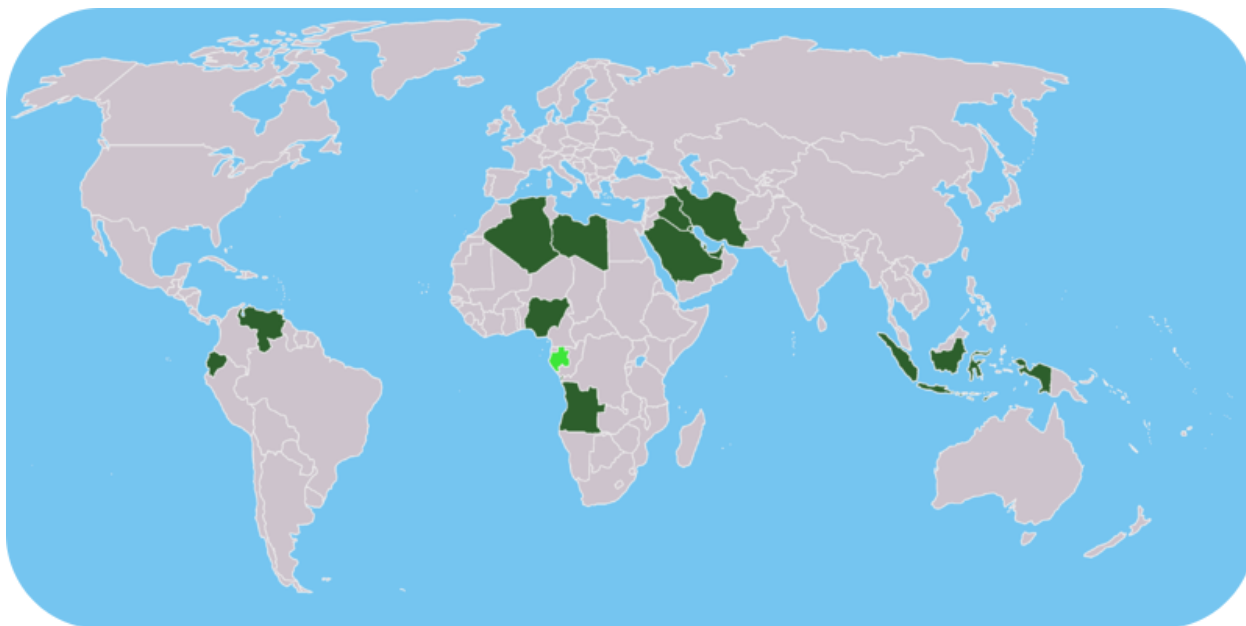
## Waste

The topic of overconsumption was touched on in Concept Life on Earth. Many people in developed countries, such as the United States and most of Europe, use many more natural resources than people in many other countries. We have many luxury and recreational items, and it is often cheaper for us to throw something away than to fix it or just hang on to it for a while longer. This consumerism leads to greater resource use, but it also leads to more waste. Pollution from discarded materials degrades the land, air, and water (**Figure 20.3**).

Natural resource use is generally lower in developing countries because people cannot afford many products. Some of these nations export natural resources to the developed world since their deposits may be richer and the cost of labor lower. Environmental regulations are often more lax, further lowering the cost of resource extraction.

## Summary

- The availability of a resource depends on how much of it there is and how hard it is to extract, refine, and transport to where it is needed.
- Politics plays an important role in resource availability since an unfavorable political situation can make a resource unavailable to a nation.
- Increased resource use generally means more waste; electronic waste from developed nations is a growing problem in the developing world.

**FIGURE 20.2**

The nations in green are the 11 biggest producers of oil; they are Algeria, Indonesia, Iran, Iraq, Kuwait, Libya, Nigeria, Qatar, Saudi Arabia, the United Arab Emirates, and Venezuela.

**FIGURE 20.3**

Pollution from discarded materials degrades the environment and reduces the availability of natural resources.

### Practice

Use this resource to answer the questions that follow.

<http://www.youtube.com/watch?v=0JZey9GJQP0>



#### MEDIA

Click image to the left for more content.

1. Why are they melting computer circuit boards?
2. What toxic gases are given off?
3. What metals are they extracting from these computers?
4. What do CRTs contain?
5. What do computer batteries contain?
6. How can these chemicals harm people?
7. How much does recycling a computer cost in India?
8. What companies have committed to reducing the toxic chemicals in their products?

### Review

1. Why does electronic waste that is generated in developed nations get dumped in developing nations?
2. Why is politics important in the availability of resources?
3. Why do some nations consume more goods and generate more waste than others?

---

### References

1. Image copyright Anthony Jay D. Villalon, 2010. . Used under license from Shutterstock.com
2. Redattore. . GNU-FDL 1.2
3. Courtesy of the US Environmental Protection Agency. . Public Domain

# CHAPTER 21

## Natural Resource Conservation

- Describe forms of natural resource conservation.
- Explain why natural resource conservation is important.



### Can you make a difference?

Yes! You can conserve natural resources every day with every decision you make. Should you recycle that can? Yes! Should you buy a bottle of water or drink from the water fountain? Fountain! Should you walk or ride your bike to school or ask for a ride? Walk - it's good exercise too!

### Conserving Natural Resources

So that people in developed nations maintain a good lifestyle and people in developing nations have the ability to improve their lifestyles, natural resources must be conserved and protected (**Figure 21.1**). People are researching ways to find renewable alternatives to non-renewable resources. Here is a checklist of ways to conserve resources:

- Buy less stuff (use items as long as you can, and ask yourself if you really need something new).
- Reduce excess packaging (drink tap water instead of water from plastic bottles).

**FIGURE 21.1**

Recycling can help conserve natural resources.

- Recycle materials such as metal cans, old cell phones, and plastic bottles.
- Purchase products made from recycled materials.
- Reduce pollution so that resources are maintained.
- Prevent soil erosion.
- Plant new trees to replace those that are cut down.
- Drive cars less, take public transportation, bicycle, or walk.
- Conserve energy at home (turn out lights when they are not needed).

Conserving natural resources are explored in a set of National Geographic videos found at <http://video.nationalgeographic.com/video/environment/habitats-environment/rainforests>. Search for these videos:

- “Mamiraua” is a sustainable development reserve that is protecting the Amazon
- “Vancouver Rain Forest” explores an alliance between conservationists and logging companies

Or find ways to go green from National Geographic Conservation in Action series: <http://video.nationalgeographic.com/video/environment/going-green-environment/conservation-in-action>

- “Sustainable Logging”
- The problem with plastic bags is discussed in “Edward Norton: Bag the Bag”
- Trying to mitigate problems caused by intensive logging in Ecuador while helping the people who live there improve their standards of living is in “Ecuador Conservation”

## Summary

- To conserve natural resources it is important to use less resources or even eliminate the use of some resources.
- It is important to watch unintended consumption; e.g. with packaging.
- To reduce resource use, work on making some renewable: plant trees or use recycled products.

## Making Connections

**MEDIA**

Click image to the left for more content.

**Practice**

Use this resource to answer the questions that follow.

<http://www.energyhog.org/childrens.htm>

Play the game to answer these questions.

1. What are energy hogs?
2. List 3 ways to save energy in the living room.
3. List 3 ways you can conserve energy in the kitchen.
4. List 2 ways to save water in the bathroom.
5. List 2 ways to conserve energy in the bedroom.
6. How can energy be conserved in the attic?

**Review**

1. Why should you use renewable resources rather than nonrenewable resources when possible?
2. Why should you recycle materials when possible?
3. Why should you drink tap water or install a filter on your tap for filtered water?

---

**References**

1. Terence Ong. . CC-BY 2.5

## CHAPTER

## 22

## Animal Characteristics

- Identify characteristics that all animals share.

**Is an insect an animal?**

Of course it is. Is a snail an insect? No, snails are mollusks. Notice the large "foot" that allows movement, and the antennas are obvious. Actually, a snail's eyes are on the two long projections on its head, and the projections are called eyestalks. These are characteristics of this animal.

**Characteristics of Animals**

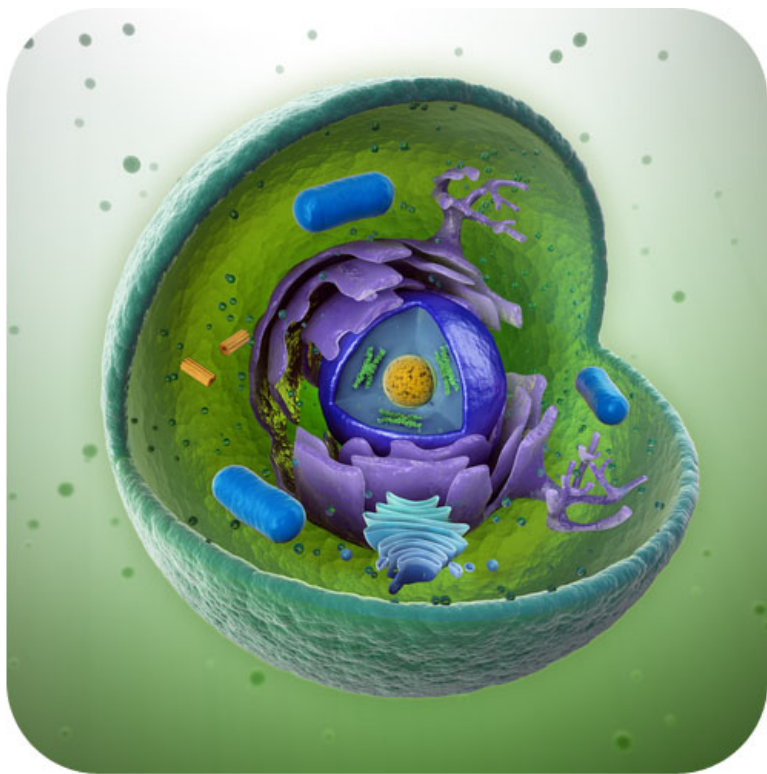
**Animals** are a kingdom of multicellular eukaryotes. They cannot make their own food. Instead, they get nutrients by eating other living things. Therefore, animals are **heterotrophs**.

**Animal Cells**

Like the cells of all eukaryotes, animal cells have a nucleus and other membrane-bound organelles (see **Figure 22.1**). Unlike the cells of plants and fungi, animal cells lack a cell wall. This gives animal cells flexibility. It lets them take on different shapes so they can become specialized to do particular jobs. The human nerve cell shown in **Figure 22.2** is a good example. Its shape suits its function of transmitting nerve impulses over long distances. A nerve cell would be unable to take this shape if it were surrounded by a rigid cell wall.

**Animal Structure and Function**

Animals not only have specialized cells. Most animals also have tissues and organs. In many animals, organs form organ systems, such as a nervous system. Higher levels of organization allow animals to perform many complex functions. What can animals do that most other living things cannot? Most animals share these characteristics: **sensory organs**, **movement**, and **internal digestion**. All of them are illustrated in **Figure 22.3**.

**FIGURE 22.1**

The shape of an animal cell is not constrained by a rigid cell wall.

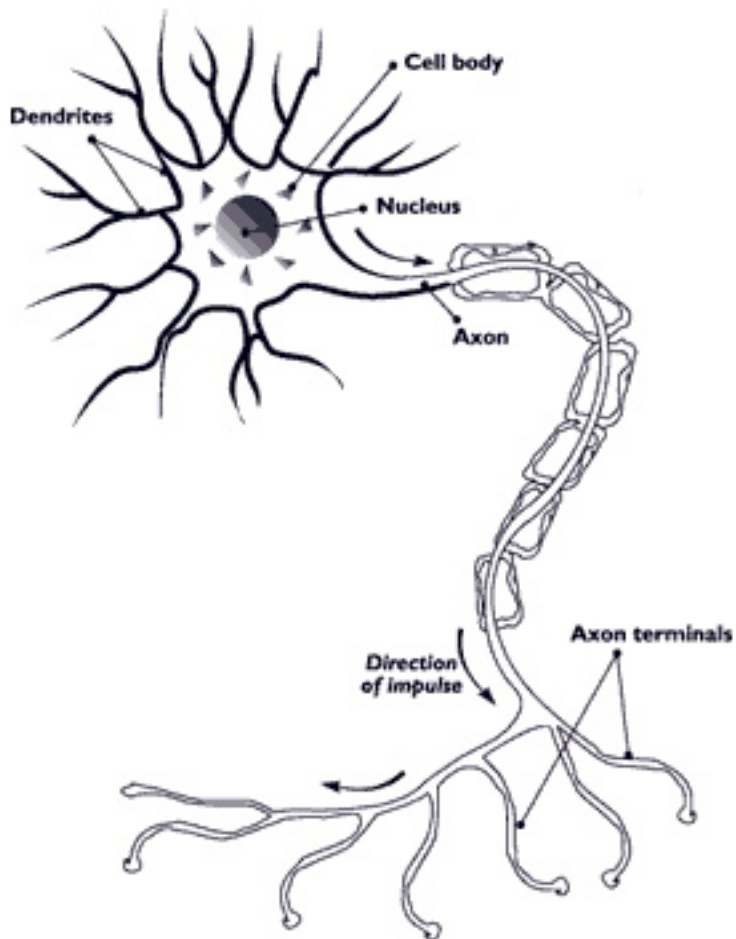
- Animals can detect environmental stimuli, such as light, sound, and touch. Stimuli are detected by sensory nerve cells. The information is transmitted and processed by the nervous system. The nervous system, in turn, may direct the body to respond.
- All animals can move, at least during some stage of their life cycle. Muscles and nerves work together to allow movement. Being able to move lets animals actively search for food and mates. It also helps them escape from predators.
- Virtually all animals have internal digestion of food. Animals consume other organisms and may use special tissues and organs to digest them. (Many other organisms absorb nutrients directly from the environment.)

## Animal Life Cycle and Reproduction

Many animals have a relatively simple life cycle. A general animal life cycle is shown in **Figure 22.4**. Most animals spend the majority of their life as diploid organisms. Just about all animals reproduce sexually. Diploid adults undergo meiosis to produce sperm or eggs. Fertilization occurs when a sperm and an egg fuse. The zygote that forms develops into an embryo. The embryo eventually develops into an adult.

## Summary

- Animals are multicellular eukaryotes that lack cell walls.
- All animals are heterotrophs.
- Animals have sensory organs, the ability to move, and internal digestion. They also have sexual reproduction.

**FIGURE 22.2**

A human nerve cell is specialized to transmit nerve impulses. How do you think the cell's shape helps it perform this function?

#### Characteristics of Animals



**Sensory Organs**  
Spiders have four pairs of eyes encircling their head. Some of the eyes form images. Some just detect the direction of light. Certain spiders can even swivel their eyes to see in different directions.



**Movement**  
Sea stars have hundreds of sucker-like tube feet for movement. Other animals move in a diversity of ways.



**Internal Digestion**  
Snakes swallow other animals whole and digest them internally. The bulge in this snake is a small mammal that the snake is in the process of digesting.

**FIGURE 22.3**

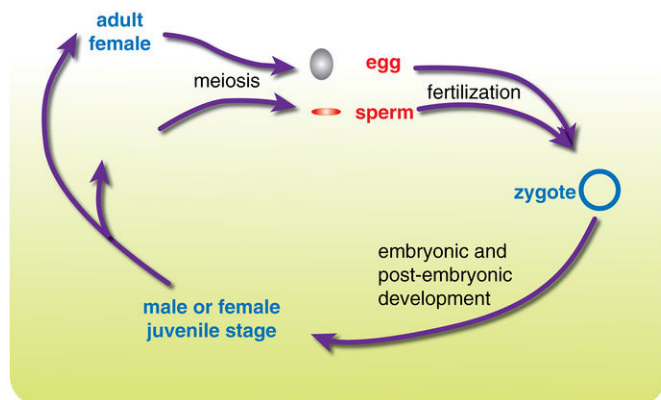
Most animals share these characteristics: sensory organs, movement, and internal digestion.

## Practice I

Use these resources to answer the questions that follow.

- <http://www.hippocampus.org/Biology> → Non-Majors Biology → Search: **Animals**

1. Animals evolved from what other group of organisms?

**FIGURE 22.4**

Animal Life Cycle. An animal life cycle that includes only sexual reproduction is shown here. Some animals also reproduce asexually. How does the animal life cycle compare with the life cycle of a plant?

2. What are 4 traits shared by all animals?
3. What are germ layers? What is the mesoderm?

• <http://www.hippocampus.org/Biology> → Biology for AP\* → Search: **Animal Fundamentals**

1. List characteristics of animals.
2. What is a major difference between animal and plant cells?
3. Describe nerve and muscle tissue.

## Practice II

- **Organism Needs** at <http://player.discoveryeducation.com/views/hhView.cfm?guidAssetId=f0d4b88e-314a-4e5b-9c76-4d2d1f85ddd4>.

## Review

1. Identify traits that characterize all animals.
2. State one way that animal cells differ from the cells of plants and fungi. What is the significance of this difference?
3. Describe a general animal life cycle.

## References

1. Image copyright Mopic, 2011. . Used under license from Shutterstock.com
2. Courtesy of National Institute of Drug Abuse. . Public Domain
3. Top to bottom: JJ Harrison; Photo Collection of Dr. James P. McVey, NOAA Sea Grant Program; Image copyright Steve Heap, 2010. . Top to bottom: CC-BY-SA 3.0; Public Domain; Used under license from Shutterstock.com

4. CK-12 Foundation. . CC-BY-NC-SA 3.0