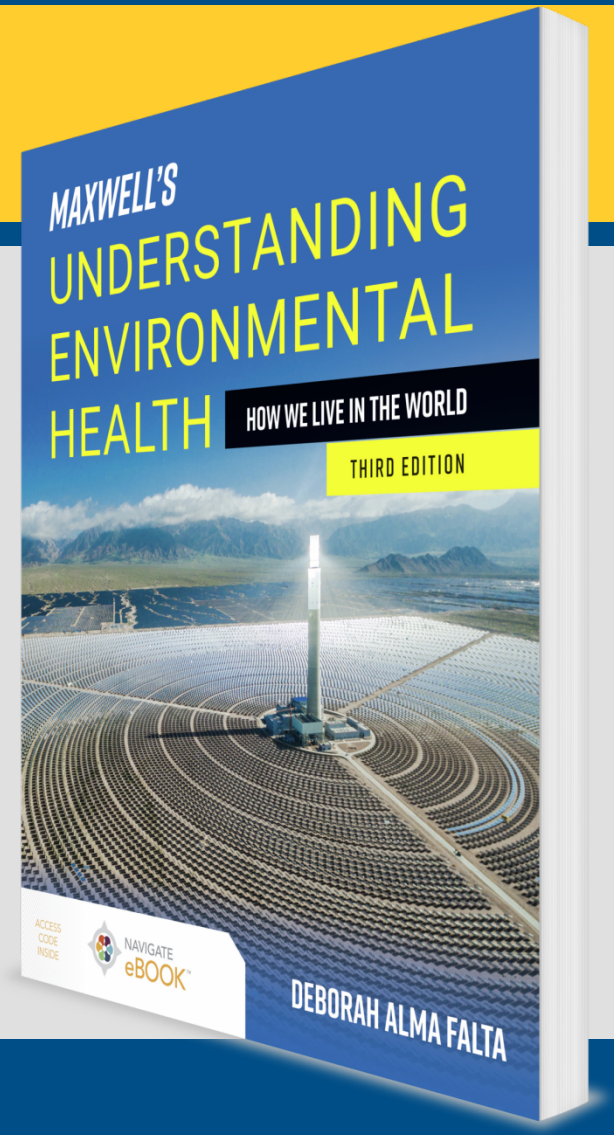
CHAPTER 7

Producing Energy



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7.1 Sources of Energy

7.2 Electricity from Fossil Fuels

7.3 Electricity from Nuclear Fuel

7.4 Energy from Renewable Resources

7.5 Energy Conservation

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Sources of Energy (1 of 3)

- Our modern world consumes *lots* of energy!
  - To power heavy agricultural equipment and transportation
  - To generate the electricity to light and heat our homes and businesses, plus run industrial machinery and our electronics
- However, production of energy exacts a toll on our environmental resources and poses many direct risks to our health at each stage:
  - Acquiring the energy resource
  - Transport and conversion to power
  - The disposal of any associated waste

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Sources of Energy (2 of 3)

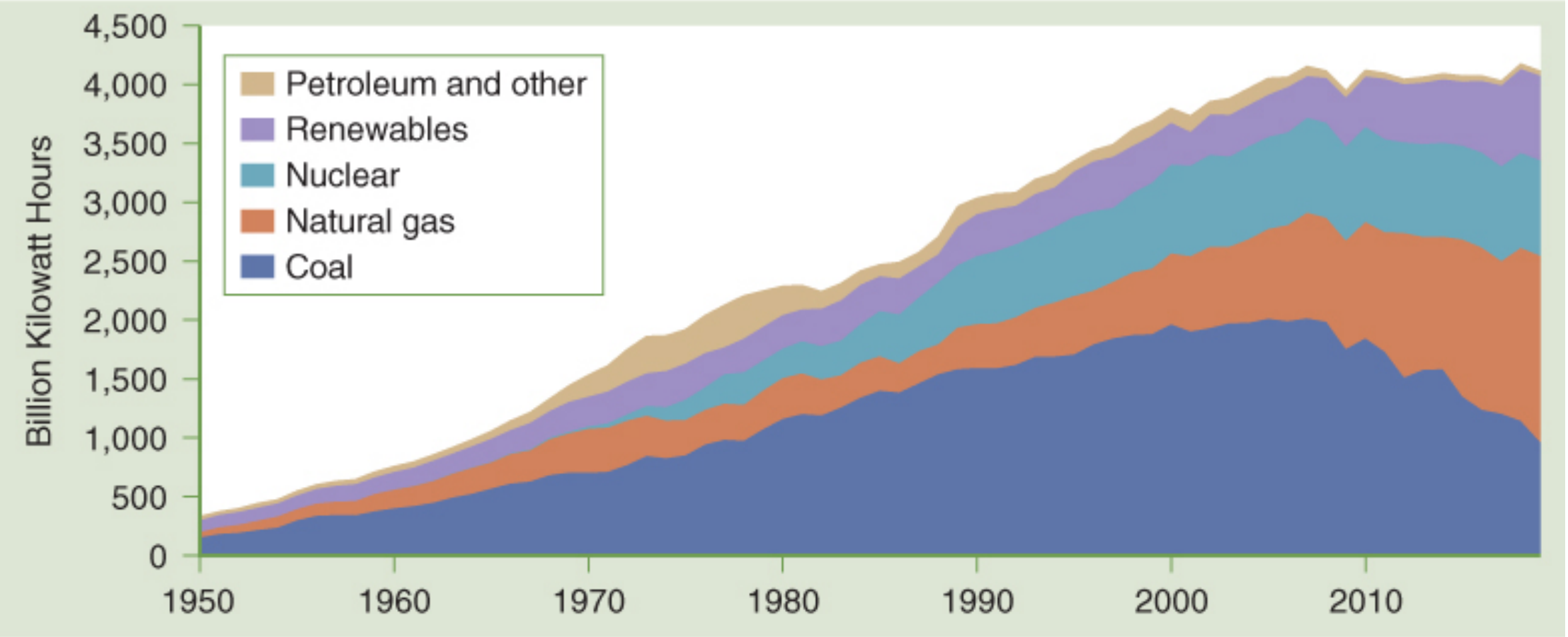

FIGURE 7.1 Electricity generation from 1950 to now by source.

Data from U.S. Energy Information Administration. Monthly Energy Review, Table 7.2a, March 2020 and Electric Power Monthly, February 2020, preliminary data for 2019.

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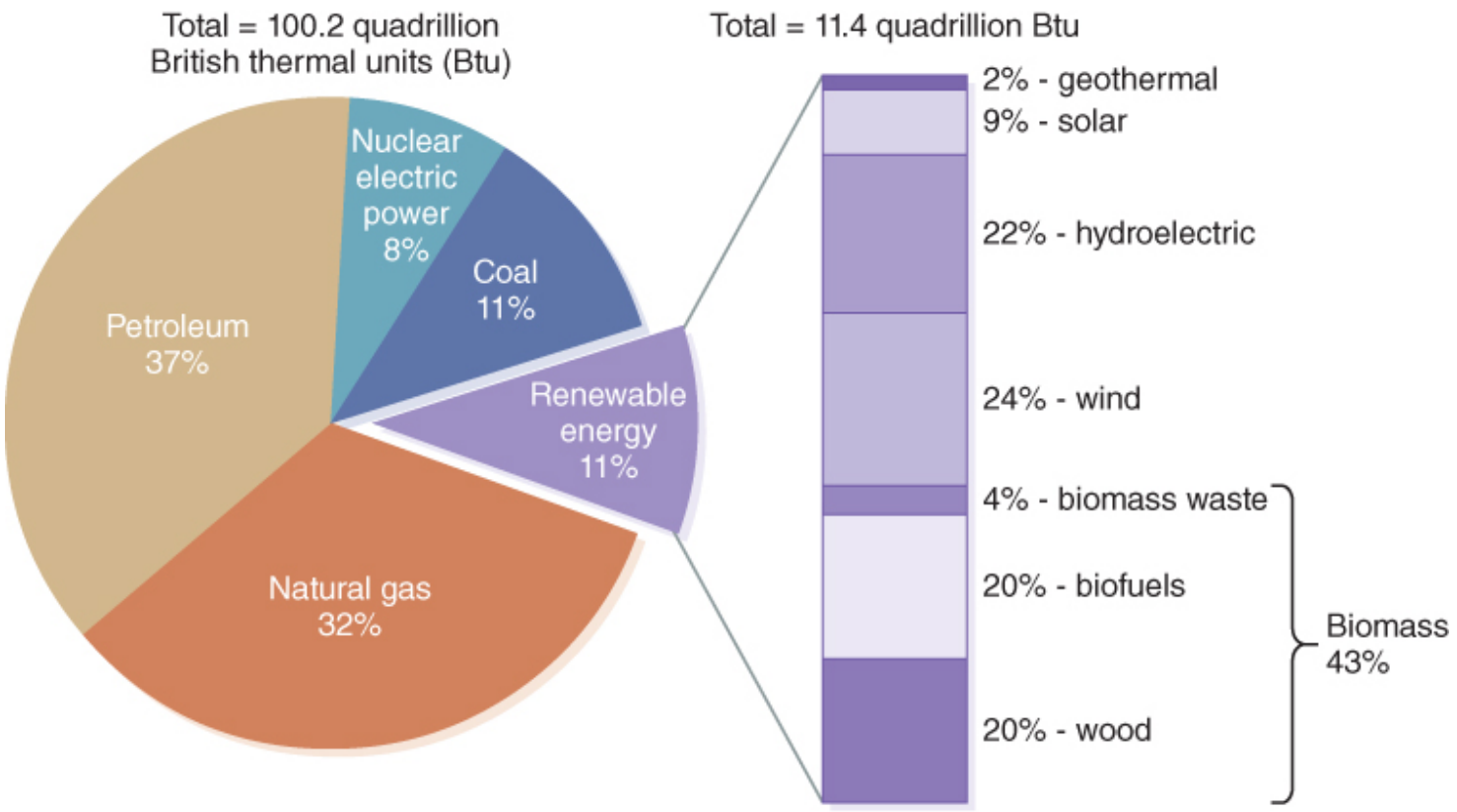
Sources of Energy (3 of 3)



Note: Sum of components may not equal 100% because of independent rounding.

FIGURE 7.2 U.S. 2019 Energy Consumption by Source.

Data from U.S. Energy Information Administration. Monthly Energy Review, Tables 1.3 and 10.1, April 2020, Preliminary Data..

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Introduction

- Fuels: substances that release energy when they are changed (e.g., burned)
  - Fossil fuels (aka hydrocarbon fuels)
    - Formed from decayed plants and animals laid down millions of years ago
    - Oil, coal, natural gas
    - Nonrenewable

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Extraction of Fossil Fuels

Environmental Impacts of Burning Fossil Fuels

Health Impacts of Burning Fossil Fuels

Global Climate Change

Regulation of Air Pollution from the Burning of Fossil Fuels

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Environmental and Health Effects of Coal Mining

- Acid mine drainage
- Surface mining (strip mining)
  - Destruction of landscape
- Underground mining
  - Respiratory effects: fibrosis, pneumoconiosis (“black lung”), silicosis
  - Fire, explosion, acute injury

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Extraction of Fossil Fuels

FIGURE 7.3 U.S. coal miners, circa 1930–1960, wear no respiratory protection as they operate a mechanized coal bin loader.

Courtesy of CDC Public Health Image Library. ID# 9558. Content providers CDC/Barbara Jenkins, NIOSH. Available at: http://phil.cdc.gov/phil/home.asp. Accessed October 14, 2012.

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Environmental and Health Effects of Oil and Gas Extraction

- Hazards to workers, wastes of drilling
- Oil spills: *Deepwater Horizon*, *Exxon Valdez,* oil pipelines
- ***Fracking***: hydraulic fracturing
  - Process that creates many small cracks in the rock and keeps them open so that gas can flow from the well
  - Achieved by injecting large quantities of a mixture made up mostly of water and sand, but also containing chemicals, into the well at high pressures
  - Process may be repeated a number of times at the same well.
  - The gas produced is accompanied by water contaminated by byproducts of the process.

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Extraction Using Fracking

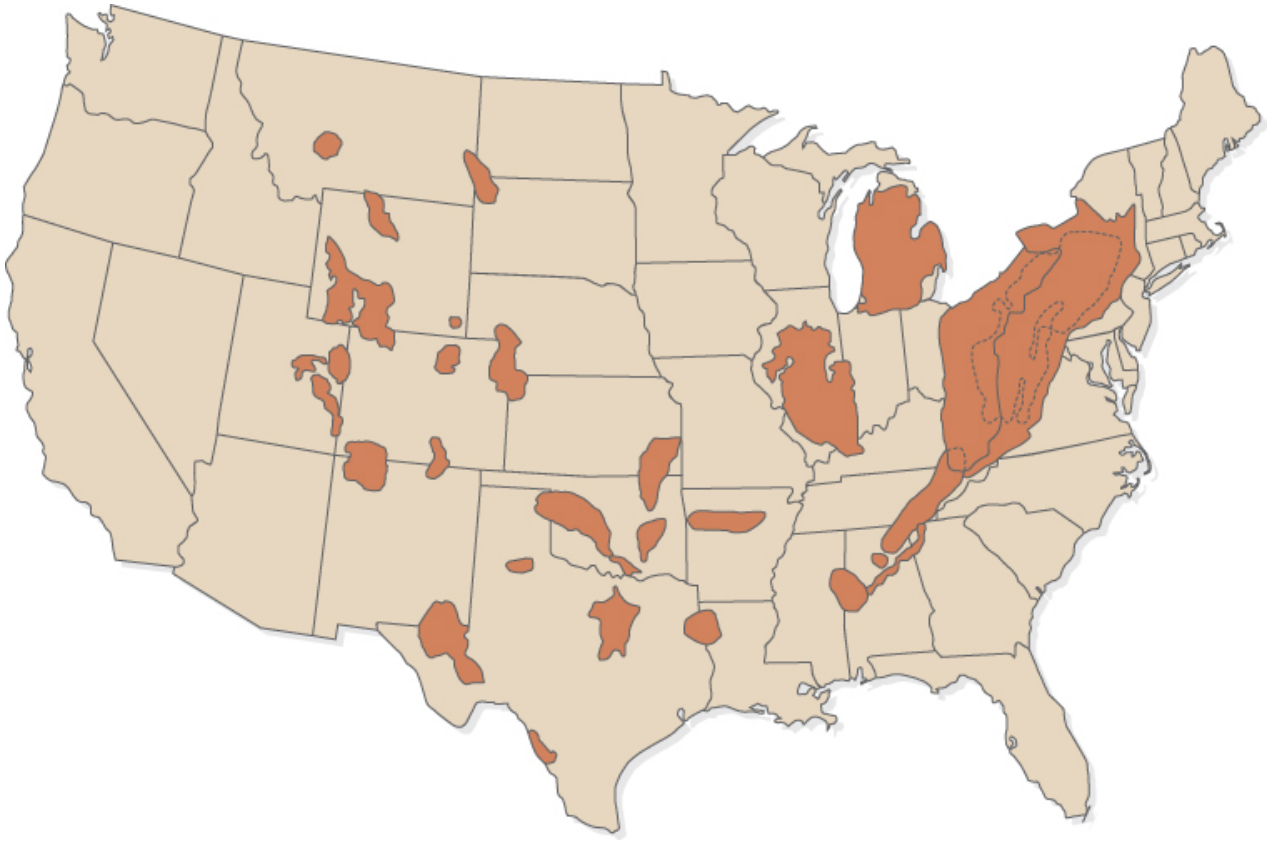

FIGURE 7.4 Shale basins in the lower 48 U.S. states.

U.S. Department of Energy. Modern Shale Gas Development in the United States: A Primer. April 2009. Available at: www.netl.doe.gov/technologies/oil-gas/publications/EPreports/Shale_Gas_Primer_2009.pdf. Accessed March 28, 2012.

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Fracking is Controversial

Benefits

- Helped U.S. achieve energy independence
  - Reducing reliance on trade and associated geopolitical tensions
- Fracking has created jobs and generated income.
  - Particularly in regions that were economically depressed
- Natural gas is a cleaner-burning fuel to use for electricity generation, reducing emissions of CO2

Drawbacks

- Methane released
  - Contributes to pollution and poses hazards to workers and nearby residents
- Water contamination associated with the chemicals used during the process and introduced to drinking water from naturally occurring sources
- Seismic instability and subsidence in regions with extensive fracking sites

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Air Pollution from Burning Fossil Fuels (1 of 4)

- Basic products of combustion: oxides and particulates
  - Key sources of pollutants: vehicles, electric power plants, heating of buildings, manufacturing
  - Combustion is oxidation; hence oxides of carbon, nitrogen, sulfur
  - Particulate matter (PM)
    - Complex mixture
    - Polycyclic aromatic hydrocarbons (PAHs): organic compounds with multiple carbon rings which make up some particulates

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Air Pollution from Burning Fossil Fuels (2 of 4)

Table 7.1 Key Sources of Major Air Pollutants from Burning Fossil Fuels

Pollutant	*Sources of Pollutants*			
	Vehicles (gasoline, diesel)	Electric Power Plants (coal, oil)	Heating Buildings (oil, natural gas)	Manufacturing (coal, oil, natural gas)
Basic products of the combustion process				
Carbon dioxide (CO_2)	x	X	x	X
Carbon monoxide (CO)	x			
Nitrous oxide (N_2O)	x	X		
Nitrogen dioxide (NO_2), Nitric oxide (NO)	x	x		
Sulfur dioxide (SO_2)		X		(some)
Particulate matter (PM)	x	X	x	X
Other pollutants liberated by combustion				
Mercury (from coal)		X		(some)
Lead (from leaded gasoline)	x			
Volatile organic compounds (from gasoline)	x			

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Air Pollution from Burning Fossil Fuels (3 of 4)

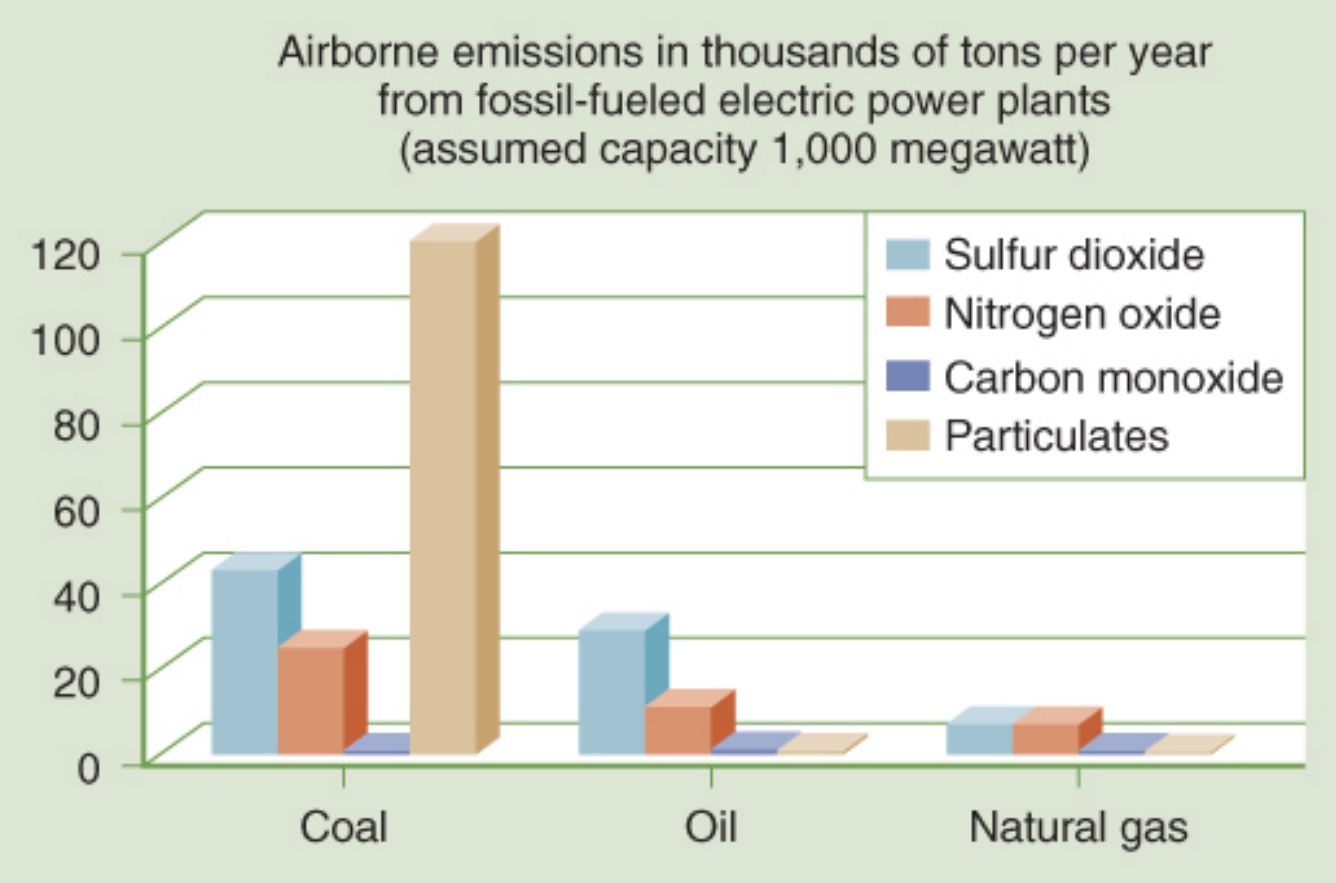

FIGURE 7.5 Comparison of airborne emissions from coal, oil & natural gas.

Data from Moeller DW. *Environmental Health* (3rd ed.). Harvard University Press. 2005.

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Air Pollution from Burning Fossil Fuels (4 of 4)

- Other pollutants liberated by combustion
  - Mercury (neurotoxic): present in coal
    - Converted to methylmercury; bioaccumulates and biomagnifies; high concentrations in large fish
  - Lead (neurotoxic): gasoline additive
    - Burden of lead in soil
  - Volatile organic compounds
    - Some naturally present in oil; others added to gasoline
    - Released to air when oil or gasoline is burned

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Secondary Pollutants Formed in the Atmosphere

- Ozone
  - Key component of photochemical smog
  - Formed from NO_X, VOCs, and other chemicals in the presence of sunlight
- Nitric acid and sulfuric acid from oxides of nitrogen and sulfur
  - Acid deposition (“acid rain”)

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Health Impacts of Burning Fossil Fuels (1 of 7)

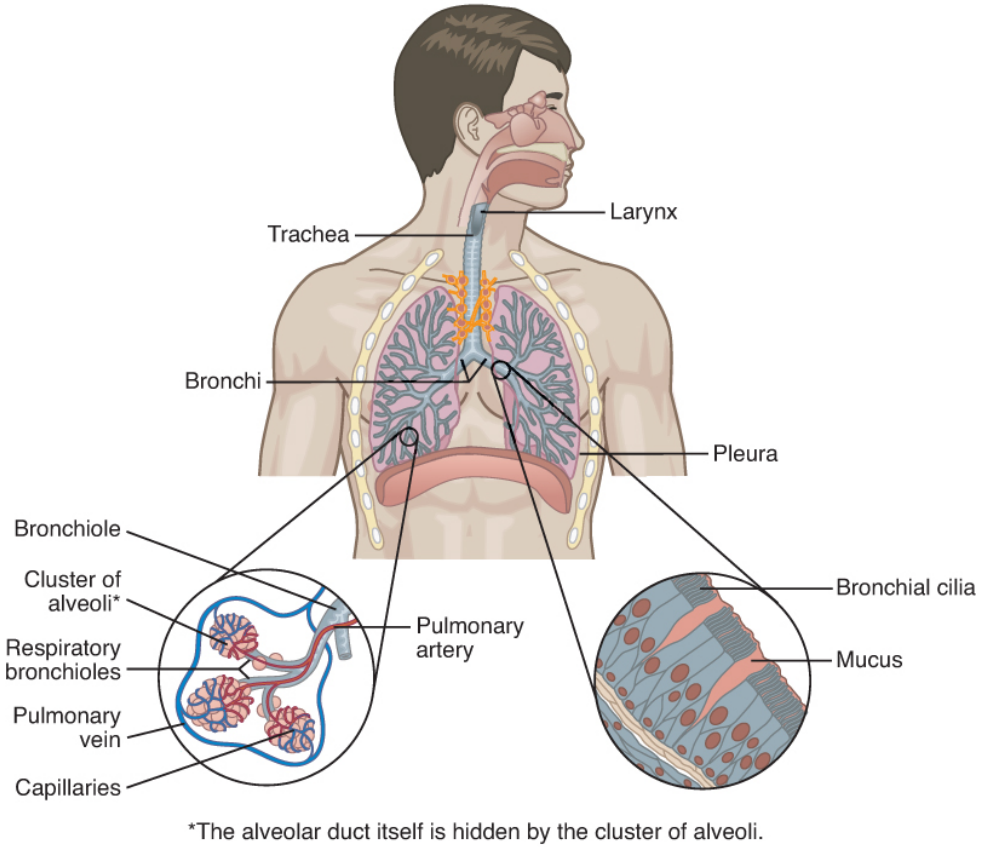

FIGURE 7.6 The human respiratory system.

Data from 2012 American Lung Association. www.lung.org

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Health Impacts of Burning Fossil Fuels (2 of 7)

- Key physiologic processes:
  - Inhalation
  - Respiration
  - Mucociliary escalator

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Health Impacts of Burning Fossil Fuels (3 of 7)

- Sources and fate in respiratory system depends upon particulate size
  - Size classifications:
    - PM_{10}: respirable
    - $PM_{2.5}$: “fine” (mostly from combustion)
    - Ultrafine particulates

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Health Impacts of Burning Fossil Fuels (4 of 7)

Table 7.3 Likely Sources and Fates of Respirable Particulates, by Size Category

Diameter (microns)	Key Sources	Penetration and Fate in Body
2.5 to 10	Natural and mechanical sources	Settle out in trachea and bronchi; are removed via mucociliary escalator
0.1 to < 2.5	Combustion	Reach small airways and alveoli; in alveoli, are removed by macrophages
< 0.1 (ultrafine)	Combustion (especially of diesel fuel)	Can pass through alveolar wall into bloodstream

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Health Impacts of Burning Fossil Fuels (5 of 7)

Table 7.4 Key Respiratory Effects of Common Air Pollutants

Pollutant	Effects in Respiratory System			
	Irritating Effects			
	Damage to Cells Lining the Respiratory Tract	Local Inflammation	Bronchoconstriction	Impairment of Immune Scavenger Cells in Alveoli
PM	x	X		x
NO_2			(in asthmatics)	x
SO_2			x	
O_3	x	X	(in asthmatics)	

Data from Bernstein JA. Health effects of air pollution. *J Allergy Clin Immunol*. 2004;114:1116-1123; Chen-Yeung, MN. Air pollution and health. *Hong Kong Med J*. 2000;6:390-398; Costa DL, Amdur MO. Air pollution. In Klaassen CD, ed. *Casarett & Doull's Toxicology: The Basic Science of Poisons* [5th edition]. McGraw-Hill. 1996:857-880; Olivieri D, Scoditti E. Impact of environmental factors on lung defences. *Eur Respir Rev*. 2005;14:51-56.

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Health Impacts of Burning Fossil Fuels (6 of 7)

- Health impacts of particulates and pollutant gases
  - A turning point: the London Smog
  - PM, NO_2, SO_2, O_3 have been linked to:
    - Acute overall mortality and acute cardiovascular mortality [20,21,26]
    - Acute stroke mortality [32]
    - Acute morbidity (hospital admissions for: any respiratory disease, chronic obstructive pulmonary disease; any cardiovascular disease, heart failure)[21,22, 30,31]
    - Exacerbation of asthma [20, 34-38]
    - Infant mortality and low birth weight[41]

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Health Impacts of Burning Fossil Fuels (7 of 7)

- PM linked to:
  - Long-term overall mortality, lung cancer mortality, acute and chronic cardiopulmonary mortality [28,29]
  - Cardiovascular mortality and hospitalizations [31]
  - Reduced life expectancy [30]
- Greatest impact of air pollution on mortality is through effects on cardiovascular disease

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Global Climate Change (1 of 8)

- Anthropogenic gases and the enhanced greenhouse effect
  - Burning of fossil fuels puts sequestered carbon back into circulation as CO_2
  - Enhances natural greenhouse effect
  - CO_2 is single most influential greenhouse gas.
  - Lesser greenhouse gases: methane, ozone, halocarbons, nitrous oxide

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Global Climate Change (2 of 8)

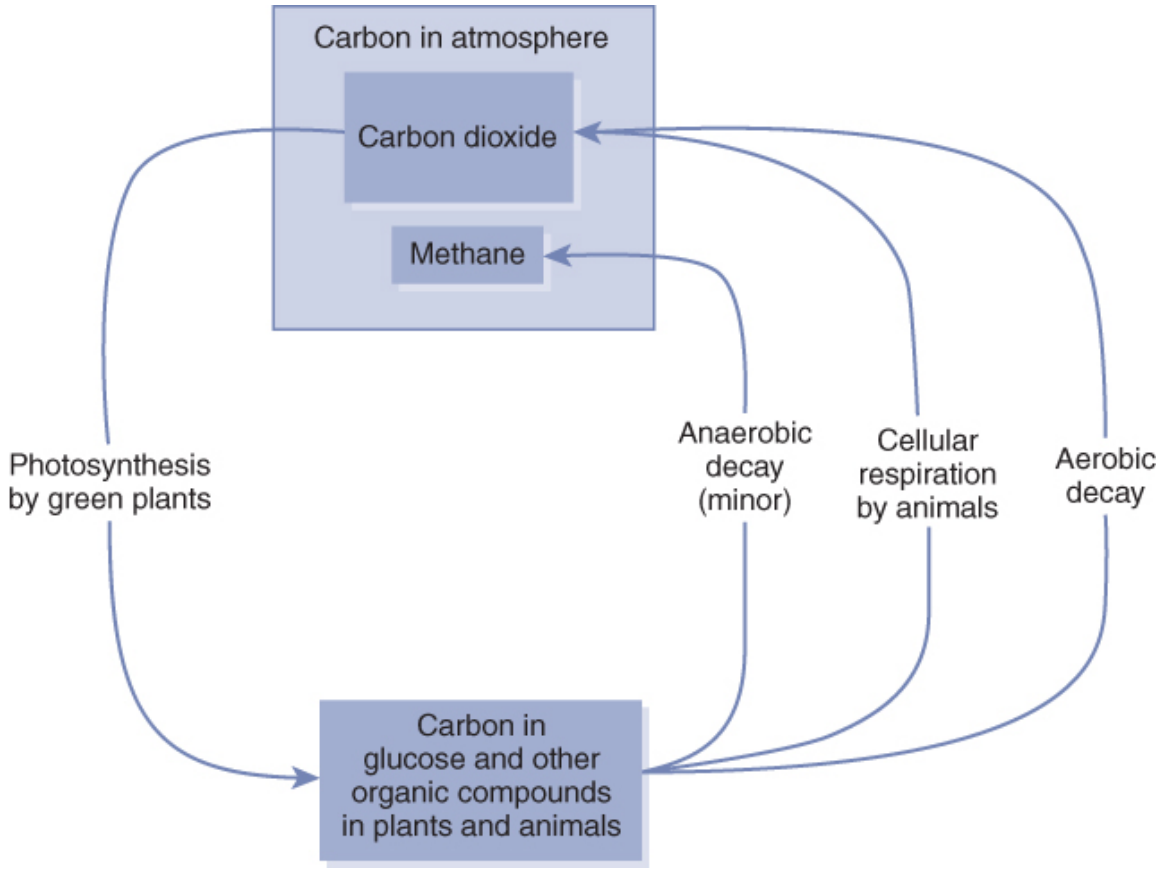

FIGURE 7.7 The global carbon cycle (excluding fossil fuels).

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Global Climate Change (3 of 8)

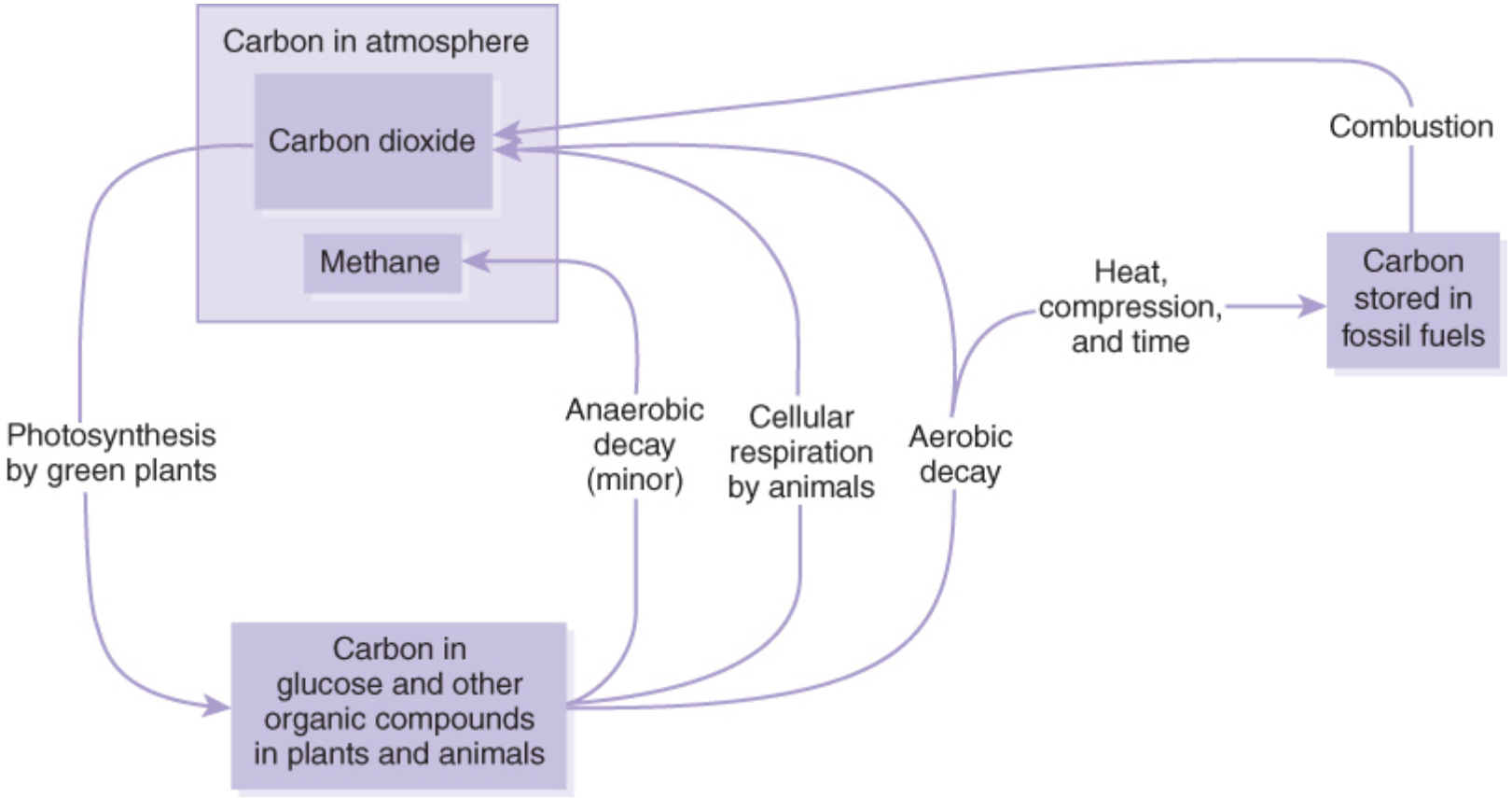

FIGURE 7.8 The global carbon cycle (including fossil fuels).

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Global Climate Change (4 of 8)

- Environmental impacts of global climate change
- Intergovernmental Panel on Climate Change (IPCC) assessments (1990, 1995, 2001, 2007, 2014)
- IPCC observations[47]:
  - The global surface temperature rose by approximately 0.74°C (about 1.3°F) from 1906 to 2005.
  - There has been a worldwide decline since the mid-1960s in the area covered by snow and glaciers.
  - In 2014, global sea level was 2.6 inches above the 1993 average.[48]

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Global Climate Change (5 of 8)

Table 7.5 Percentage of Net Gain in Energy in the Earth–Atmosphere System from Five Major Greenhouse Gases That Are Attributable to Each Gas

Greenhouse Gas	Percentage of Net Gain
Carbon dioxide	56.5
Methane	16.3
Ozone	10.2*
Halocarbons**	11.6
Nitrous oxide	5.4

*The warming effect of ozone as listed here represents the net effect of an increase in tropospheric ozone (caused mostly by the burning of fossil fuels) and the depletion of stratospheric ozone (caused by certain organic chemicals, described elsewhere).

** Organic compounds containing halogens, such as chlorine or fluorine.

Data from Intergovernmental Panel on Climate Change. Technical summary. In *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press. 2007.

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Global Climate Change (6 of 8)

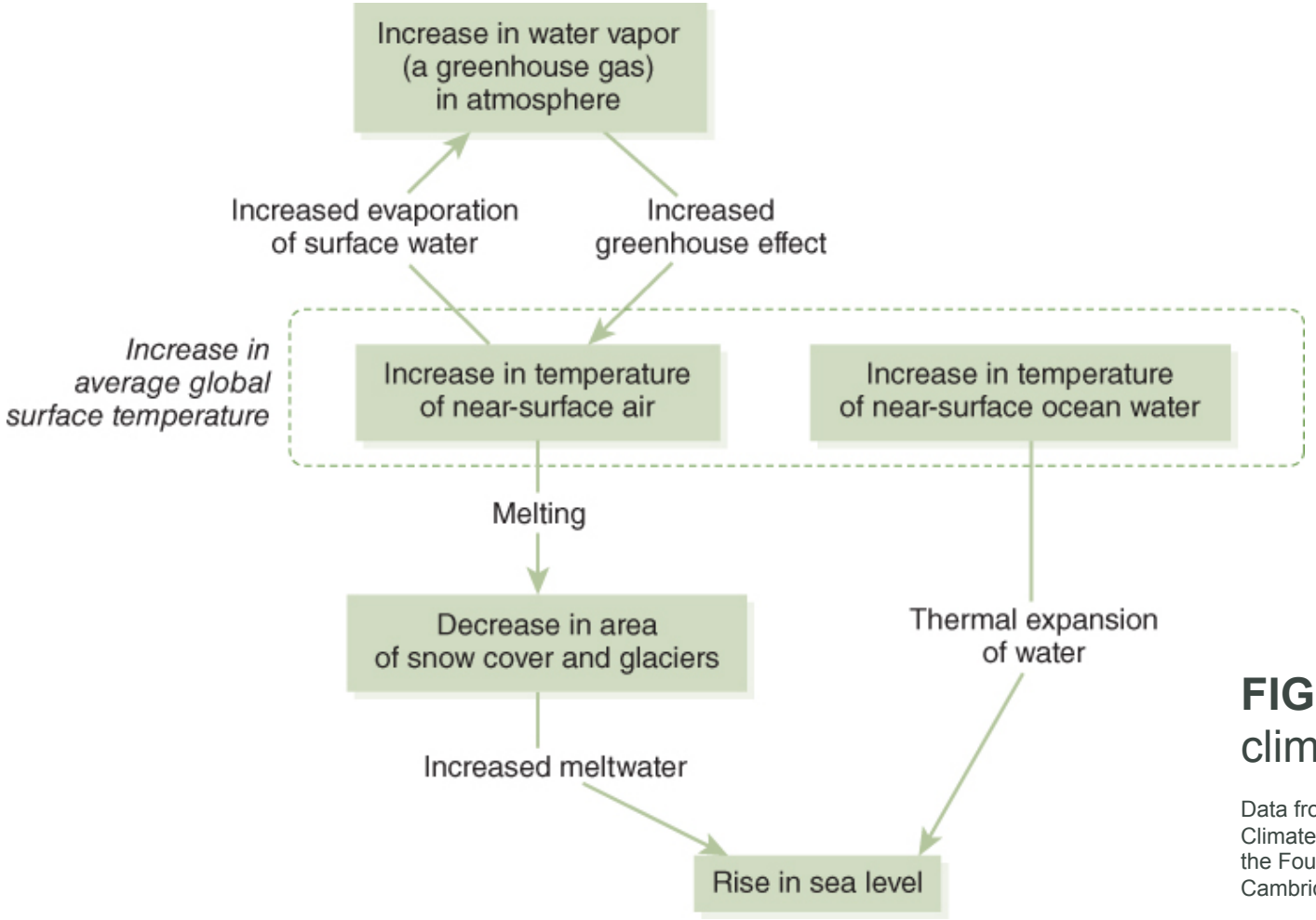

FIGURE 7.9 Connections among major climate-related environmental changes.

Data from Intergovernmental Panel on Climate Change. Technical summary. In Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press. 2007.

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Global Climate Change (7 of 8)

- Human health impacts of global climate change[51-53]
  - Higher temperatures → increased range of disease vectors
  - Coastal flooding → impacts on food supplies; refugees
  - Extreme weather events → crop failures, injuries, famine, infectious disease

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Global Climate Change (8 of 8)

- International Agreements on Global Climate Change
  - The U.N. Conference on Environment and Development in Rio de Janeiro (1992)
  - The Kyoto Protocol on global climate change (1997; went into effect in 2005)
  - The Paris Climate Agreement (2015)

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Regulation of Air Pollution from Burning of Fossil Fuels (1 of 4)

- U.S. Clean Air Act
  - National Ambient Air Quality Standards (NAAQS): health-based limits on concentration in ambient air for six common pollutants called Criteria Air Pollutants
  - National Emission Standards for 188 Hazardous Air Pollutants: emissions limits for long list of less common, more toxic pollutants
    - To date, only 7 of 188 listed have been regulated

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Regulation of air pollutants

Table 7.6 Current National Ambient Air Quality Standards

Pollutant	Concentration	Averaging Time
Carbon monoxide	9 ppm 35 ppm	8-hour 1-hour
Nitrogen dioxide	53 ppb 100 ppb	Annual 1-hour
Sulfur dioxide	75 ppb	1-hour
Particulate matter (PM_{10})	150 mg/m^3	24-hour
Particulate matter ($PM_{2.5}$)	12 mg/m^3 35 mg/m^3	Annual 24-hour
Lead	0.15 mg/m^3	Rolling 3-month average
Ozone	0.070 ppm	8-hour

Note: Units of parts per million (ppm) and parts per billion (ppb) are by volume. For additional detail on the form of the standard, see source.

U.S. Environmental Protection Agency. *National Ambient Air Quality Standards (NAAQS)*. Available at: www.epa.gov/air/criteria.html. Accessed July 23, 2020.

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Regulation of Air Pollution from Burning of Fossil Fuels (2 of 4)

- Regulation of mobile sources of air pollution (vehicles):
  - Tailpipe emissions, with state inspections
  - Engine performance (e.g., mileage requirements)
  - Fuel: unleaded gasoline, limits on VOCs in gas
- 2007 Supreme Court decision: CO_2 can be regulated as an air pollutant

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Regulation of Air Pollution from Burning of Fossil Fuels (3 of 4)

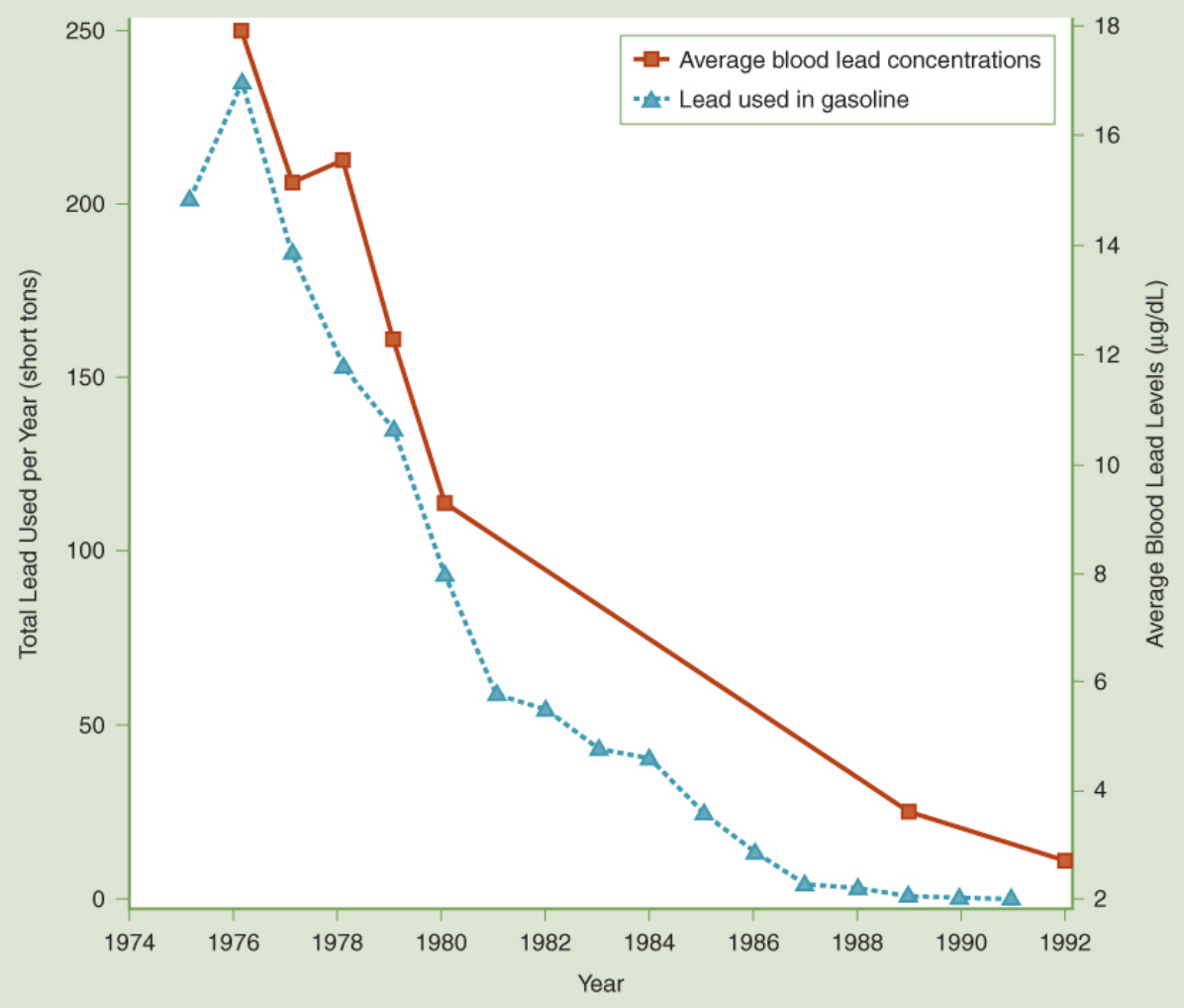

FIGURE 7.11 Decline in lead used in gasoline, and of average blood levels in U.S. children, 1974–1992.

U.S. Environmental Protection Agency. Great Lakes National Program Office. Great Lakes Binational Toxics Strategy Report on Alkyl-lead: Sources, Regulations and Options, 2000. Available at: www.epa.gov/glnpo/bns/lead/Step%20Report/steps.pdf. Accessed April 12, 2008.

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Regulation of Air Pollution from Burning of Fossil Fuels (4 of 4)

- National Environmental Policy Act (NEPA; 1970)
  - Requires all federal agencies in the executive branch of government to evaluate and disclose the environmental impacts of their proposed actions
  - May involve an environmental impact statement (EIS)

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The Nuclear Fuel Cycle

Health Impacts of the Nuclear Fuel Cycle

Regulation of Activities in the Nuclear Fuel Cycle

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The Nuclear Fuel Cycle (1 of 11)

- The front end of the nuclear fuel cycle
  - Mining; piles of waste rock (tailings)
  - Milling
    - Yellowcake
    - Also leaves tailings enrichment
    - *Increases* proportion U-235 by *removing* U-238 from yellowcake

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The Nuclear Fuel Cycle (2 of 11)

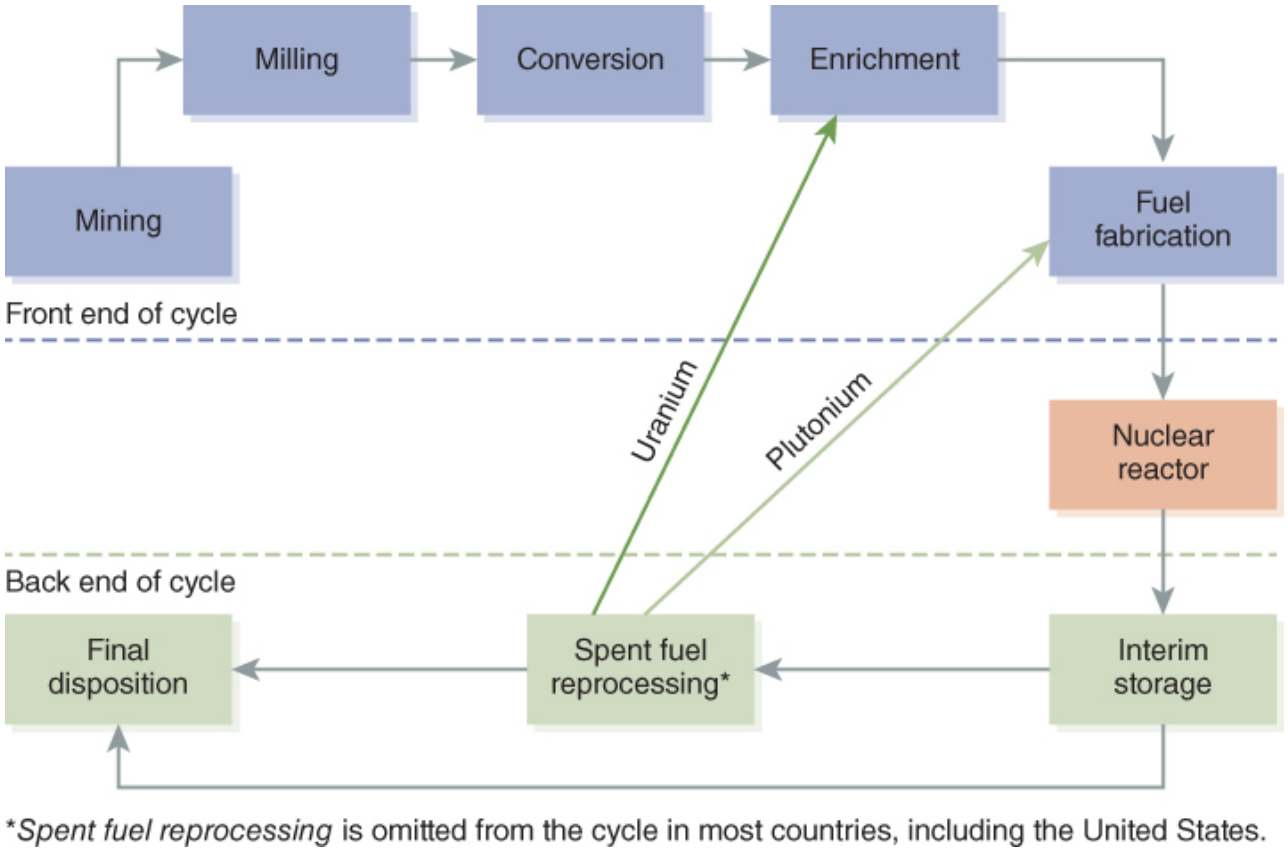

FIGURE 7.12 The nuclear fuel cycle.

U.S. Energy Information Administration. Nuclear explained, The nuclear fuel cycle. Available at: https://www.eia.gov/energyexplained/nuclear/the-nuclear-fuel-cycle.php

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The Nuclear Fuel Cycle (3 of 11)

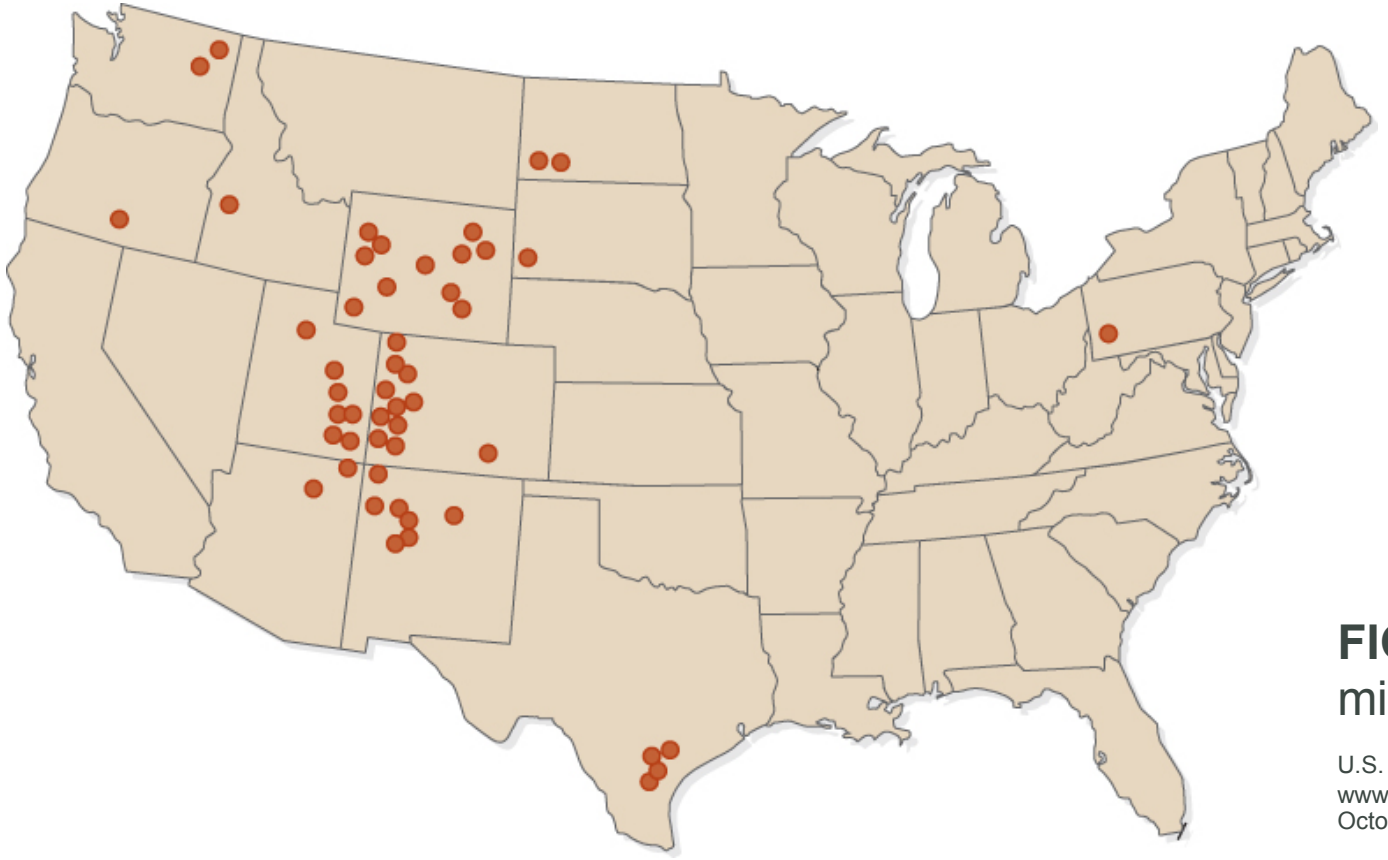

FIGURE 7.13 Locations of uranium mill tailings piles in the United States.

U.S. Environmental Protection Agency. Uranium mill tailings. Available at: www.epa.gov/rpdweb00/docs/radwaste/402-k-94-001-umt.htm. Accessed: October 14, 2012.

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The Nuclear Fuel Cycle (4 of 11)

- Nuclear power plants
  - 58 plants in U.S., mostly in eastern U.S.
  - Normal operations
    - Controlled nuclear fission chain reaction
    - Fuel rods, control rods
    - Containment building, cooling towers

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The Nuclear Fuel Cycle (5 of 11)

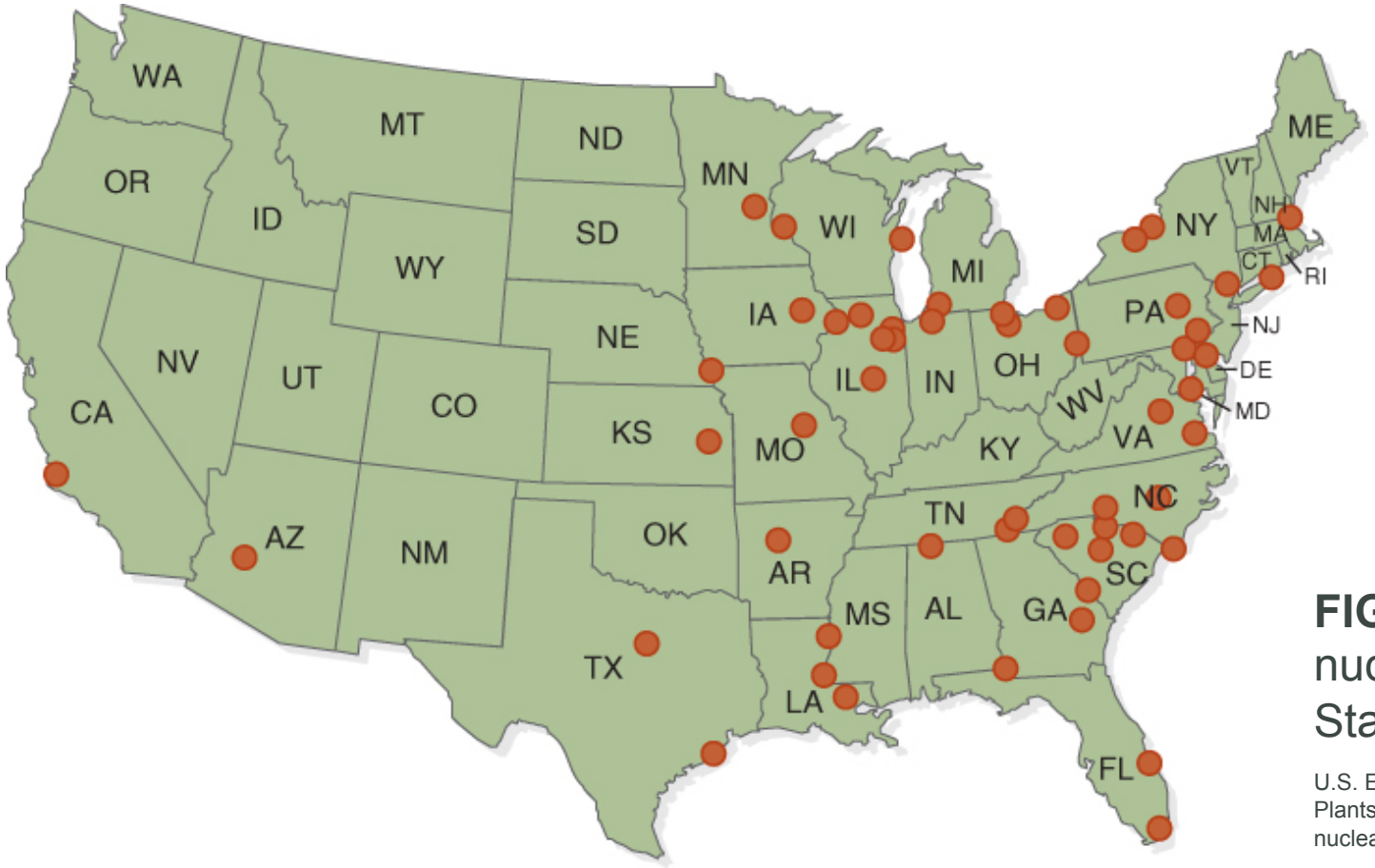

FIGURE 7.14 Locations of operating nuclear power plants in the United States, 2020.

U.S. Energy Information Administration. Location of U.S. Nuclear Power Plants. Available at: https://www.eia.gov/energyexplained/nuclear/us-nuclear-industry.php

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The Nuclear Fuel Cycle (6 of 11)

- Accidents at nuclear power plants
  - Unforgiving technology; mundane factors that cause accidents
  - Three Mile Island (1979): worst U.S. accident
  - Chernobyl (1986) and Fukushima (2011): most serious accidents worldwide

- International Atomic Energy Agency Significance of Nuclear Event Scale:
  - Level 1: Anomaly
  - Level 2: Incident
  - Level 3: Serious incident
  - Level 4: Accident with local consequences
  - Level 5: Accident with wider consequences
  - Level 6: Serious accident
  - Level 7: Major accident

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The Nuclear Fuel Cycle (7 of 11)

FIGURE 7.15 The Three Mile Island nuclear power plant in Pennsylvania was the site of the most serious accident at a U.S. commercial nuclear plant.

Courtesy of CDC Public Health Image Library. ID# 1194. Content provider CDC. Available at: http://phil.cdc.gov/phil/home.asp. Accessed October 14, 2012.

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The Nuclear Fuel Cycle (8 of 11)

- The back end of the nuclear fuel cycle
  - Spent nuclear fuel: highly radioactive, long-lived (300,000 years) [74]
  - Original plan: reprocess
  - Second plan: single permanent repository in Nevada
  - Current plan[73]: start over; one or more facilities for interim and permanent storage
  - Meanwhile, spent fuel in interim storage

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The Nuclear Fuel Cycle (9 of 11)

- Low-level radioactive wastes
  - From nuclear fuel cycle, medicine, research
  - Require only hundreds of years to be comparable to background radiation
  - States required to form compacts; as of May 2010, 40 states have done so [75]
  - But still only three active facilities in U.S.

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The Nuclear Fuel Cycle (10 of 11)

- The future of nuclear power
  - Still used in the U.S., France, Russia, China, and Japan, but with growing opposition
  - Potential for new nuclear technologies (fusion)
  - Relatively long timeline for nuclear fuels

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The Nuclear Fuel Cycle (11 of 11)

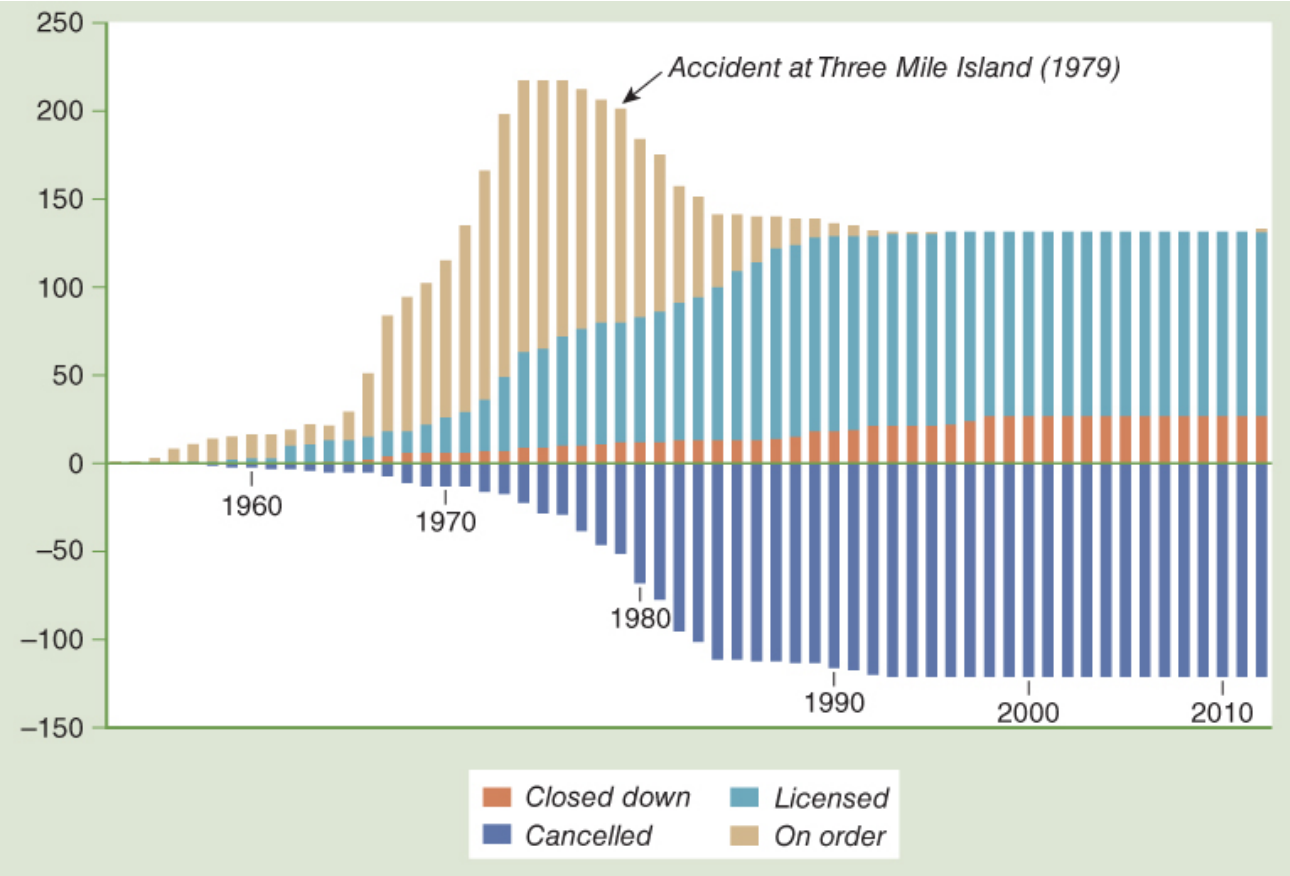

FIGURE 7.16 Number of nuclear power plants in the United States, 1953–2012.

Data from U.S. Energy Information Administration. U.S. Nuclear Reactors: Reactor status list. Available at: www.eia.doe.gov/cneaf/nuclear/page/nuc_reactors/reactsum.html. Accessed: October 7, 2006; and Wald ML. Federal regulators approve two nuclear reactors in Georgia. New York Times. February 9, 2012; Available at: www.nytimes.com/2012/02/10/business/energy-environment/2-new-reactors-approved-in-georgia.html. Accessed November 19, 2012..

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The Nuclear Fuel Cycle

Health Impacts of the Nuclear Fuel Cycle

Regulation of Activities in the Nuclear Fuel Cycle

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Health Impacts of the Nuclear Fuel Cycle (1 of 4)

- Radiation exposures and health effects of the nuclear fuel cycle
  - Front end: occupational radon exposures, heavy metal contamination from uranium mining[83,84]
  - Accidents at power plants; typically
    - Iodine-131: thyroid cancer
    - Strontium-90: leukemia
    - Cesium-137
  - Back end: transportation and storage of spent fuel
    - Long-term groundwater contamination

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Health Impacts of the Nuclear Fuel Cycle (2 of 4)

- Major accidents at reactors
  - Chernobyl (1986)[87]
    - Dose-related increase in thyroid cancer in children and adolescents
    - Evidence of increase in leukemia among cleanup workers
    - Depression and PTSD in cleanup workers and mothers of young children

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Health Impacts of the Nuclear Fuel Cycle (3 of 4)

- Major accidents at reactors
  - Fukushima (2011)[89]
    - Combined hazards of an earthquake, tsunami, and nuclear accident evacuation
    - Long-term effects of exposures will not be known for years and will be difficult to assess given the broad social disruption that followed the accident
    - No acute radiation health effects
      - Majority of the workers as well as the evacuated population received exposures at doses far below concerns for latent, deterministic risks
    - Thirteen workers did receive absorbed doses that increases their deterministic risk for hypothyroidism as well as their latent risk for thyroid cancer.
      - Overall, only 173 workers (0.7% of the workforce) received effective doses of 100 mSv or more, and among this group, a small increased risk of cancer would be expected.
    - Among the general public, radiation exposures were low and any increase in cancer incidence would not be expected to be discernable over baseline levels.
      - Concern with infants and children and their risks for the subsequent development of thyroid cancer or leukemia
        - Will require special follow-up to discern

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Health Impacts of the Nuclear Fuel Cycle (4 of 4)

- Health impacts at the back end
  - Uncertain, because plans for long-term storage remain uncertain
  - Any facility will be engineered to prevent releases of ionizing radiation.
  - But time frame for radioactive decay is so long that nothing is certain
  - Transportation risks are real and near-term.

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The Nuclear Fuel Cycle

Health Impacts of the Nuclear Fuel Cycle

Regulation of Activities in the Nuclear Fuel Cycle

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Regulation of Activities in the Nuclear Fuel Cycle

- Energy Reorganization Act of 1974 created Nuclear Regulatory Commission
  - Licenses reactors, sets emissions limits, responds to incidents, regulates storage of spent fuel
- Low-Level Radioactive Waste Policy Amendments Act of 1985
  - Calls for compacts
- Uranium Mill Tailings Radiation Control Act (1978)

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7.1 Sources of Energy

7.2 Electricity from Fossil Fuels

7.3 Electricity from Nuclear Fuel

7.4 Energy from Renewable Resources

7.5 Energy Conservation

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Biomass and Biomass Fuels

The Hydrogen Fuel Cell

Freedom from Fuels

Regulatory Support for Alternatives to Fossil and Nuclear Fuels

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Fuels Derived from Biomass

- Biomass energy: stored in plant material or animal dung (biomass)
- Biomass fuels (derived from biomass)
  - Gaseous: biogas
  - Liquid: ethanol, biodiesel
  - Advantage: carbon-neutral
  - Limitation: require energy plantations; compete with food crops [94, 95]
- Nontraditional fossil fuels: some are blends of fossil fuel and a biomass fuel

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Biomass as Fuel

- Wood, charcoal, peat, straw, brush, dung
- “Alternative”; but not always benign
  - Open fires, simple stoves
  - Very high particulate concentrations [97]
  - Women and girls highly exposed [98]
  - Respiratory and other health effects [99-102]

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Biomass and Biomass Fuels

The Hydrogen Fuel Cell

Freedom from Fuels

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The Hydrogen Fuel Cell

- Environmentally benign, but:
  - What is source of hydrogen?
  - How much energy to produce hydrogen fuel?
  - Insert figure shown in hydrogen fuel cell case study

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Biomass and Biomass Fuels

The Hydrogen Fuel Cell

Freedom from Fuels

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Freedom from Fuels (1 of 3)

- Wind power
  - Modern turbine
  - Often installed in grids (wind farms)
  - Potential negatives
    - Noise; visual impact
    - Harm to birds; weigh against ecological benefits

FIGURE 7.18 This modern wind turbine is one of two now generating electricity for the coastal town of Hull, Massachusetts.

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Freedom from Fuels (2 of 3)

- Large-scale hydropower
  - Large dam has environmental impacts
- Solar energy
  - Challenges: sunlight is variable and low-intensity energy source
  - Solar collection panels; photovoltaic cell
- Geothermal energy
  - Availability depends on local geology

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Freedom from Fuels (3 of 3)

FIGURE 7.19 The water stored behind this dam will be used to generate electric power.

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Biomass and Biomass Fuels

The Hydrogen Fuel Cell

Freedom from Fuels

Regulatory Support for Alternatives to Fossil and Nuclear Fuels

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Regulatory Support for Alternatives to Fossil And nuclear Fuels

- Energy Policy Act of 2005
  - Incentives for energy producers
  - Income tax credits
    - Hybrid vehicles, home improvements
  - U.S. government to get 7.5% of power from renewable sources by 2013
  - Also substantial supports for traditional energy sectors

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7.1 Sources of Energy

7.2 Electricity from Fossil Fuels

7.3 Electricity from Nuclear Fuel

7.4 Energy from Renewable Resources

7.5 Energy Conservation

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Energy Conservation (1 of 2)

- Simple steps to use less energy and to make devices more energy-efficient
- Change transportation habits in U.S.
  - Lack of public transportation, reliance on cars
  - Turnaround in size of vehicles in 2010?
- Alternative: the hybrid car
  - Power to transmission from combustion engine directly or via electric motor/ generator/battery

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Energy Conservation (2 of 2)

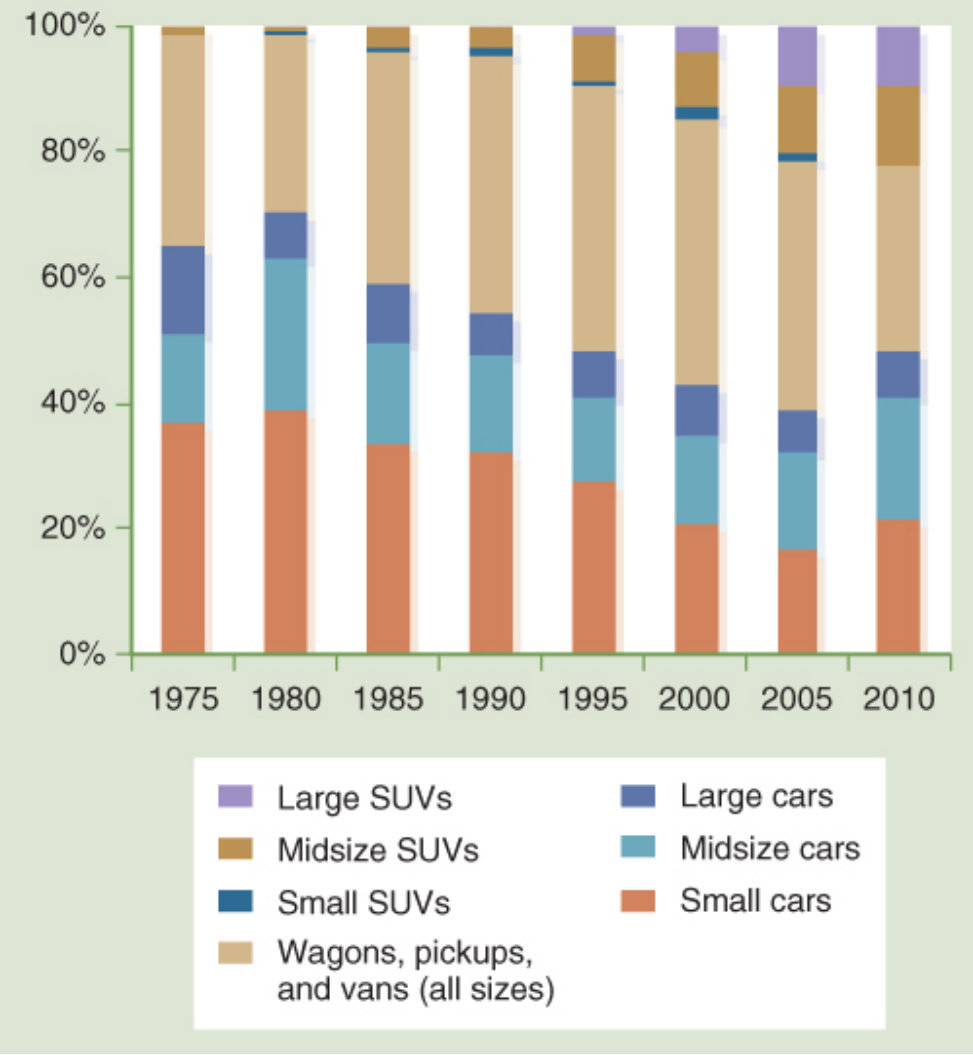

FIGURE 7.20 Market shares of light vehicles in the United States, by size class and model year, 1975–2010.

Data from U.S. Department of Energy, Transportation Energy Data Book. Available at: http://cta.ornl.gov/data/download31.shtml. Accessed October 14, 2012.

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The Modern Lifestyle Thrives on the Consumption of Energy

- Environmental and human health costs associated with producing energy have not been well accounted for in the price society pays for its power.
  - Must consider and incorporate the costs of these *externalities*
  - A comprehensive accounting should also include benefits associated with mitigating pollution from energy production, such as health care savings from reduced asthma attacks in children.
- Should feel a sense of urgency to find a more sustainable energy plan for the sake of not only ourselves, but also our planet

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