Natural Resources

Dana Desonie, Ph.D.

AUTHOR
Dana Desonie, Ph.D.

To access a customizable version of this book, as well as other interactive content, visit www.ck12.org

CK-12 Foundation is a non-profit organization with a mission to reduce the cost of textbook materials for the K-12 market both in the U.S. and worldwide. Using an open-content, web-based collaborative model termed the **FlexBook®**, CK-12 intends to pioneer the generation and distribution of high-quality educational content that will serve both as core text as well as provide an adaptive environment for learning, powered through the **FlexBook Platform®**.

Printed: September 26, 2014

flexbook
next generation textbooks

CHAPTER 1

Natural Resources

CHAPTER OUTLINE

Introduction

How important are natural resources to you?

Look around you. Wherever you happen to be and whatever you are doing, you're using natural resources. Since you're reading this you're probably on a screen attached to some sort of computer, which uses metals, plastics that come from fossil fuels, and many other materials. The computer is powered by electricity, which may come from a nearby coal or nuclear plant or possibly from solar panels on the roof of your house. One thing is certain, modern life requires lots of natural resources!

1.1 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. Two points!

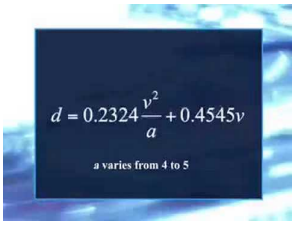
Energy Basics

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: http://www.youtube.com/watch?v=v-Z2-jxCqVw (6:01).



MEDIA

Click image to the left for use the URL below.

URL: http://gamma.ck12.org/flx/render/embeddedobject/11

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

FIGURE 1.1
A controlled fire.

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.

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
Click image to the left for use the URL below.
URL: http://gamma.ck12.org/flx/render/embeddedobject/53699

Practice

Use this resource to answer the questions that follow.

https://www.youtube.com/watch?v=LIh9ueO9FBM

1. How can the energy of a weight at the top of a pulley be transferred into heat in a tub of water? List the types of energy involved.
2. What is true about energy in a closed system?
3. What are the two things that energy can become in a closed system?

4. Where is the energy to drive a car stored and what type is it? What type of energy does that become?

Practice Answers

1. At the top of the pulley the weight has gravitational potential energy. When the weight is going down it has kinetic energy. The weight spins blades in the water and the friction of the blades increases the temperature of the water.
2. Energy can't escape from a closed system; it is conserved.
3. heat and work
4. It is chemical energy in gasoline. Mechanical energy and heat, maybe electrical and light.

Review

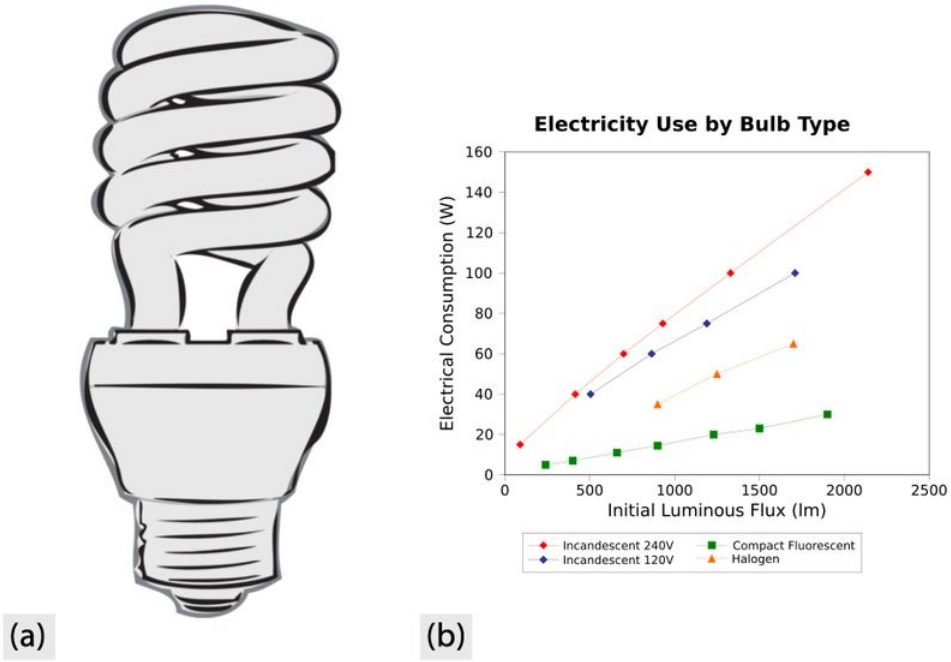
1. Give an example of how the law of conservation of energy works.
2. Compare and contrast chemical energy, kinetic energy, and potential energy.
3. Think about a candle flame and a bathtub full of hot water. Which has the highest temperature and which has the highest heat? What's the difference?

Review Answers

1. Solar energy is used by plants for photosynthesis. The plants are eaten by a person who stores this chemical energy until she is about to kick a soccer ball. The leg in position contains potential energy and the ball shooting outward contains kinetic energy. Some of that energy converts to work and heat.
2. Chemical energy is broken down by chemicals to create usable energy. Kinetic energy is the energy of something in motion. Potential energy is the energy of something that could release its energy but hasn't, like a sled on top of a hill.
3. The candle flame has the highest temperature but the hot bathtub probably has the highest heat. There is more of the energy stored in the water than in the candle flame.

1.2 Obtaining Energy Resources

- Describe how useable energy from an energy source is obtained and measured.



Have you converted to compact fluorescent light bulbs at your house?

Compact fluorescent light bulbs are more efficient than incandescent light bulbs. Look at the chart and try to see how much more efficient. The answer is that they could be as much as six times more efficient. So why aren't all people using compact fluorescent bulbs all the time? Early ones were large and expensive, and many people don't like the color of the light. But they are much more environmentally friendly.

Net Energy

Net energy is the amount of useable energy available from a resource after subtracting the amount of energy needed to make the energy from that resource available. For example, every 5 barrels of oil that are made available for use require 1 barrel for extracting and refining the petroleum. What is the net energy from this process? About 4 barrels (5 barrels minus 1 barrel).

What happens if the energy needed to extract and refine oil increases? Why might that happen? The energy cost of an energy resource increases when the easy deposits of that resource have already been consumed. For example, if all the nearshore petroleum in a region has been extracted, more costly drilling must take place further offshore (**Figure** 1.2). If the energy cost of obtaining energy increases, the resource will be used even faster.

Net-Energy Ratio

The **net-energy ratio** demonstrates the difference between the amount of energy available in a resource and the amount of energy used to get it. If it takes 8 units of energy to make available 10 units of energy, then the net-energy

FIGURE 1.2

Offshore drilling is taking place in deeper water than before. It takes a lot of energy to build a deep drilling platform and to run it.

ratio is 10/8 or 1.25. What does a net-energy ratio larger than 1 mean? What if the net-energy ratio is less than 1? A net-energy ratio larger than 1 means that there is a net gain in usable energy; a net-energy ratio smaller than one means there is an overall energy loss.

Table 1.1 shows the net-energy ratios for some common energy sources.

TABLE 1.1: Net-Energy Ratios for Common Energy Sources

Energy Source	Net-energy Ratio
Solar Energy	5.8
Natural Gas	4.9
Petroleum	4.5
Coal-fired Electricity	2.5-5.1

Notice from the table that solar energy yields much more net energy than other sources. This is because it takes very little energy to get usable solar energy. Sunshine is abundant and does not need to be found, extracted, or transported very far. The range for coal-fired electricity is because of the differing costs of transporting the coal. What does this suggest about using coal to generate electricity? The efficiency is greater in areas where the coal is locally mined and does not have to be transported great distances (**Figure** 1.3).

FIGURE 1.3

Obtaining coal for energy takes a lot of energy. The coal must be located, extracted, refined, and transported.

This is not to say that solar energy is less expensive than other types of energy. The cost of energy is dependent on lots of different factors, such as the cost of the equipment needed to harness the energy. If solar power cost less to use, it would be more widespread.

- The cost is kept lower.

Because so much of the energy we use is from fossil fuels, we need to be especially concerned about using them efficiently. Sometimes our choices affect energy efficiency. For example, transportation by cars and airplanes is less energy-efficient than transportation by boats and trains.

Summary

- Net energy is the amount of that is actually useable from an energy resource. Net-energy ratio is the ratio of the amount of useable energy from a resource and the amount it takes to make that energy useful.
- Many factors besides net-energy ratio go into determining if a type of energy will be used.
- An energy source with high energy efficiency provides a lot of work for the amount of energy used.

Practice

Use this resource to answer the questions that follow.

How to save money and energy: http://www.youtube.com/watch?v=VC3C_8eQgeE

MEDIA

Click image to the left for use the URL below.

URL: http://gamma.ck12.org/flx/render/embeddedobject/114939

1. Besides energy, what is lost when energy drips away?
2. Why should you replace incandescent bulbs with CFLS?
3. Why is it good to plug electronics into a power strip?
4. Why should you use a programmable thermostat?
5. What is the purpose of insulation?
6. Why is an old appliance an energy sink?
7. If you did these things, how much money would you save in a decade on average (in Minnesota)?

Practice Answers

1. money
2. CFLS last 7 to 10 times longer and use 75% less electricity than incandescent.
3. You can turn off the power strip; 75% of the energy used by a computer is when no one is there.
4. You can forget it and it will make the temperature less comfortable when you know you won't be home.
5. Insulation keeps air temperature more constant.
6. New models are more energy efficient?
7. $575 per year

Review

1. Compare and contrast net energy, the net-energy ratio, and energy efficiency.
2. Since the net-energy ratio for solar energy is higher than other types of energy, why don't we use solar for electricity almost exclusively?

3. Why would the energy needed to make a type of energy useful increase or decrease? In other words, why would the net-energy ratio change?

Review Answers

1. Net energy is the amount of useable energy available from a resource after taking away the energy needed to make the resource available. Net-energy ratio is the difference in the amount of energy in the resource and the amount of energy used to get it. Energy efficiency is the amount of useful work extracted from the energy All are similar because the are concerned with the amount of usable energy obtained from a resource.
2. Solar energy costs more because the technology is less well developed. Solar energy is not always available. Also, industries depend on fossil fuels and are not ready to switch to solar
3. It could become much more or less expensive to obtain energy depending on the technology, the amount of the resource, the distance the resource is from where it will be used and may other factors.

1.3 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** 1.4) shows how energy is used in the United States.

Table 1.2 shows some ways that people can decrease energy use and use energy more efficiently in transportation, residences, industries, and office settings.

TABLE 1.2: Ways to Use Energy More Efficiently

Where Energy is Used	How We Can Use Less Energy	How We Can Use Energy More Efficiently

TABLE 1.2: (continued)

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. Reduce the number of trips you make. Use public transportation.	Increase fuel efficiency in cars. Buy and drive smaller cars. 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. Only run appliances when necessary. Unplug appliances when not in use. Wear a sweater instead of turning up heat. Use fans instead of turning down air conditioner. Engage in activities that do not involve electronics. Rely on sunlight instead of artificial light.	Replace old appliances with newer more efficient models. Insulate your home. Make sure windows and doors are well sealed. Use LED bulbs if available, or compact fluorescent light bulbs (and dispose of properly!).
Industrial	Recycle materials like soda cans and steel. Reduce use of plastic, paper, and metal materials.	Practice conservation in factories. 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.

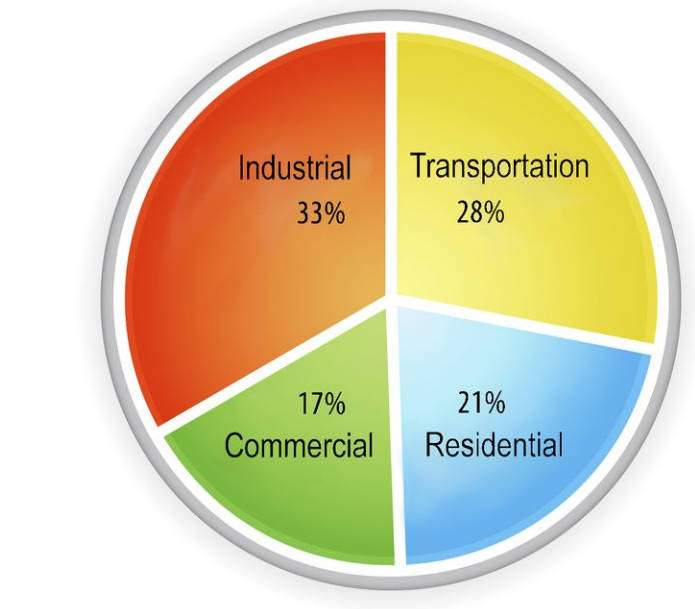


FIGURE 1.4

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

Summary

- Conserving energy is 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 use the URL below.

URL: http://gamma.ck12.org/flx/render/embeddedobject/1556

1. What will the population be in 2030?
2. How much will our energy demands increase by 2030? How much will that elevate global carbon dioxide emissions if this demand is met by fossil fuels?
3. What is the single most important source of future energy?
4. What is energy efficiency?
5. How can industries optimize their energy efficiency?
6. What can be done to make vehicles more efficient?
7. How can we make our homes more energy efficient?
8. How effective can using energy efficiently be?

Practice Answers

1. 8.3 billion
2. +53%; +55%
3. energy efficiency
4. Getting more use out of the energy we use.
5. Industry can take more advantage of their used materials and resources;they can use best available technologies and optimize processes.
6. Vehicles can become lighter; fuels can be optimized; vehicles can be made more aerodynamic.
7. Insulation can trap in cooling or heating.
8. Only 16% increase and 11% increase in CO2 by 2030.

Review

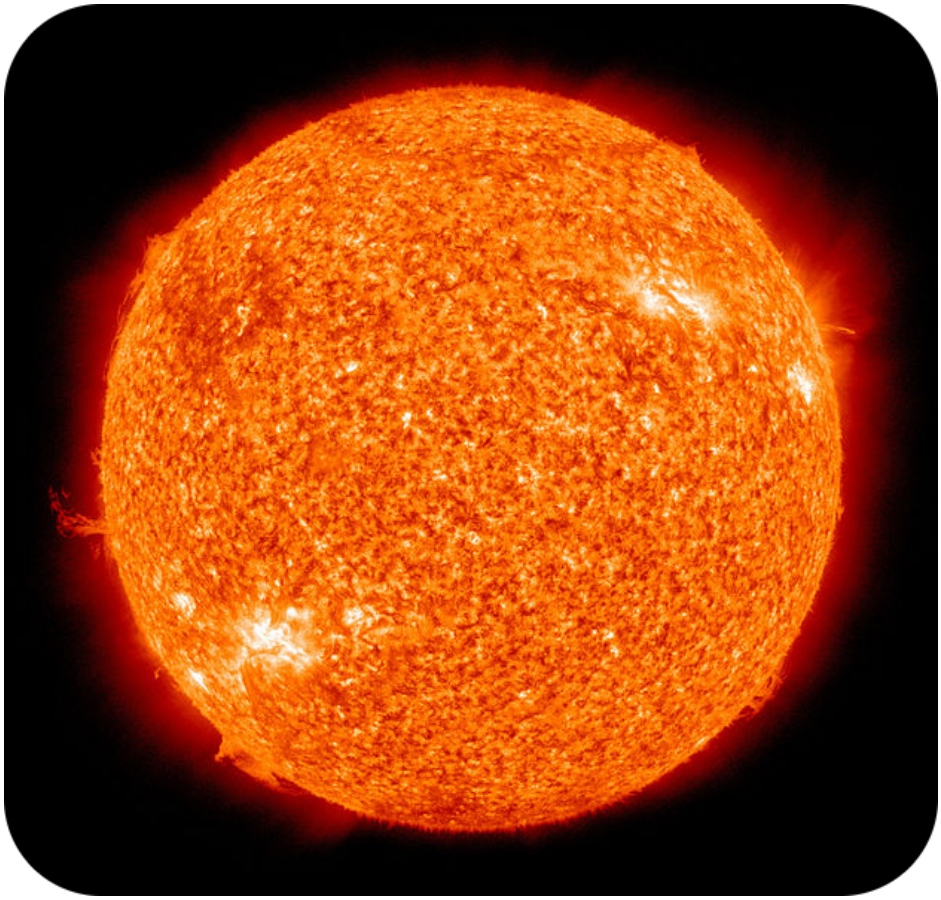
1. Why is conservation the best way to stretch our energy resources?
2. List some ways that society can conserve energy.
3. List some ways that you and the other members of your household can conserve energy.

Review Answers

1. Less energy is needed so less energy must be produced, which keeps costs down and keeps the energy for future use.
2. Society can require everyone to be more energy efficient by designing vehicles that use less energy, creating more energy efficient appliances, incentivizing less energy use.
3. Use compact fluorescent light bulbs instead of incandescent; keep appliances off when not in use; keep heating and cooling down; open the blinds instead of turning on a light in the daytime.

1.4 Renewable vs Non-Renewable Energy Resources

- Define renewable resource and non-renewable resource.
- Compare and contrast renewable and non-renewable resources.
- Identify renewable and non-renewable 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 non-renewable. **Non-renewable 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** 1.5). Can you think of some renewable and non-renewable energy sources?

FIGURE 1.5
An old windmill in the Netherlands.

Non-Renewable Resources

Fossil fuels —coal, oil, and natural gas —are the most common example of non-renewable 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 non-renewable resources will become more expensive. At some point, even if renewable energy costs are high, non-renewable 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 non-renewable 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 go 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 use the URL below.

URL: http://gamma.ck12.org/flx/render/embeddedobject/116510

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 use the URL below.

URL: http://gamma.ck12.org/flx/render/embeddedobject/54764

Practice

Use this resource to answer the questions that follow.

https://www.youtube.com/watch?v=q5JEiqy6WLs

1. What is renewable energy?
2. Which energy resources are renewable and why?
3. Which energy resources are non-renewable and why?

Practice Answers

1. Any natural resource that can replace itself quickly and dependable; an energy source that can't be used up.
2. Solar power converts sunlight into electricity; the sun has been around for billions of years and will continue to. Geothermal is energy produced by the Earth's core, it's continually replaced by heat from the interior. Wind power turns motion into electricity, winds keep blowing so this is renewable.
3. Fossil fuels were formed deep in earth from plant and animal remains that are millions of years old. It can only be used once and it replaces itself too slowly to be renewable. This includes coal, natural gas and oil.

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 non-renewable?
3. Why aren't renewable resources used for everything that we use energy for?

Review Answers

1. It means that the process of making that energy usable, from finding it to extracting it to changing it to a usable for to getting it to where it needs to go, uses more energy than the energy that is obtained from that energy source.
2. Renewable resources can become non-renewable if they are not treated well. For examples, fisheries should be renewable because fish always have baby fish. But if there are too few adult fish left to mate, the fishery may die out and then it is non-renewable.
3. There is an entire structure of our society based on fossil fuels: corporations to find and make them available, industries to use them. It's expensive to change and it meets with a lot of opposition when it is tried.

1.5 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.

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** 1.6).

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

FIGURE 1.6
This wetland may look something like an ancient coal-forming swamp.

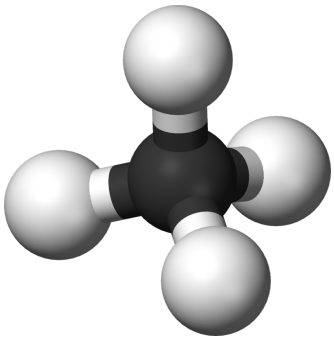


FIGURE 1.7
Hydrocarbons are made of carbon and hydrogen atoms. This molecule with one carbon and four hydrogen atoms is methane.

turned into chemicals called **hydrocarbons** (**Figure** 1.7). An animated view of a hydrocarbon is seen here: http://www.nature.nps.gov/GEOLOGY/usgsnps/oilgas/CH4_3.MPG .

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.

https://www.youtube.com/watch?v=_8VqWKZIPrM

1. What are fossil fuels made from?
2. How long has it taken for these fuels to form?

3. What do these fuels contain that we need?
4. What are most of the plants that create fossil fuels and where do they live?
5. What happens next?
6. How does this turn into fossil fuel? What happens to the energy?
7. How are different fossil fuels created?
8. What makes coal? Oil? Natural gas?
9. Why are fossil fuels non-renewable?
10. What is the problem with fossil fuels?

Practice Answers

1. Mostly plants that lived and died long ago.
2. hundreds of millions of years
3. carbon and energy
4. They are phytoplankton like diatoms that grow in the photic zone of the ocean.
5. They use carbon dioxide and energy to grow and create more plankton. They die and settle to the bottom. They do not have exposure to oxygen.
6. Earth's heat and pressure turns it into fossil fuels, which concentrates the energy collected by the plankton.
7. By varying what goes into the ground and the temperature at which it converts to fuel.
8. woody plants; slimy plants and algae; Woody plants, slimy plants and algae.
9. They formed over a few hundred million years, but we're using them over a few hundred years so they must run out.
10. We're reversing the process by which they formed so that we are changing the composition of Earth's atmosphere.

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?

Review Answers

1. They form by the same processes that create fossils.
2. They come from living organisms that have died and their remains were buried and exposed to heat and pressure.The organisms turned into chemicals called hydrocarbons.
3. solar energy

1.6 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** 1.8). Anthracite coal has been metamorphosed and is nearly all carbon. For this reason, anthracite coal burns more cleanly than bituminous coal.

FIGURE 1.8
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** 1.9). 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** 1.10). 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 the chapter Materials of Earth's Crust (**Figure** 1.11). Mining, especially

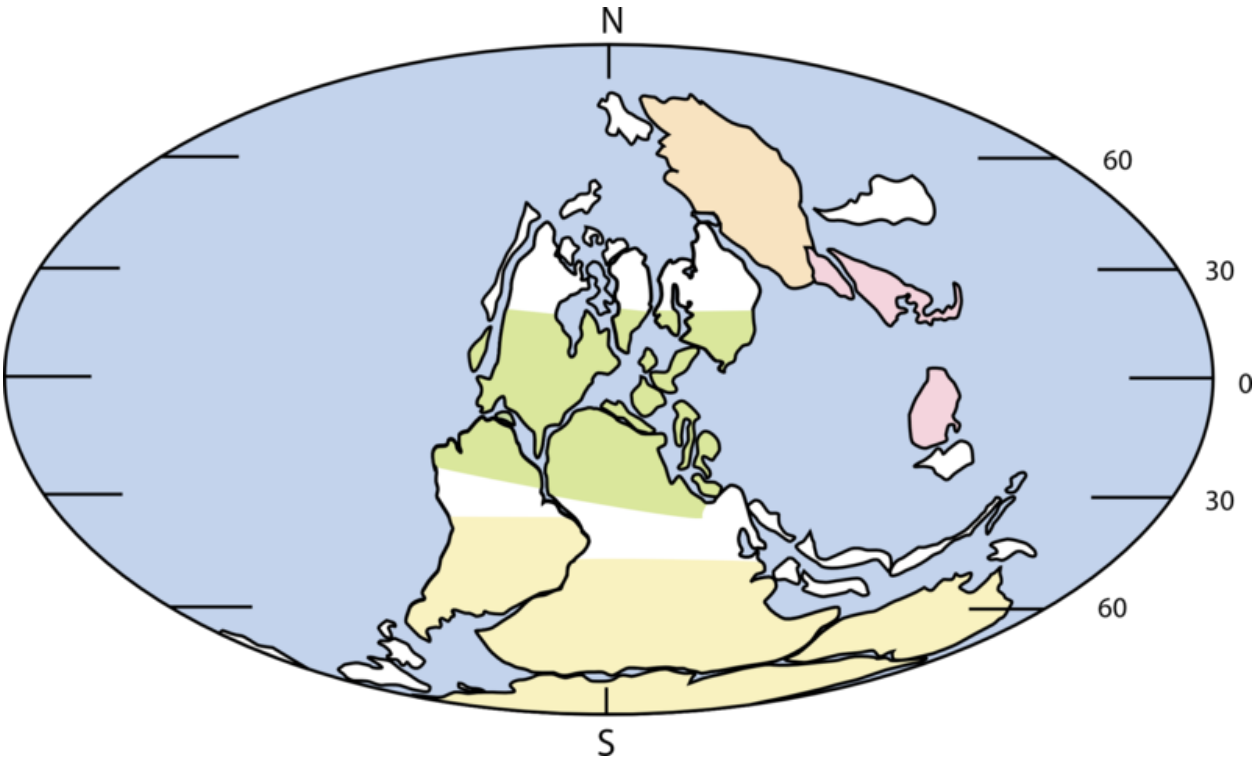


FIGURE 1.9

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

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 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.

https://www.youtube.com/watch?v=QEa36qNo86E Stop at 6:17.

1. What environment is best for coal formation?

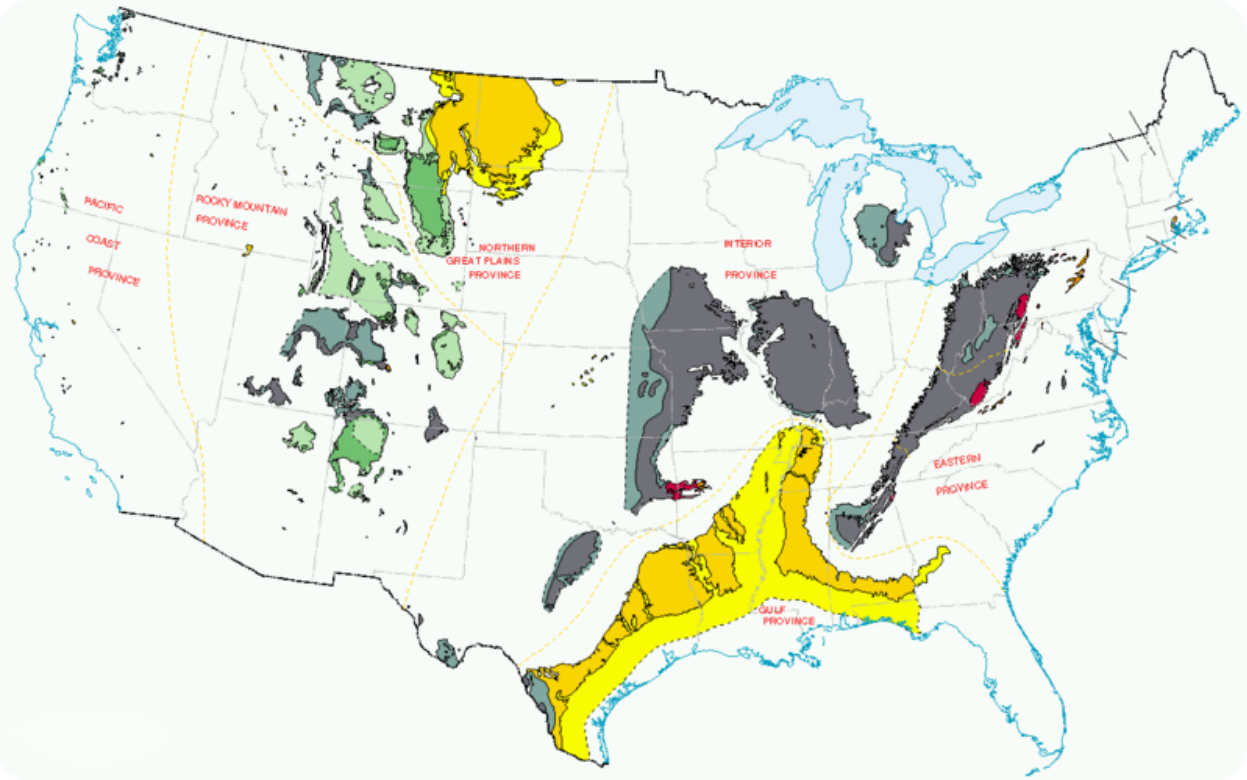


FIGURE 1.10

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.

2. Although the implication is that coal formed due to the Cretaceous-Tertiary extinction, most coal formed before that. What do the plants that become coal undergo in the swamp?
3. How does this organic material become coal?
4. How does brown coal turn into usable bituminous and higher grade coal?
5. What is the gas exchange done by plants? What is the gas exchange done by coal burning?
6. Ultimately where does the energy in coal come from?

Practice Answers

1. In ancient times climate was mild and wet. Low-lying marshes contained nutrients. Plants grew and died.
2. March plants grew and died and were laid down layer after layer. Anaerobic microorganisms tarted biochemical reactions that transformed the plants into peat.
3. The peat is buried deep underground. Pressure from rock and high temperatures causes the peat to solidify into coal.
4. The brown coal is subjected to high pressure and temperature; water is lost; carbon content increases.
5. Plants use carbon dioxide to make oxygen. Coal burning uses oxygen to release carbon dioxide.
6. the sun

Coal being mined by mountaintop removal.

A small coal-fired power plant.

FIGURE 1.11

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

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?

Review Answers

1. Dead plants settle to the bottom of ancient swamps. they are buried by sediment and the environment is anaerobic. Over time heat and pressure turns the organic material into coal.
2. Conditions aren't right today for vast coal swamps; also it takes a long time for coal to form.
3. Coal mining can be very destructive to the land. Coal mining can be very dangerous. Coal releases pollutants into the air that may also cause acid rain and global warming.

1.7 Petroleum Power

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

What is the connection between ancient organisms and the Indy 500?

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

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** 1.12). 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.

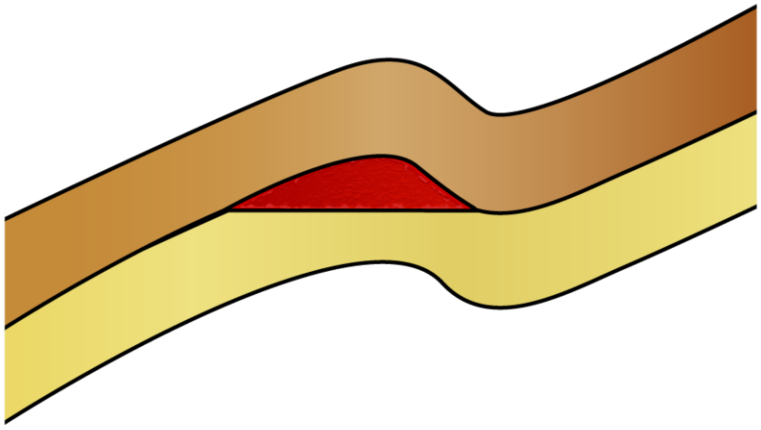


FIGURE 1.12

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.

- An animation of an oil deposit forming is shown here: http://www.nature.nps.gov/GEOLOGY/usgsnps/oilgas/ENTRAP_3.MPG .
- 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 .
- 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 .

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** 1.13. 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.

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.

FIGURE 1.13

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

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** 1.14). 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 .

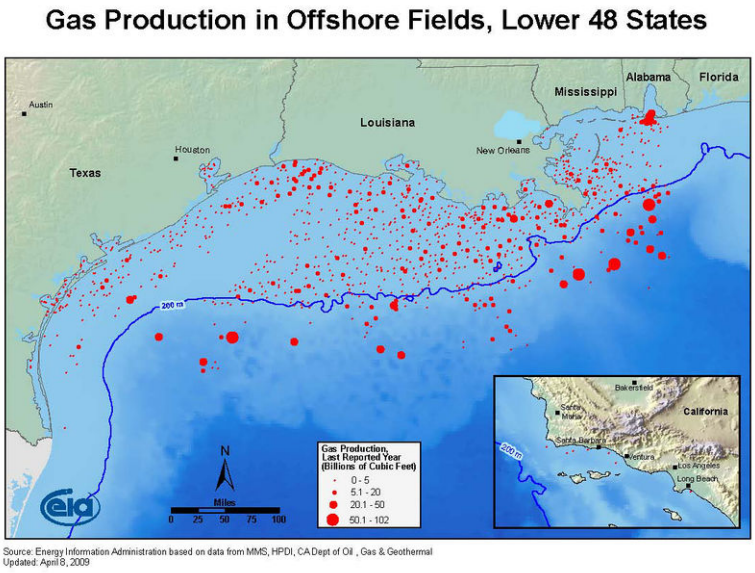


FIGURE 1.14

Offshore well locations in the Gulf of Mexico. Note that some wells are located in very deep water.

As in every type of mining, mining for oil has environmental consequences. Oil rigs are unsightly (**Figure** 1.15), and spills are too common (**Figure** 1.16).

FIGURE 1.15

Drill rigs at the San Ardo Oil Field in Monterey, California.

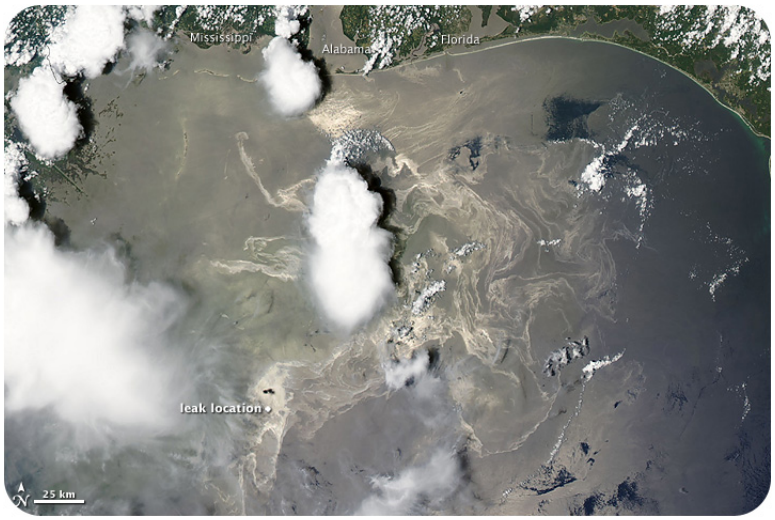


FIGURE 1.16

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.

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.

https://www.youtube.com/watch?v=vSvzuwwGZtE

1. What is petroleum?
2. What is a barrel of crude oil used for?
3. Where do you find petroleum and natural gas?
4. How does crude oil form?
5. What is needed for us to be able to get oil from a formation?
6. How is the oil extracted?
7. How is oil refined?

Practice Answers

1. Also called crude oil, it is an oily, flammable liquid consisting of compounds that are produced from organic matter in sedimentary rocks.
2. 50% gasoline; 40% diesel fuel, heating oil, jet fuel and kerosene; 10% rsidental fuel oil
3. In sedimentary rocks that are rich in organic materials.
4. Organic matter decays at the bottom of a lake or marsh. The organic matter gets trapped between two layers of rock or sediments. There is no oxygen or the matter would oxidize into the air. Eventually heat and pressure over millions of years drive water out of oil.
5. The oil must be trapped by a nonporous layer in an anticline or dome.
6. Steam is pumped into the well and the oil comes out?
7. Boil the crude oil, then it separates into different components based on their boiling point.

Review

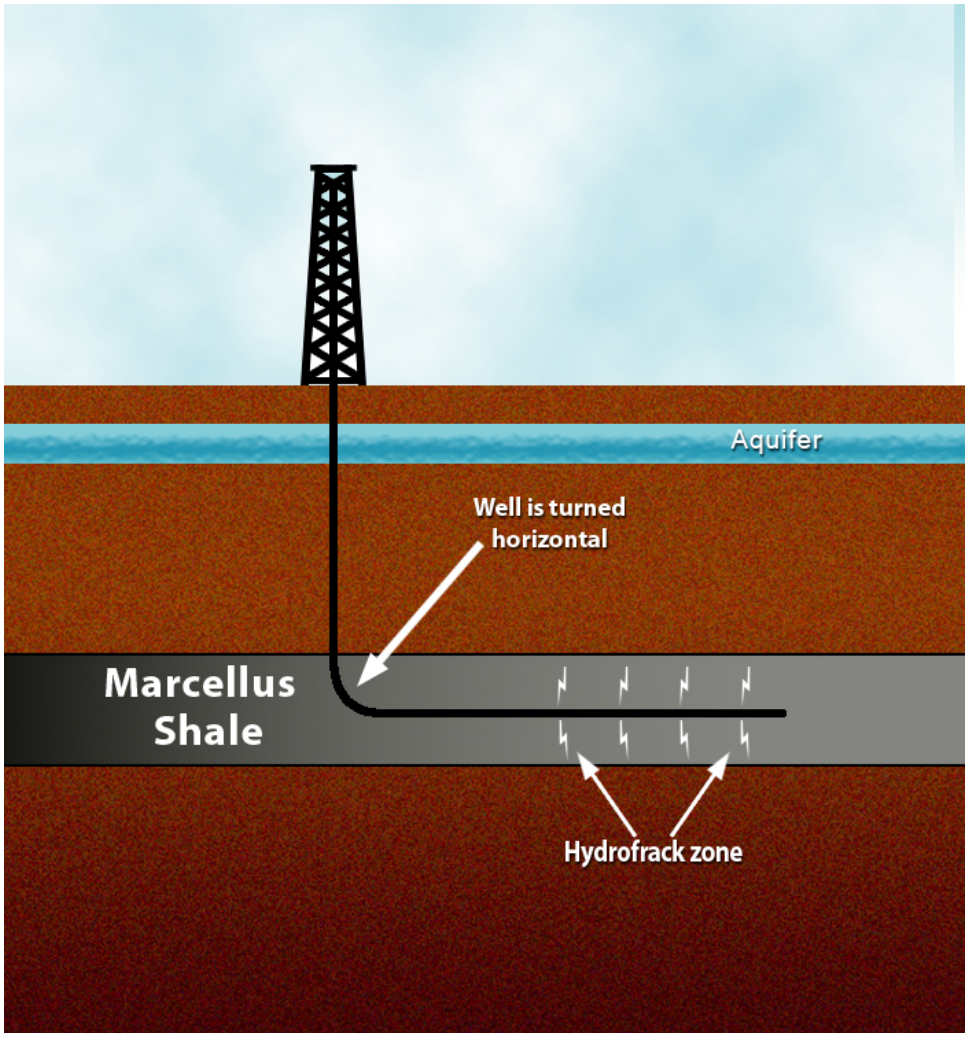
1. Why is it harder to find a substitute for petroleum than it is for coal? Think about what these fuels are used for.
2. Why are there more likely to be hazardous consequences for deep oil drilling than for the shallow drilling that's been taking place for centuries?
3. How does crude oil form?

Review Answers

1. Petroleum creates gasoline that is used in vehicles. It is hard to find a substitute for a liquid fuel. Coal is easier to replace because a lot of it makes electricity and other things can be used for that.
2. There is less experience with deep drilling; the technologies are newer.
3. Oil forms from plankton die and fall to the seafloor. They are covered by sediments, kept from oxygen and they turn to liquid oil as they are exposed to heat and pressure.

1.8 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 Untied 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 .

The largest natural gas reserves in the United States are in the Appalachian Basin, North Dakota and Montana, Texas, and the Gulf of Mexico region (**Figure** 1.17). 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).

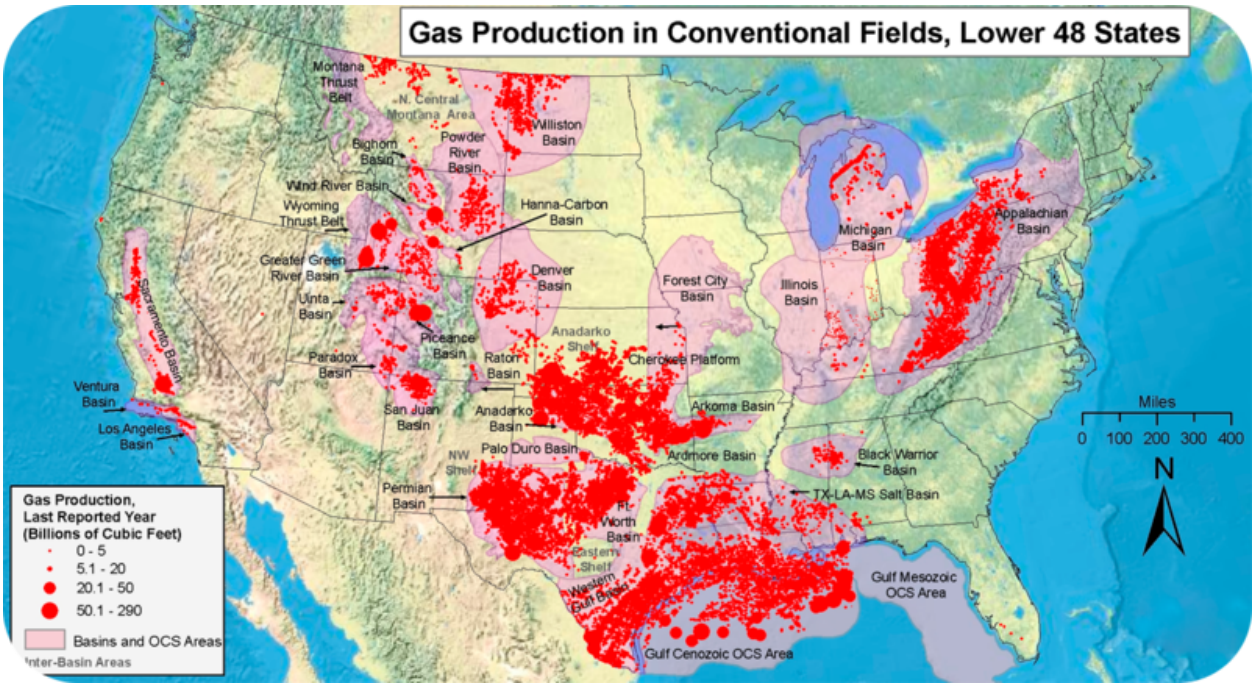


FIGURE 1.17

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 .

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** 1.18).

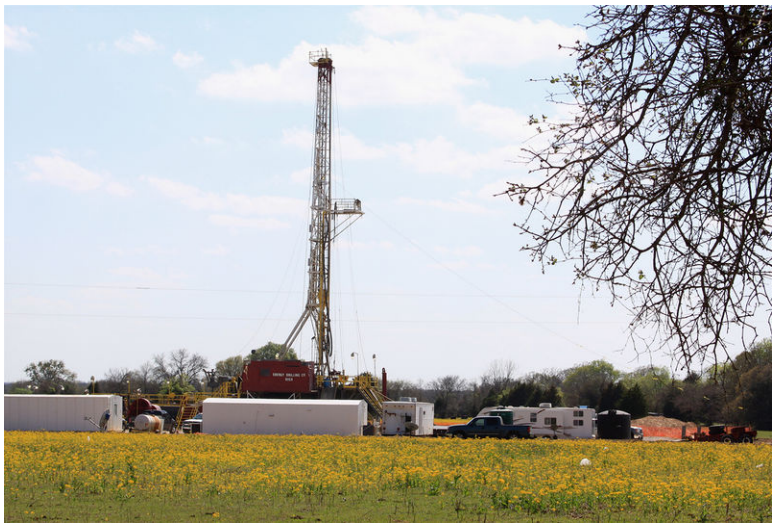


FIGURE 1.18
A natural gas drill rig in Texas.

- 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 .

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.

https://www.youtube.com/watch?v=YemKzEPugpk

1. What does hydraulic fracturing do and how long has it been happening?
2. How is a fracking well drilled?
3. According to the video, why is groundwater not adversely affected.
4. What happens in the shale unit?
5. What all is in fracturing fluid?
6. What does the fracturing fluid do?
7. How long will a fracking well last?
8. What are the advantages to fracking?

Practice Answers

1. Fracking provides safe extraction of oil and natural gas from underground shale formations for more than 60 years.
2. A well bore is drilled using a pipe and bit. The pipe is taken out and concrete casing is introduced to the hole to protect the hole and the water. Cement goes through and out the casing to secure the casing and send fluids through the bottom. Drilling continues and more casing and cementing goes on.
3. Drilling goes past the aquifer.
4. Angle drilling begins to put a horizontal path through the shale with the hole undergoing casing and cementing. A perforating tool creates holes in the shale layer, which allows hydrocarbons into the hole.
5. It is mostly water and sand. The remainder of the contents are not explained.
6. It opens tiny fractures in the shale. Water is removed but sand remains. Fractures are held open.
7. 20 to 40 years
8. It reduces the footprint of drilling and it gets oil and natural gas out that were previously not accessible.

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?

Review Answers

1. Fracking injects fluids into a natural gas-bearing shale to break the shale and allow the gas to rise to the surface. It is a technique for getting gas out of rock that has low permeability.
2. Natural gas is formed in the same way, just at higher temperature.
3. Natural gas burns more cleanly.

1.9 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 .

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** 1.19).

Alternative Fossil Fuels

As the easy-to-reach fossil fuel sources are depleted, alternative sources of fossil fuels are increasingly being exploited (**Figure** 1.20). 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** 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.

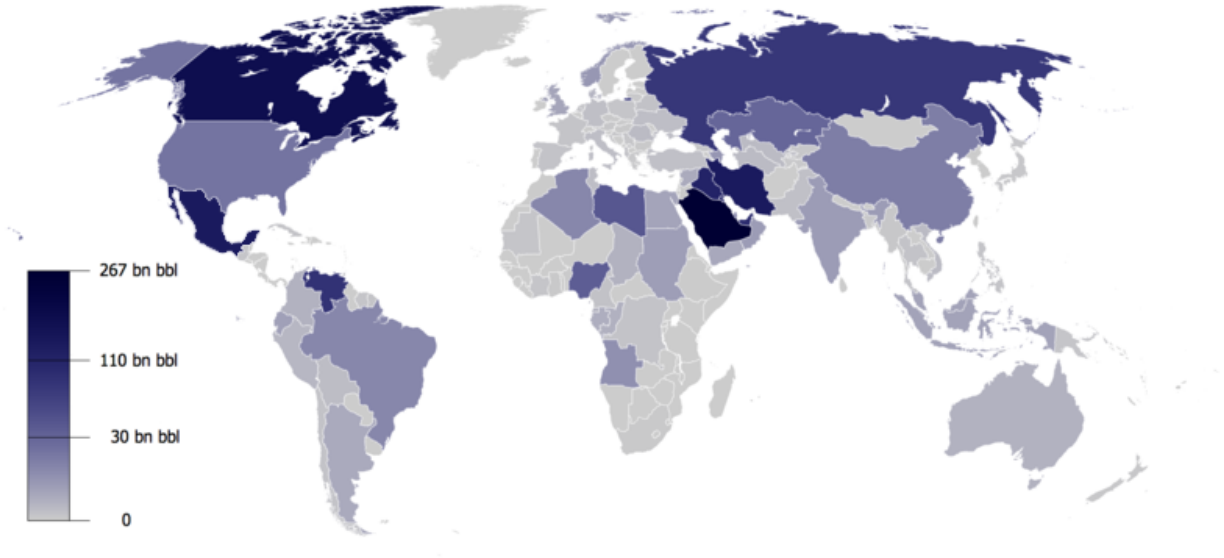


FIGURE 1.19
Worldwide oil reserves.

FIGURE 1.20
A satellite image of an oil-sands mine in Canada.

- 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 work use more and more people in the developing world want them.

Practice

Use this resource to answer the questions that follow.

https://www.youtube.com/watch?v=4uKgU7krWzE

1. Why is oil so great?
2. How long did it take for nature to make oil? How long did it take us to use the best of it?
3. What is peak oil?
4. What happened to world crude oil production? What were the consequences of that?
5. What does fracking do to this situation?
6. What is old and what is new? What is the effect of the new thing?
7. What is needed for fracking?
8. How does the economy respond to high oil prices?
9. What is inevitable? What should we do to prepare?

Practice Answers

1. It's the cheapest, most portable and energy dense source we've ever found.
2. tens of millions of years; less than 200 years
3. The idea that global oil production would hit a peak and then decline so that it could no longer reach demand.
4. It flattened in 2005. Oil prices went up, wars erupted, global economy went into a tailspin.
5. It makes oil available that wasn't previously available.
6. Old is the technology and the deposits. New is high oil prices so that unconventional sources are now worth producing.
7. Money, energy, water, environmental risks
8. It goes into recession.
9. Eventually we will run out of fossil fuels. Wean ourselves off of high energy lifestyle.

Review

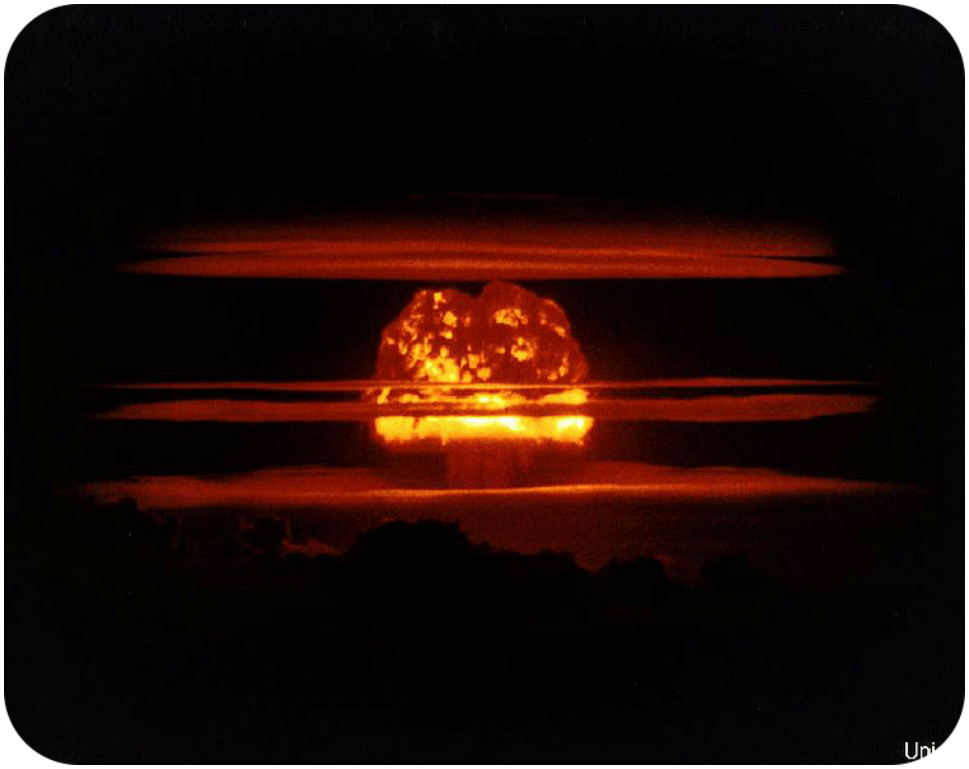
1. What are oil shales and tar sands?
2. What do you think goes into calculations that try to determine how much fossil fuel energy is left? Why is this difficult to calculate?
3. Why is the need for fossil fuels increasing?

Review Answers

1. Oil shale is fine-grained sedimentary rock that contains oil. Tar sands are sands mixed with oil.
2. The size of the deposits, the difficulty of getting to them, technology, cost, rates of use are some of the things.
3. There are more people. People in the developing world want some of the things that people int eh developed world have. And people in the developed world always want more.

1.10 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** 1.21).

Nuclear Energy Use

Nuclear power plants, such as the one seen in **Figure** 1.22, 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.

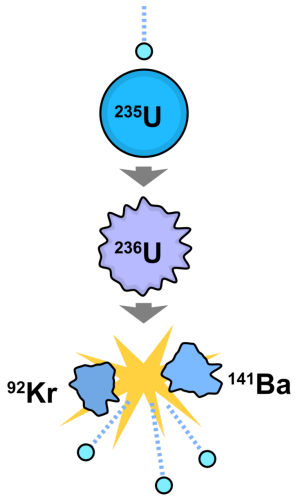


FIGURE 1.21

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

FIGURE 1.22

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** 1.23). 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** 1.24).

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.

FIGURE 1.23
Uranium mine in Kakadu National Park, Australia.

FIGURE 1.24
Damaged building near the site of the Chernobyl disaster.

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

Adobe Flash

MEDIA
Click image to the left for use the URL below.
URL: http://gamma.ck12.org/flx/render/embeddedobject/60950

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. https://www.youtube.com/watch?v=96ejyj68IqE

1. What is nuclear power?
2. What are the two most common nuclear fuels? Where do these materials come from?
3. What are some of the pros of getting energy from nuclear power?
4. What one major con of getting energy from nuclear power?
5. When does contamination occur?
6. What are the three examples of nuclear disasters?
7. What is another problem with nuclear reactors?
8. How does the price of nuclear power compare with other nonrenewable sources? Why?

Practice Answers

1. Exothermic nuclear processes to generate energy.
2. Uranium-235 and plutonium-239 must be mined, refined and purified from ore.
3. It is carbon neutral. If what is now nuclear power was replaced with fossil fuels we'd generate 2 billion tons more carbon dioxide each year. It is economically stable. It doesn't fluctuate like fossil fuels or alternatives. It is capable of producing large amounts of energy.
4. Catastrophic and widespread radioactive contamination.
5. Nuclear power relies on a controlled environment for nuclear fission. When this environment is compromised ten meltdowns become possible.
6. Chernobyl, Three Miles Island and Fukushima Diaiichi.
7. They generate a lot of nuclear waste that is radioactive for tens of thousands of years and releases heat.
8. The costs are higher than other renewable sources because nuclear power plants are very expensive to construct.

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?

Review Answers

1. Atomic nuclei are split in a nuclear reactor and the energy released is nuclear energy.
2. Answers will vary.
3. There should be a great deal of caution for nuclear power plants. Ultimately it's not clear whether any place is safe. And there is the problem of nuclear waste.

1.11 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** 1.25). 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.

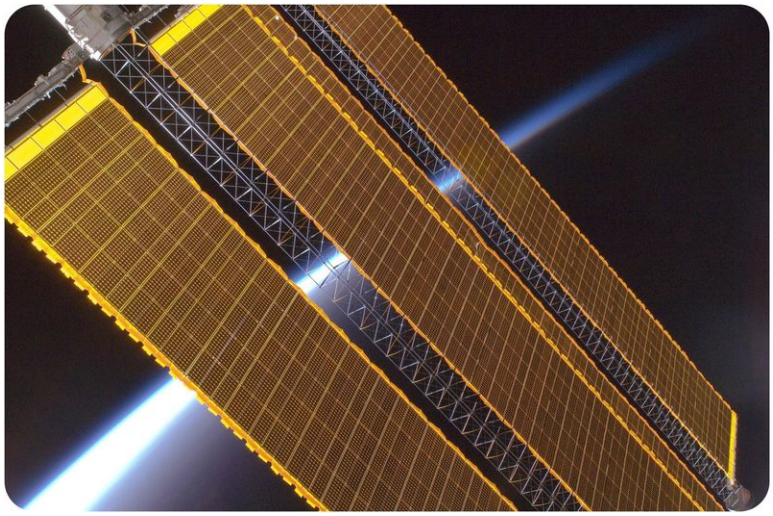


FIGURE 1.25
Solar panels supply power to the International Space Station.

Solar power plants turn sunlight into electricity using a large group of mirrors to focus sunlight on one place, called a receiver (**Figure** 1.26). 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 1.26
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 .

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** 1.27).
- 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.

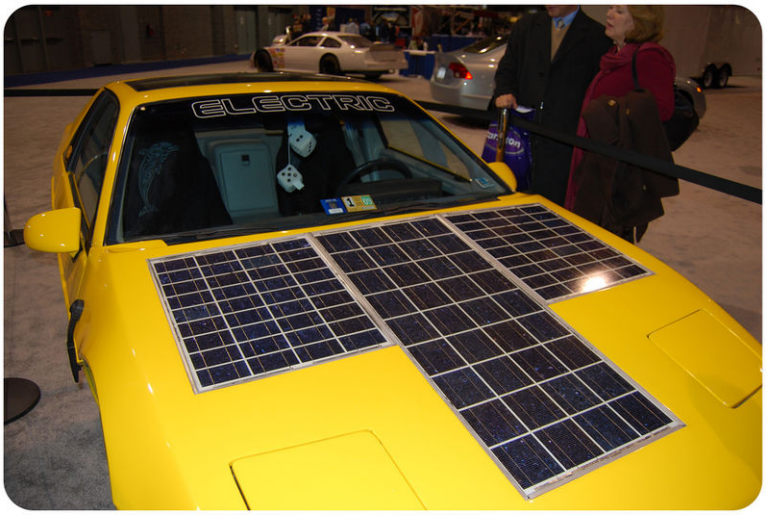


FIGURE 1.27

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.youtube.com/watch?v=4uPVZUTLAvA

1. How effective could solar energy be as a power source?
2. How are fossil fuels solar power? How are wind and hydroelectric power sources from the sun?
3. What do we use to collect solar energy?
4. How do photovoltaic panel work?
5. What is one of the advantages of solar power over power that is generated at large plants?
6. What is the advantage of using mirrors to concentrate solar energy?
7. What is the expensive part of photovoltaics? What is the expensive part of concentrated solar power?

8. How do you get the best of both those technologies?
9. What could we do to keep solar power working at night? What's the problem with this?
10. Rather than discounting solar power because it is expensive, what is another way to look at this?

Practice Answers

1. A good desert collects more solar energy in 6 hours than the entire world uses in a year.
2. They are fossilized plants, which used solar power to grow. The sun drives the atmosphere and the hydrosphere so that they too are really just solar energy.
3. photovoltaic cells
4. If you hit a poly-silicon wafer with light some of the electrons will be knocked off and they will be free electrons. If you dope the silicon with phosphorous to make N-type silicon it is negative, then dope another panel with boron and it makes P-type silicon since it is positive. They are connected with a conductor and can power something with the power they generate.
5. You can generate it in a single location as distributed power. When power is generated at large plants it loses about 30% as it travels to where it is needed. It is also expensive.
6. It makes oil or something very hot. Water can be vaporized and the water turns to steam and moves a turbine.
7. capture of energy; conversion of energy in to electricity
8. Using very sophisticated photovoltaic cells, mirrors can concentrate light on very small photovoltaic cells. The solar panel is no bigger, but the mirrors are bigger. It's called concentrated photovoltaics.
9. Store the energy elsewhere. Its expensive.
10. Climate is changing due to fossil fuel use so maybe it's less expensive to convert to solar than to have to deal with the changes that are coming.

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?

Review Answers

1. Solar panels can be spread across a desert area.
2. It is expensive; it's not so good at night or when it's cloudy; solar panels take up a lot of space.
3. There is a lot of solar energy; it is clean and emits no greenhouse gases.

1.12 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** 1.28).

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

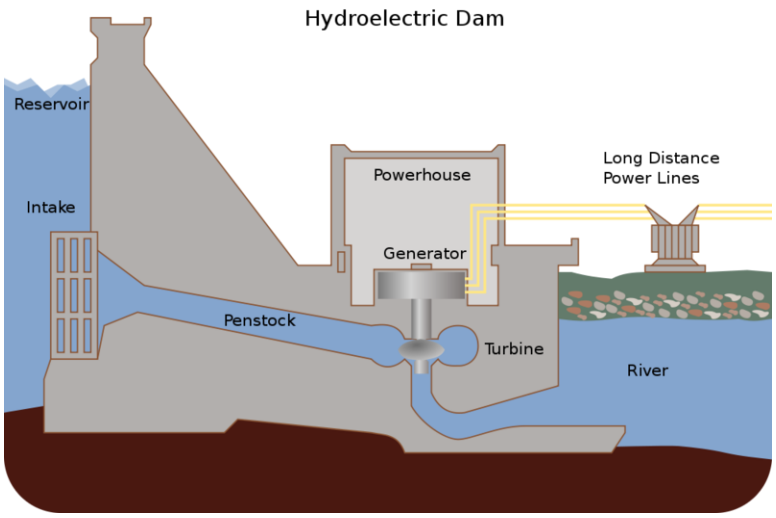


FIGURE 1.28
A cross-section of a hydroelectric plant.

state's nearly 400 hydropower plants are mostly located in the eastern mountain ranges, where large streams descend down a steep grade.

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** 1.29).

FIGURE 1.29
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 use the URL below.

URL: http://gamma.ck12.org/flx/render/embeddedobject/60951

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.

https://www.youtube.com/watch?v=tpigNNTQix8

1. How does a hydropower facility generate electricity?
2. How much of the energy in the US is generated by hydropowr?
3. What makes hydropower renewable?
4. How does an impoundment generate electricity?
5. How does a diversion generate electricity?
6. What is pumped storage hydropower?
7. What is new in hydropower technology?

Practice Answers

1. Water flows from a higher elevation to a lower elevation. It goes through turbines and generators to generate electricity.
2. 7%
3. The water cycle. Water evaporates into clouds then precipitates back to earth. It goes down a stream and goes through a dam.
4. Water is stored in a reservoir. When the water is released it flows through and spins a turbine, turning a generator that generates electricity.
5. A river is diverted through a canal or pipe and it sends it trough a turbine.
6. Water is pumped back up into a reservoir during low energy use. When people need power during the day the water is released to produce electricity.

7. Efficiency is being increased in the components of the system. Dams that were built without hydropower can have hydropower added. New technology is helping to reduce impacts on fish.

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?

Review Answers

1. Water behind a dam has potential energy. When it runs through a turbine it has kinetic energy, which makes the turbine spin.
2. The water uses its kinetic energy to make the turbine spin and the turbine is connected to a generator, which makes electricity.
3. A dam changes ecosystems up and downstream. Landscapes and cultural locations can be lost in the flooded reservoir.

1.13 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 .

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** 1.30).

FIGURE 1.30

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

This animation shows how wind power works: http://www.energysavers.gov/your_home/electricity/index.cfm/mytopic=10501 .

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** 1.31).

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 Gorgonio 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.

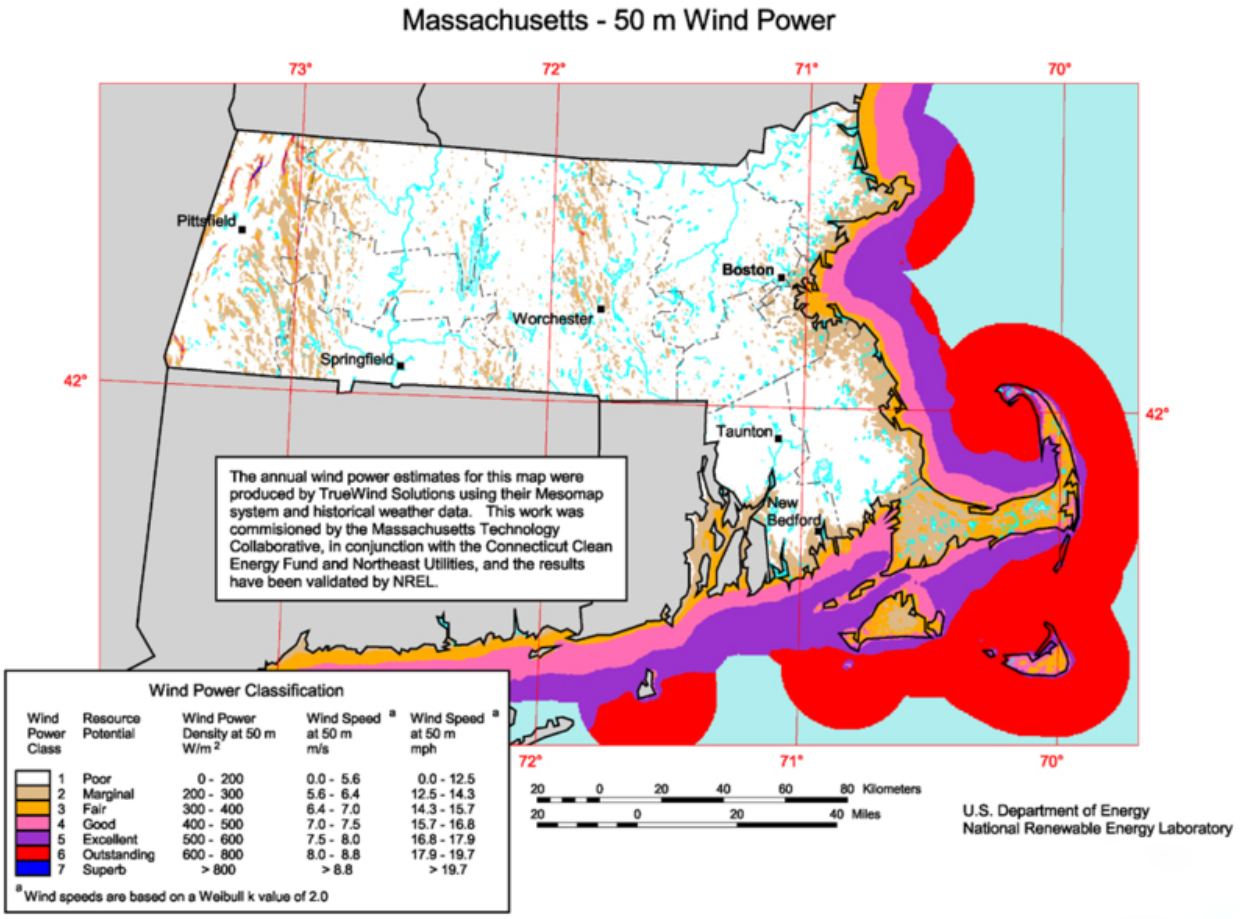


FIGURE 1.31

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.

Practice

Use this resource to answer the questions that follow.

https://www.youtube.com/watch?v=EYYHfMCw-FI

1. Think about what you know about local winds. Why would a desert near tall mountains be a good place for wind turbines?
2. How does a wind turbine capture energy?
3. Why are turbines high in the sky?
4. Are all wind farms on land?

Practice Answers

1. The desert heats up and hot air rises. This draws wind through the mountain passes so the wind whips through. It reaches the desert and generates wind power in the turbines.

2. The blade works like an airplane wing; air passes over both sides of the blade. Due to the shape of the blade the air pressure is uneven, higher on one side than the other. That makes it spin around the center of the turbine. The blades turn a rotor shaft that spins gears that increases the rotation so the generator can produce electricity.
3. It's windier up in the sky.
4. They can also be built offshore.

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?

Review Answers

1. The sun heats a location more than other nearby locations and the air rises. That sucks cooler air in from elsewhere creating wind. The wind has kinetic energy that can be harnessed.
2. Wind turbines are expensive. Wind doesn't blow all the time. Residents can complain about the looks of the wind turbines.
3. Most places have wind and the turbines can be put almost anywhere, even on lands that have other uses, like farmland.

1.14 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** 1.32).

FIGURE 1.32

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

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.

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

MEDIA

Click image to the left for use the URL below.
URL: http://gamma.ck12.org/flx/render/embeddedobject/116511

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.

https://www.youtube.com/watch?v=mCRDf7QxjDk

1. How does geothermal energy work?
2. Where were geothermal plans in the past?
3. How does dry steam geothermal work?
4. How does a flash steam power plant work?

Practice Answers

1. Heat from Earth's crust heats water that has seeped into underground reservoirs. In some places it breaks through to the surface.
2. They could only be in places where hot water flowed near the surface.
3. Underground steam flows to a turbine to drive a generator and produce electricity.
4. A pump pushes hot fluid into a tank at the surface where it cools. As it cools teh fluid turns into vapor which drives a turbine.

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?

Review Answers

1. Hot water comes up to the surface and the steam makes a turbine spin to generate electricity.
2. Water is pumped down to the hot area and then pumped back up to the surface.
3. The technology is improving and it is available to some degree everywhere. Geothermal is clean and renewable.

1.15 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** 1.33). 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 1.33
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/.

Adobe Flash

MEDIA
Click image to the left for use the URL below.
URL: http://gamma.ck12.org/flx/render/embeddedobject/60953

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/.

Adobe Flash

MEDIA
Click image to the left for use the URL below.
URL: http://gamma.ck12.org/flx/render/embeddedobject/60954

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 use the URL below.
URL: http://gamma.ck12.org/flx/render/embeddedobject/60957

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.

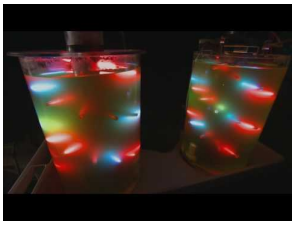
MEDIA
Click image to the left for use the URL below.
URL: http://gamma.ck12.org/flx/render/embeddedobject/60955

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 use the URL below.
URL: http://gamma.ck12.org/flx/render/embeddedobject/453

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.

https://www.youtube.com/watch?v=-ck3FYVNl6s

1. What is used to create biomass fuels?
2. Why do biofuels have an advantage?
3. Besides fuel, what can biomass be used to create?
4. How can biofuels reduce the amount of petroleum we use without entirely replacing it?
5. How are biofuels created?
6. How does biochemical refining work?
7. How does thermochemical refining work?
8. What happens if you add oxygen to the process - thermochemical gasification?
9. Why are biofuels favorable?

Practice Answers

1. trees, plants, forest residues, algae - organic material
2. leftovers can be used to create fuel. Crops can be grown for fuel.
3. plastics, soaps and cosmetics
4. They can be added to fossil fuels to reduce the amount we use.
5. Biomass solids are broken down and then refined into biofuels.
6. Enzymes break down the biomass into liquid sugars. Microbes ferment sugars into usable fuel.
7. Extreme heat in an anaerobic environment biomass is broken down into biocrude oil that can be refined.
8. Biomass solids are converted to gas and that gas is converted to biofuel.
9. They are clean and renewable.

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?

Review Answers

1. Algae can be grown with less land and energy, and in places where other crops can't be grown. Algae can be fed wastes and it's carbon neutral.
2. Corn must be grown on land that can also be used to grow food. Corn takes a lot of energy to grow so the net energy produced is not high. The fertilizers and pesticides used to grow corn may be damaging to the environment.
3. It takes a lot of energy to grow some crops. If the amount of energy that is obtained from that crop as a biofuel is now that great then the crop may not be worth growing for fuel.

1.16 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** 1.3 shows some common objects, the materials they are made from, and whether they are renewable or non-renewable.

TABLE 1.3: Common Objects We Use From the Earth

Common Object	Natural Resources Used	Are These Resources Renewable or Non-Renewable?
Cars	15 different metals, such as iron, lead, and chromium to make the body.	Non-renewable
Jewelry	Precious metals like gold, silver, and platinum. Gems like diamonds, rubies, emeralds, turquoise.	Non-renewable

TABLE 1.3: (continued)

Common Object	Natural Resources Used	Are These Resources Renewable or Non-Renewable?
Electronic Appliances (TV's, computers, DVD players, cell phones, etc.)	Many different metals, like copper, mercury, gold.	Non-renewable
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.	Non-renewable and Renewable
Gasoline	Petroleum drilled from wells.	Non-renewable
Household Electricity	Coal, natural gas, solar power, wind power, hydroelectric power.	Non-renewable and Renewable
Paper	Trees; Sunlight Soil.	Renewable
Houses	Trees for timber. Rocks and minerals for construction materials, for example, granite, gravel, sand.	Non-renewable and Renewable

Summary

- Many objects, such as a car, contain many types of resources.
- Resources may be renewable or non-renewable, 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.

https://www.youtube.com/watch?v=xqoQfN9DgNs

1. What do we use neodymium for?
2. What are rare earth elements used for in general?
3. Where do we get our REEs? Why are there signs that this can't continue?
4. Can we develop alternatives?
5. What is the problem with the deposit of REEs that is offshore of Japan?
6. What is the danger for the future?

Practice Answers

1. medical imagine equipment, wind power turbines, medications
2. LCD screens, mobile phones, computers, sources of renewable energy
3. China provides 95%, but we need so much and demand is skyrocketing.
4. REEs are good because they can do things that are tiny; there are no good alternatives.
5. We can't figure out how to mine it safely and efficiently.

6. China running out of their supply before we can get it from other places.

Review

1. What resources are important to you that are renewable? Non-renewable?
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 non-renewable?

Review Answers

1. Most resources are non-renewable, but some are renewable. Plant fibers are renewable for clothing and soil for food are renewable. Water can be renewable if its treated right. All metals and fossil fuels are nonrenewable, although some are in huge supply.
2. Answers will vary, but may include water, fossil fuels, and things to make stuff.
3. If a resource, especially a biological resource, is overused it could go from renewable to non-renewable because it can't reproduce fast enough to keep up with demand.

1.17 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** 1.34) 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.

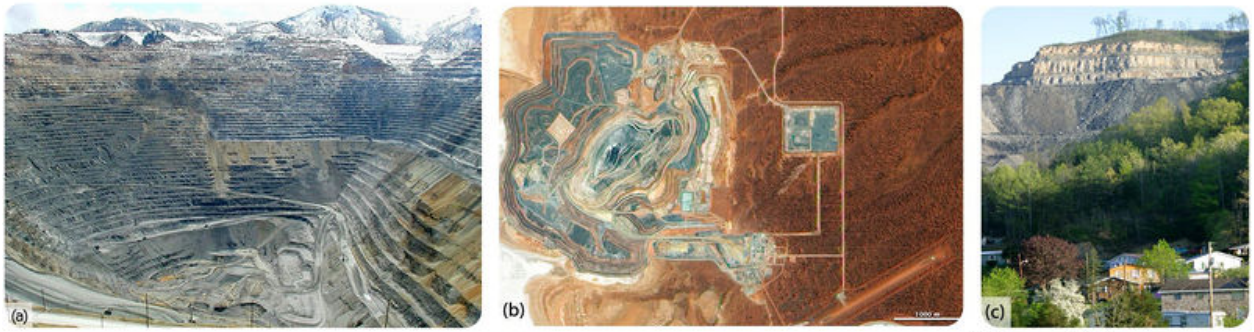
FIGURE 1.34

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

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.

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** 1.35, 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.



Bingham Canyon Open Pit Copper Mine

An aerial view of an open pit gold mine in Australia

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 1.35

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 1.36
Underground mine.

Ore Extraction

The ore's journey to becoming a useable material is only just beginning when the ore leaves the mine (**Figure** 1.37). 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^{o}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.

FIGURE 1.37
Enormous trucks haul rock containing ore from a mine site to where the rock is processed.

FIGURE 1.38
A steel mill.

Summary

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

http://news.discovery.com/earth/videos/how-gold-mining-works-video.htm

1. How does panning for gold work?
2. What is prospecting?
3. What are the countries with the most gold currently?
4. Where is the most gold in the world and why don't we mine it?
5. What is open pit mining?
6. How is a deposit that is not near the surface mined?
7. What happens to the chunks of rock that are sent to the mill?
8. What is one problem with this type of mining?
9. What is smelting?
10. What happens to the gold after smelting?'
11. Why is gold worth so much more than iron?

Practice Answers

1. Gold is heavy than most minerals so you shake the pan and the rocks and water come off and the gold stays at the bottom.
2. Searching out sites that contain enough gold to be profitable.
3. South Africa, the U.S., Australia
4. The most gold is the ocean floor and we don't have a cost effective way to get to it.
5. Detonate explosives to create chunks of rocks.
6. Miners drill an access shaft and dig multiple vertical pits out from that. They place explosives through the stokes, the chunks get carted to the mill.
7. The rocks are crunched into fine dust, mixed with water, cyanide and oxygen are added and suck the gold out.
8. After the leaching is over the cyanide has to be disposed of.
9. All the little bits of gold are thrown into a furnace with flux that gets rid of stuff other than gold.
10. The gold is poured into solid bars and sent to refineries to get rid of remaining impurities.
11. Gold is much harder to obtain and purify than iron.

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?
4. Why should you recycle your aluminum cans?

Review Answers

1. The deposit can become economical to mine. This could happen if technologies improve or the price of the resource goes up.
2. Bauxite is extracted and refined and the aluminum must be moved to where it is needed. To extract the metal fro the ore the temperature must be extremely high.
3. The rock is crushed and the minerals are separated by one of many processes.
4. Refining aluminum takes so much energy that it's way more energy efficient to recycle.

1.18 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 concept "Materials Humans Use," you can see that many of the resources we depend on are non-renewable. Non-renewable resources vary in their availability; some are very abundant and others are rare. Materials, such as gravel or sand, are technically non-renewable, 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** 1.39). As the cost of desalination plants comes down, more will likely be built.

FIGURE 1.39
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. Twelve countries have approximately 80% of all of the world's oil (**Figure** 1.40). 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 the chapter 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** 1.41).

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.

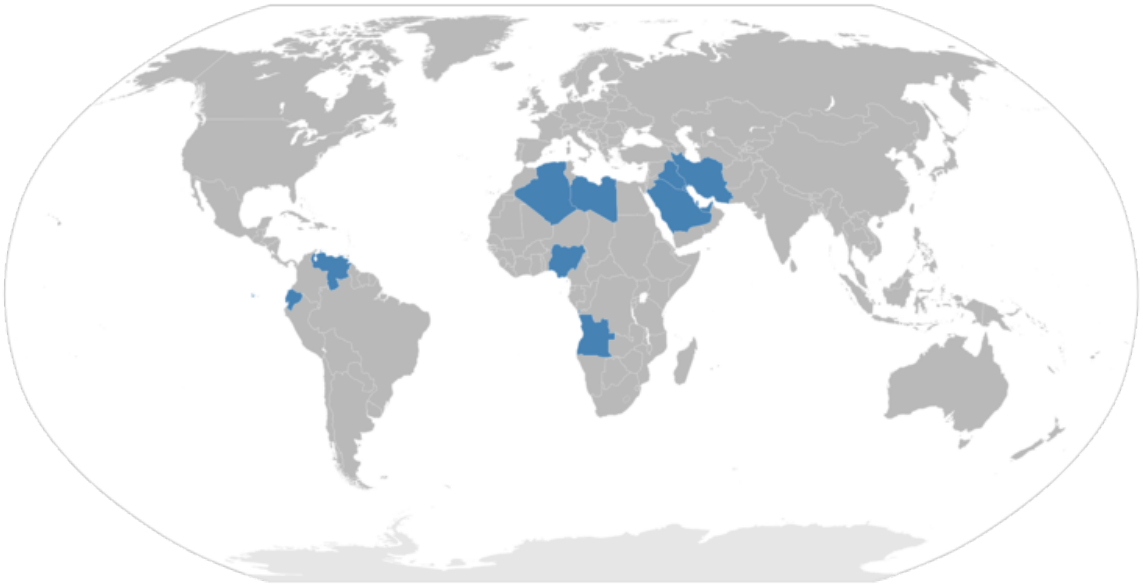


FIGURE 1.40

The nations in blue are the 12 biggest producers of oil; they are Algeria, Angola, Ecuador, Iran, Iraq, Kuwait, Libya, Nigeria, Qatar, Saudi Arabia, the United Arab Emirates, and Venezuela.

FIGURE 1.41

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

Practice

Use the resource below to answer the questions that follow.

- **Where Does E-Waste End Up?** at http://www.youtube.com/watch?v=0JZey9GJQP0 (7:43)

MEDIA

Click image to the left for use the URL below.

URL: http://gamma.ck12.org/flx/render/embeddedobject/1564

1. What is **e-waste**?
2. Why are they melting computer circuit boards?
3. Why are the workers doing this work?
4. What metals are they extracting from these computers?
5. What do CRTs contain?
6. What do computer batteries contain?
7. How can these chemicals harm people? Which people are most at risk and why?
8. Why do computers from North America and Europe end up in India for recycling? #Which factors go into this difference in costs?
9. How often do you replace you computer or cell phone?

Practice Answers

1. Electronic waste such as computers, smart phones, etc.
2. They strip off the computer chips and transistors.
3. They are recycling the valuable materials, such as the heavy metals.
4. The metals include lead, mercury, cadmium, copper, silver and gold.
5. high levels of poisonous lead
6. toxic cadmium
7. They burn eyes, do damage to the nervous system and kidneys. Children are most at risk because they are still growing.
8. Recycling in India is $2, in the US and Europe is $20. In India labor costs are much lower and health and environmental regulations are not nearly as strict.
9. Answers will vary.

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?

Review Answers

1. It is cheap to dump it there and the people look for usable materials in the trash.
2. Some nations have things that other nations want so this can be a source of conflict.
3. Some nations have a higher disposable income per capita so the people in those nations buy more goods, which generates more wastes. Where people can barely make ends meet, they don't have the luxury of buying consumer goods.

1.19 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** 1.42). 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).
- Recycle materials such as metal cans, old cell phones, and plastic bottles.

FIGURE 1.42
Recycling can help conserve natural resources.

- 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:

- "Mamirarua" 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 use the URL below.

URL: http://gamma.ck12.org/flx/render/embeddedobject/54764

Practice

Use this resource to answer the questions that follow.

http://www.globalonenessproject.org/library/interviews/reduce-reuse-recycle

1. What does reduce refer to?
2. What does reuse refer to?
3. What is good about recycling trends?
4. What role can artists play in making people aware?

Practice Answers

1. The US is some of the biggest consumers in the world so we should reduce consumption.
2. Do not use things only once. Use them multiple times.
3. The amount of materials being recycled are increasing all the time.
4. Photographers can take photos of wsste and e-waste.

Review

1. Why should you use renewable resources rather than non-renewable 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?

Review Answers

1. We won't run out of renewable resources so in the long term they are the smarter choice.
2. Recycling is ore energy efficient and better at conserving materials than creating something new.
3. Plastic bottles are a tremendous source of waste and they are not necessary. Often the water in them isn't any better than water from the tap.

Summary

Natural resources, including energy resources, may be renewable or non-renewable. Non-renewable resources will not be replaced faster than they can be used up; when they're gone, they're gone. Renewable resources can be replaced as rapidly or more rapidly than they are used, so they can supply human activities forever. Fossil fuels are very popular non-renewable resources. Cheap, abundant fossil fuels have been responsible for the development of modern human society due to their impact in transportation, industrialization and agriculture. Nuclear energy is also non-renewable because the necessary element uranium is limited. Renewable resources tend to be clean, with less or even no pollution or greenhouse gas emissions, but they come with their own problems. Some are relatively expensive, hard to develop, or difficult to find locations for. Increasing demand for renewable resources increases

the research going into them, so the technologies are improving and becoming less expensive. Still, there are some problems that may not be resolved except on a case-by-case basis, such as the siting of wind farms. The best and cheapest way to increase resource availability is conservation, which can be done by an individual, a family, an industry or a society.

1.20 References

1. User:Awesomoman/Wikimedia Commons. Fire is a source of energy. Public Domain
2. Chad Teer. Picture of an offshore drilling oil platform. CC BY 2.0
3. Image copyright Brad Sauter, 2014. Picture of a train hauling coal. Used under license from Shutterstock.com
4. Hana Zavadska. Graph of energy use in the United States. CC BY-NC 3.0
5. Hans Pama. An old windmill in the Netherlands. CC BY 2.0
6. Geoff Gallice. This wetland may look something like an ancient coal-forming swamp. CC BY 2.0
7. Ben Mills (User:Benjah-bmm27/Wikimedia Commons). Structure of methane. Public Domain
8. Courtesy of the US Geological Survey and the Mineral Information Institute. Lump of bituminous coal. Public Domain
9. User:RoRo/Wikimedia Commons. Map showing the continents during the Carboniferous period. Public Domain
10. Courtesy of the US Geological Survey. US coal producing regions in 1996. Public Domain
11. (a) JW Randolph; (b) Rennett Stowe. Coal used in power plants must be mined by methods such as mountaintop removal. (a) Public Domain; (b) CC BY 2.0
12. User:Oceanh/Wikimedia Commons, modified by CK-12 Foundation. Anticlinal structural trap - traps oil between rock layers. CC BY 3.0
13. Walter Siegmund. Picture of an oil refinery, which separates crude oil. CC BY 2.5
14. Courtesy of the US Energy Information Administration. . Public Domain
15. Flickr:Loco Steve. Drill rigs at San Ardo Oil Field, California. CC BY 2.0
16. Courtesy of MODIS Rapid Response Team/NASA's Earth Observatory. Gulf of Mexico oil spill in April 2010. Public Domain
17. Courtesy of the U.S. Energy Information Administration (April 2002). Map showing gas production in the Lower 48 United States. Public Domain
18. Roy Luck. A natural gas drill rig in Texas. CC BY 2.0
19. User:HêRø/Wikimedia Commons. Map of worldwide oil reserves. Public Domain
20. Courtesy of NASA's Earth Observatory. A satellite image of an oil-sands mine in Canada. Public Domain
21. User:Fastfission/Wikimedia Commons. Illustration of nuclear fission. Public Domain
22. Gretchen Mahan. Picture of a nuclear power plant in France. CC BY 2.0
23. Alberto Otero García. Uranium mine in Kakadu National Park, Australia. CC BY 2.0
24. Image copyright Sergey Kamshylin, 2014. Abandoned building near the site of the Chernobyl disaster. Used under license from Shutterstock.com
25. Courtesy of NASA. Solar array panels on International Space Station. Public Domain
26. Flickr:afloresm. A solar power tower is used to concentrate the solar energy collected by many solar panels. CC BY 2.0
27. Daniel Borman (Flickr:borman818). Picture of a solar car. CC BY 2.0
28. User:Tomia/Wikimedia Commons. A cross-section of a hydroelectric plant. CC BY 2.5
29. Image copyright Manamana, 2014. Glen Canyon Dam in Arizona created Lake Powell. Used under license from Shutterstock.com
30. Andre Engels. Wind turbines provide electricity. CC BY 2.0
31. Courtesy of National Renewable Energy Laboratory/US Department of Energy. Cape Wind off of Cape Cod in Massachusetts. Public Domain
32. Gretar Ívarsson. A geothermal energy plant in Iceland. Public Domain
33. Michael Coté. Ethanol is added to gasoline. CC BY 2.0
34. Courtesy of US Geological Survey/Mineral Information Institute. Aluminum is made from the aluminum-bearing minerals in bauxite. Public Domain

35. (a) Flickr:Loco Steve; (b) Courtesy of Jesse Allen/NASA's Earth Observatory; (c) Matt Wasson; Composite created by CK-12 Foundation. Open pit mines, and mountaintop removal. (a) CC BY 2.0; (b) Public Domain; (c) CC BY 2.0
36. Flickr:mjtmail (tiggy). An underground mine. CC BY 2.0
37. Peter Craven. Enormous trucks haul rock containing ore from a mine site to where the rock is processed. CC BY 2.0
38. Třinecké železárny. Picture of a steel mill. The copyright holder of this file allows anyone to use it for any purpose provided that the copyright holder is properly attributed
39. Image copyright Anthony Jay D. Villalon, 2014. Desalination plant in Tampa Bay, Florida. Used under license from Shutterstock.com
40. User:Bourgeois/Wikimedia Commons. Map of the 12 biggest producers of oil. Public Domain
41. Courtesy of the US Environmental Protection Agency. Garbage and trash alongside a road. Public Domain
42. Terence Ong. Recycling bins. CC BY 2.5