

CHAPTER 13

ENERGY RESOURCES – FOSSIL FUELS

Important Concepts

1. *Fossil fuels* are nonrenewable energy sources formed from the remains of organisms and plants that lived in the geologic past. These include:

Oil (petroleum): a mixture of various liquid hydrocarbons formed from the accumulation of marine microorganisms rapidly buried by sediments.

Natural gas: a mixture of gaseous hydrocarbons, mostly methane (CH₄), formed also from marine microorganisms like petroleum but under different conditions of temperature.

Coal: a solid, carbonaceous fuel formed from ancient land plants. Grades of coal listed in order of increasing carbon content are lignite, bituminous, and anthracite.

Oil shale: a sedimentary rock containing hydrocarbons in the form of kerogen.

Tar sand: a sedimentary rock containing a thick, tar-like petroleum.

At present, oil, natural gas, and coal are the main sources of energy for the world and the United States.

2. Once the solid organic matter is converted to liquids or gases, the hydrocarbons migrate through permeable rocks and accumulate where impermeable rocks prevent further migration. The exploration of hydrocarbon reservoirs is a search for structures (*traps*) favorable for oil/gas accumulation.
3. Much of the world's oil and natural gas deposits are concentrated in a few countries, especially in the Middle East countries. The world distribution of production and consumption of oil and natural gas are also very even.
4. The United States faces rapidly declining reserves of oil and natural gas, and at present the U.S. imports about 50% of its annual consumption of oil. The discovery of additional reservoirs of oil and natural gas through exploration, enhanced oil recovery methods, the extraction of natural gas from geopressurized zones and appropriate conservation measures might extend oil and gas reserves; however, such measures are not necessarily economically feasible and not without environmental risk. Oil spills caused by accidents during drilling and transport in tankers continue to be major environmental concerns.
5. The United States possesses about 25% of the world's coal reserves — an amount that could satisfy the energy needs of the country for more than two hundred years at current levels of energy use, if coal were a more versatile fuel. The conversion of coal to liquid fuels (liquefaction) or to gaseous fuels (gasification) is possible but subject to economic considerations and concerns over detrimental environmental impacts.
6. The mining and burning of coal create several environmental hazards. Among these are:

The release of carbon dioxide into the atmosphere, which enhances the greenhouse effect.

The release of sulfur gases into the atmosphere, which contributes to acid rainfall.

The accumulation of coal ash that may contain unacceptable concentrations of toxic metals.

Coal-mining hazards such as mine collapse, contraction of black lung disease from breathing coal dust, exposure to radioactive radon gas, explosions, and underground fires in coal mines.

Problems associated with strip-mining, including acidification of streams and lakes from runoff water containing sulfuric acid and disturbance of the original topography.

7. The United States has about two-thirds of the world's known resources of oil shale, but no production at present because of a lack of economically viable processing technology and potential environmental impacts. The United States has virtually no tar sand deposits, but extensive tar sand deposits occur in Canada (the Athabasca deposits) and are being mined at present.

Key Terms

acid rainfall
anaerobic
anthracite
bituminous coal
enhanced oil recovery
fossil fuel
gasification (coal)
geopressurized zones
greenhouse effect
hydrocarbon

kerogen
lignite
liquefaction (coal)
methane hydrate
natural gas
nonrenewable resource
oil (petroleum)
oil shale
tar sand

Multiple Choice

- Oil, natural gas, and coal are examples of
 - fossil fuels.
 - hydrocarbon fuel.
 - nonrenewable resources.
 - All of the above are correct.
- As societies evolve from primitive to technological, the energy consumption associated with agriculture
 - increases.
 - decreases.
 - remains constant.
 - may either increase or decrease depending upon what foods the individuals eat.
- As heat and pressure act upon petroleum, it finally becomes
 - oil.
 - tar.
 - natural gas.
 - coal.
- One barrel of oil is equal to how many gallons?
 - 21
 - 42
 - 56
 - 100

5. The nation having the largest proven reserves of crude oil is
 - a. the United States.
 - b. Kuwait.
 - c. Saudi Arabia.
 - d. Algeria.

6. Petroleum accounts for about _____ percent of the energy used in the United States.
 - a. 10
 - b. 25
 - c. 40
 - d. 75

7. Natural gas supplies about _____ percent of the energy used in the United States.
 - a. 5
 - b. 11
 - c. 15
 - d. 25

8. An oil well “gusher” would be an example of
 - a. primary recovery.
 - b. secondary recovery.
 - c. forced recovery.
 - d. enhanced recovery.

9. Geopressurized zones might one day become an important source of
 - a. petroleum.
 - b. natural gas.
 - c. lignite.
 - d. kerogen.

10. The reservoir now believed to contain the largest amount of carbon is
 - a. the atmosphere.
 - b. natural gas.
 - c. coal (bituminous and anthracite).
 - d. gas hydrates.

11. Which one of the following fuels would give off the most heat per given unit weight?
 - a. peat
 - b. lignite
 - c. bituminous
 - d. anthracite

12. Coal subjected to overly high temperatures will metamorphose into
 - a. graphite.
 - b. oil shale.
 - c. tar sand.
 - d. peat.

13. The largest recoverable U.S. energy reserve is
 - a. petroleum.
 - b. coal.
 - c. natural gas.
 - d. uranium oxide.

14. The worst oil spill in United States waters was the
- Santa Barbara spill
 - Amoco Cadiz* spill
 - Exxon *Valdez* spill
 - Torrey Canyon* spill
15. Coal supplies about _____ percent of the energy used in the United States.
- 10
 - 25
 - 50
 - 80
16. The substance found in coal that contributes to acid rainfall is
- carbon.
 - sulfur.
 - chlorine.
 - nitrogen.
17. The environmental disaster that has affected the town of Centralia, Pennsylvania was caused by
- toxic coal-ash residue.
 - acid rainfall.
 - an underground coal-mine fire.
 - an oil spill.
18. The United States has about two-thirds of the world's known resources of
- tar sands.
 - natural gas.
 - coal.
 - oil shale.
19. The hydrocarbon fuel in oil shale is
- petroleum.
 - kerogen.
 - natural gas.
 - methane.
20. All of the following are problems in the development of oil shale in the U.S. as a viable energy resource except
- extraction and processing technologies are not competitive with those of conventional petroleum.
 - environmental problems associated with the surface mining of oil shale.
 - the problem of waste rock disposal.
 - the low quality of the oil.

Fill In the Blanks

- _____ are hydrocarbon energy sources formed from the remains of once-living organisms.
- _____, or petroleum, is not a single chemical compound, but a liquid mixture of various hydrocarbons.
- _____ is the most common gaseous hydrocarbon in natural gas.
- _____ energy resources are those not being replenished or formed on a human time scale.

5. The term _____ describes processes that occur in the absence of oxygen.
6. _____ is a soft, brown coal formed directly from peat.
7. _____ is the process by which coal is converted into a gaseous hydrocarbon fuel.
8. _____ is the process by which coal is converted into a liquid hydrocarbon fuel.
9. _____ is a sedimentary rock containing the waxy hydrocarbon fuel called kerogen.
10. _____ are sedimentary rocks containing a viscous, tar-like petroleum.

True or False

Indicate whether the following statements are true or false. If false, correct the statement to make it true.

- ____ 1. Oil and natural gas are believed to have formed from the bodies of large land animals such as dinosaurs.
- ____ 2. Most petroleum source rocks are highly permeable, coarse-grained, clastic sedimentary rocks.
- ____ 3. Most petroleum is found in rocks no older than one to two million years old.
- ____ 4. The United States consumes about 10% of all the world's oil resources.
- ____ 5. Coal formation from land plants takes place under conditions in which oxygen is absent, or nearly so.
- ____ 6. The United States has consumed almost half of its total coal resources.
- ____ 7. The richest oil shale deposits in the United States occur in the western states of Colorado, Utah, and Wyoming.
- ____ 8. The potential fuel in tar sands is a waxy solid called kerogen.
- ____ 9. The United States has about two-thirds of the world's supply of tar sands.
- ____ 10. The United States obtains almost 90% of its energy from fossil fuels.

Review Questions

1. How do deposits of (a) oil and natural gas and (b) coal form?
2. Discuss the status of oil and natural gas reserves in the United States. How do these reserves compare with the world reserves?
3. What percentage of the oil consumption in the United States is being met by importing foreign oil? What measures should be adopted to reduce the oil imports?
4. Discuss the potential adverse environmental impacts of coal utilization.
5. Describe the cause and impact of the Valdez oil spill on the environment.
6. What are gas hydrates and where are they found? Is this a viable future source of natural gas?
7. The United States has vast resources of oil shale, but it is not mined at present. What are the problems associated with the exploitation of this resource?

Surfing the Net

Online version of “Annual Energy Review,” a comprehensive compilation of U.S. and international energy information (Energy Information Administration, U.S. Department of Energy):
<<http://www.eia.doe.gov/emeu/aer/>>

General information about energy (U.S. Geological Survey):
<<http://www.usgs.gov/themes/energy.html>>

General information about oil spills and other sources of pollution in the marine environment (International Tanker Owners’ Pollution Federation):
<<http://www.itopf.com/>>

A summary of sulfur and nitrogen emission trends:
<<http://capita.wustl.edu/CAPITA/CapitaReports/EmisTrends/soxnema.html>>

CHAPTER 13 ANSWER KEY

Multiple Choice

- | | | | |
|--------------------|----------------------|-----------------------|-------|
| 1. d | 6. c | 11. d | 16. b |
| 2. a (figure 13.1) | 7. d | 12. a | 17. c |
| 3. c | 8. a | 13. b (figure 13. 15) | 18. d |
| 4. b | 9. b | 14. c | 19. b |
| 5. c (figure 13.5) | 10. d (figure 13.10) | 15. b | 20. d |

Fill In the Blanks

- | | |
|-----------------|-----------------|
| 1. Fossil fuels | 6. Lignite |
| 2. Oil | 7. Gasification |
| 3. Methane | 8. Liquefaction |
| 4. Nonrenewable | 9. Oil shale |
| 5. anaerobic | 10. Tar sands |

True or False

1. False. Oil and natural gas are believed to have formed from the remains of accumulated marine microorganisms.
2. False. The majority of petroleum source rocks are fine-grained clastic sedimentary rocks of low permeability.
3. False. Almost no petroleum is found in rocks younger than 1 to 2 million years old.
4. False. The United States consumes over 25% of the oil used worldwide.
5. True
6. False. The United States has consumed only a few percent of its coal resources. United States reserves could satisfy the country's energy needs for more than two centuries at current use levels.
7. True
8. False. The potential fuel in tar sands is a thick, tar-like petroleum. Kerogen is a waxy solid found in oil shales.
9. False. The United States has almost no tar-sand reserves.
10. True