Chapter 12
Nonrenewable Energy Resources

Santa Barbara and Alaska

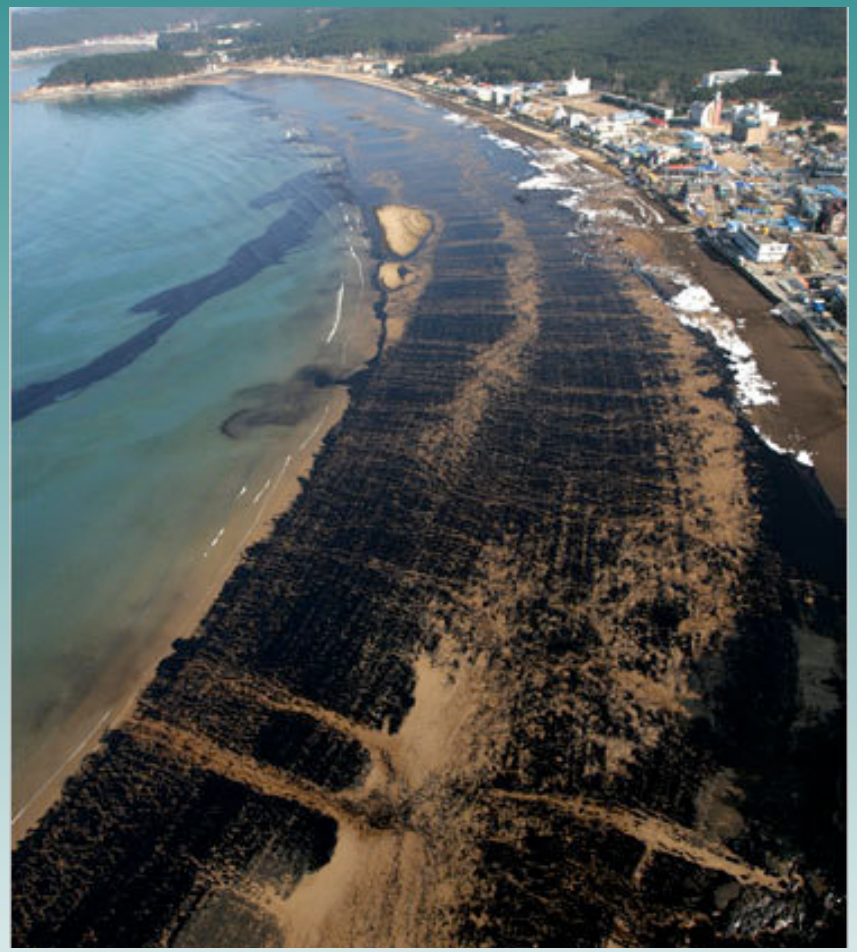
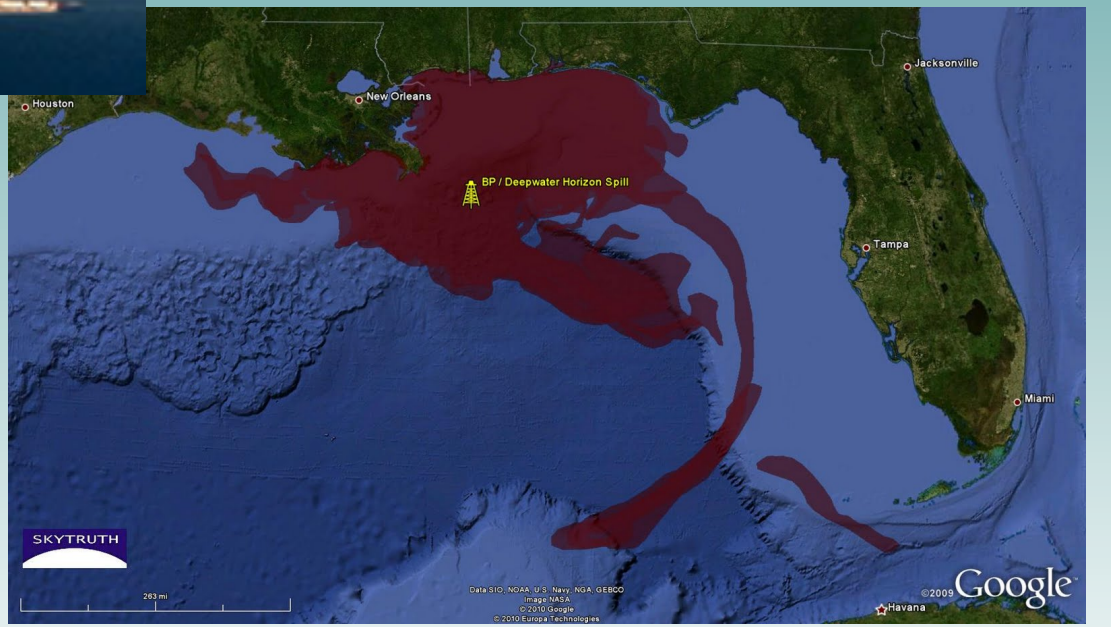
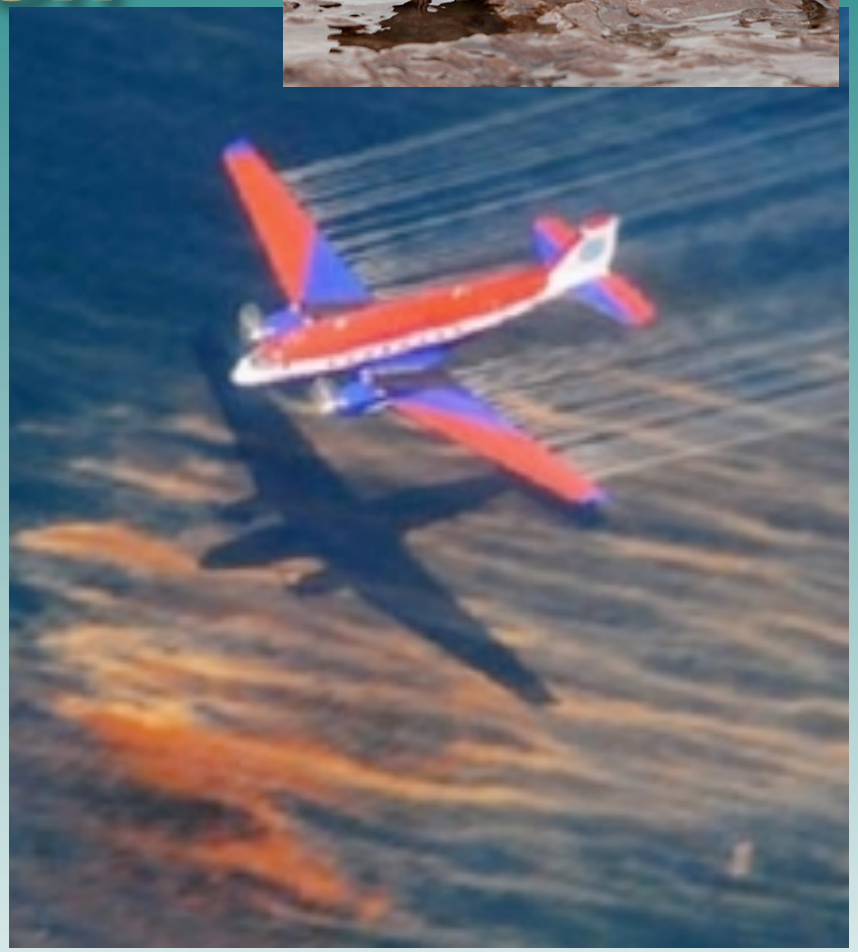


Figure 14.14
Environmental Science

BP Deepwater Horizon



Oil Spill Remediation



Energy Use

- Commercial energy sources- those that are bought and sold, such as coal, oil and natural gas.
- Subsistence energy sources- those gathered by individuals for their own use such as wood, charcoal and animal waste.

Recall: Energy Units

- **Joule** = basic unit of energy…the amount of energy used by a 1 watt bulb in 1 second.
- **1 Calorie** = 4.184 Joules…energy needed to heat one gram of water, 1 degree C.
- **1Btu** = 1,055 Joules…energy required to heat one pound of water, 1 degree F.
- **1 Gigajoule (GJ)** = amount of energy in 8 gallons (30 Liters) of gasoline.
- **1 Exajoule (EJ)** = one billion GJ

Comparing total energy Consumption with Per-Captia energy Consumption…

Some of the largest And smallest users

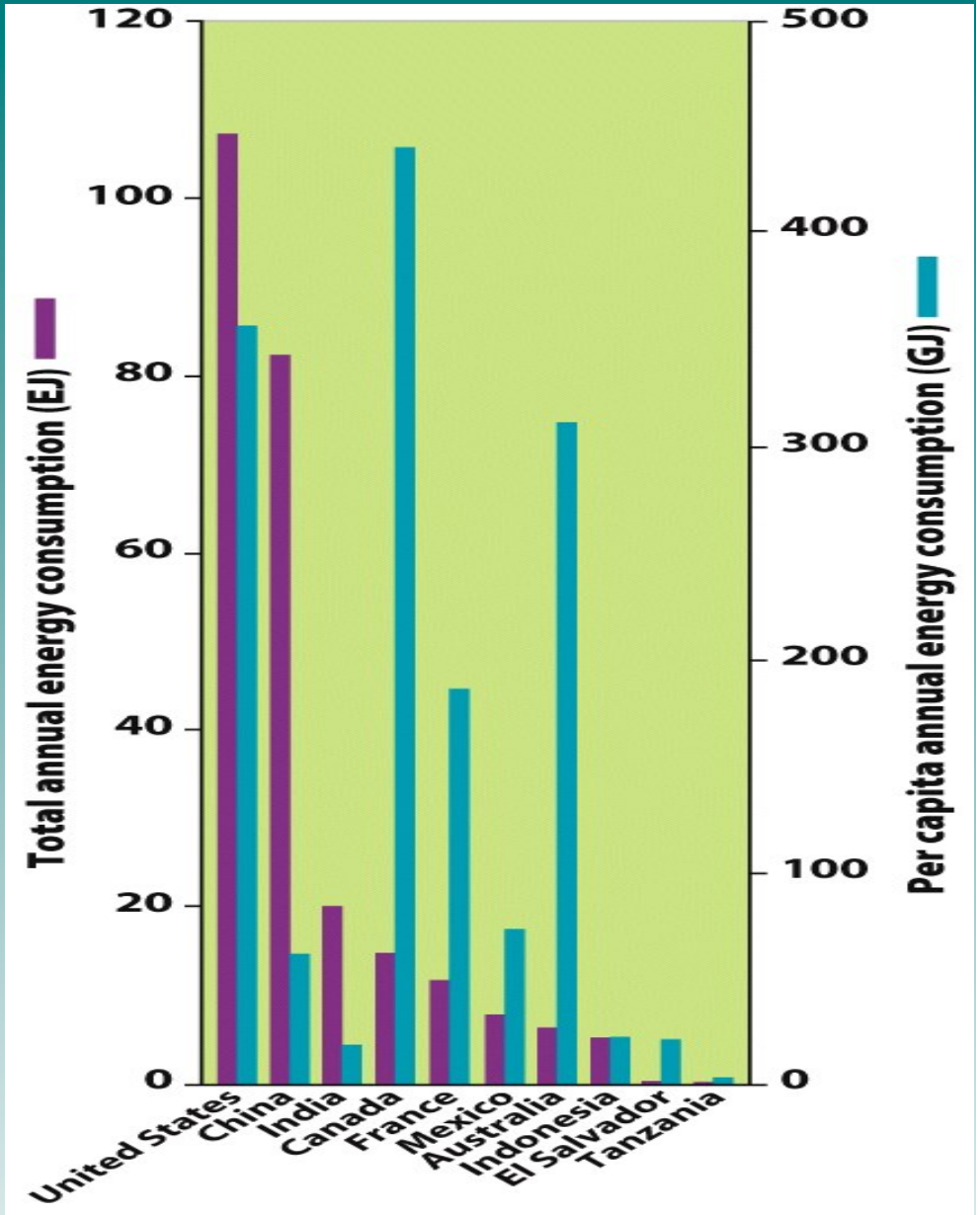


Figure 12.2
Environmental Science

Nonrenewable Energy

- Nonrenewable energy resources- fossil fuels (coal, oil, natural gas) and nuclear fuels.

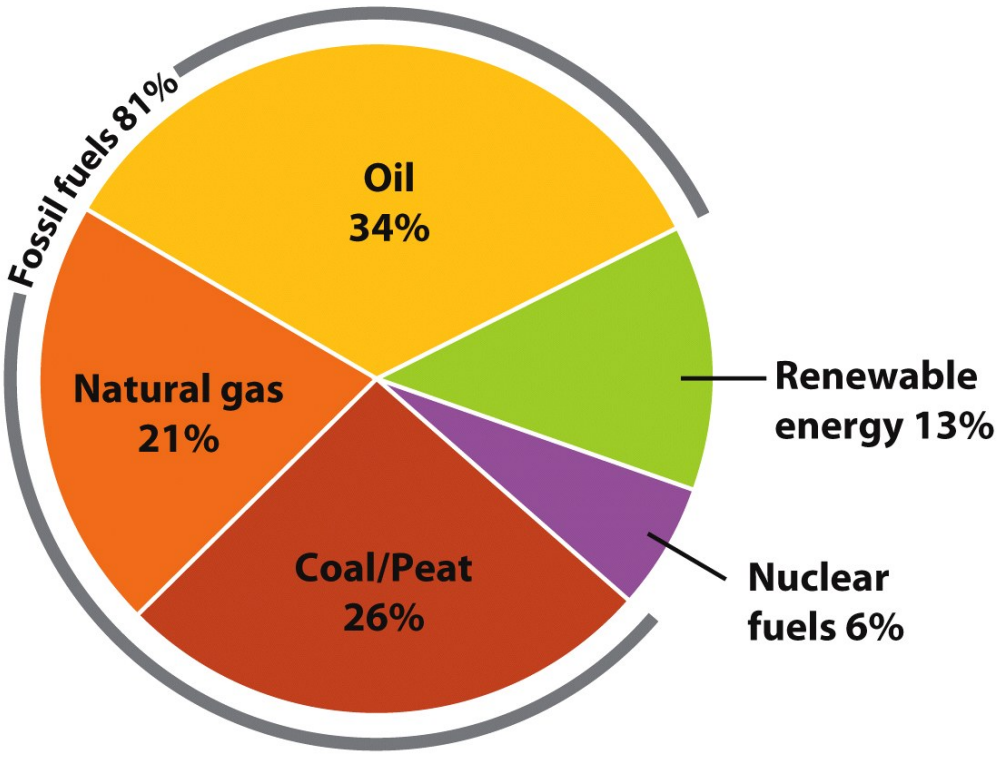


Figure 12.1
Environmental Science

Inefficiencies in energy extraction and use – obeying the 2nd Law of Thermodynamics… Ex: Electricity from coal = 35%

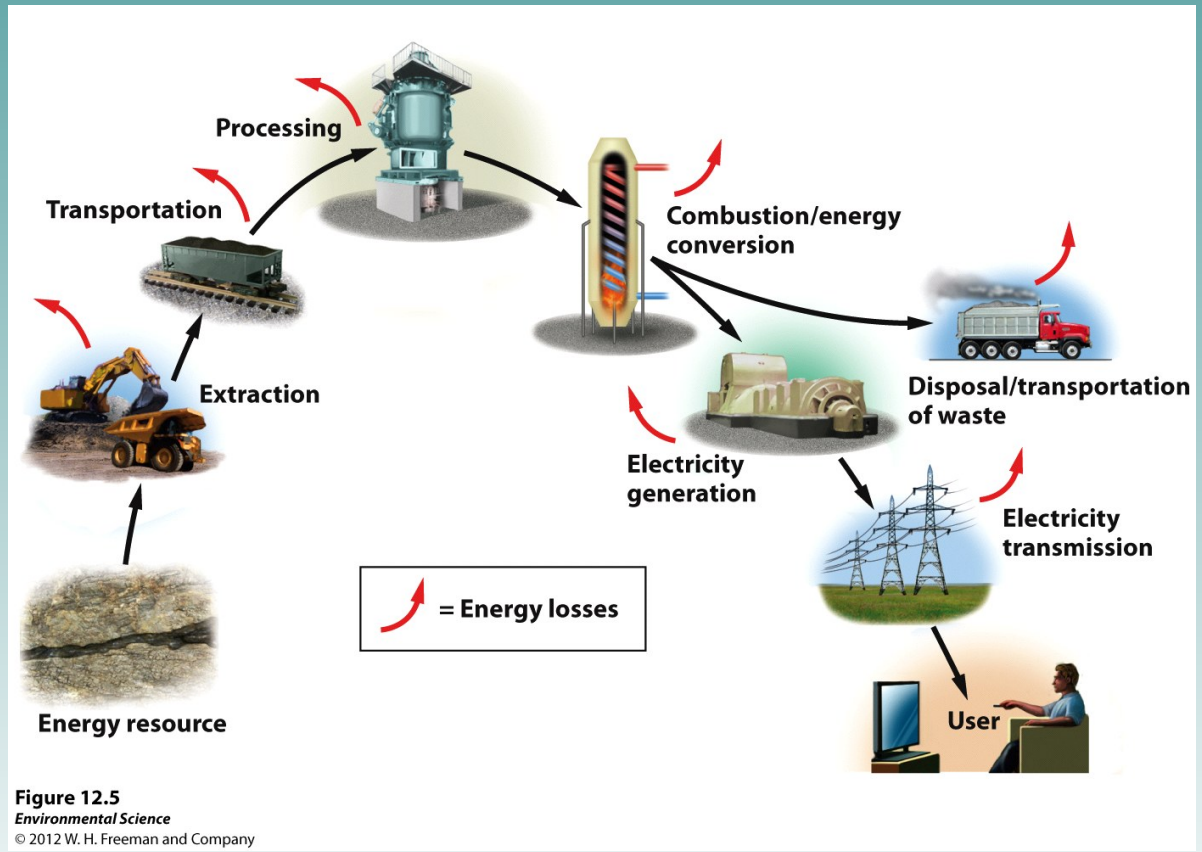


Figure 12.5
Environmental Science

US energy consumption since 1850… When we started running out of wood!

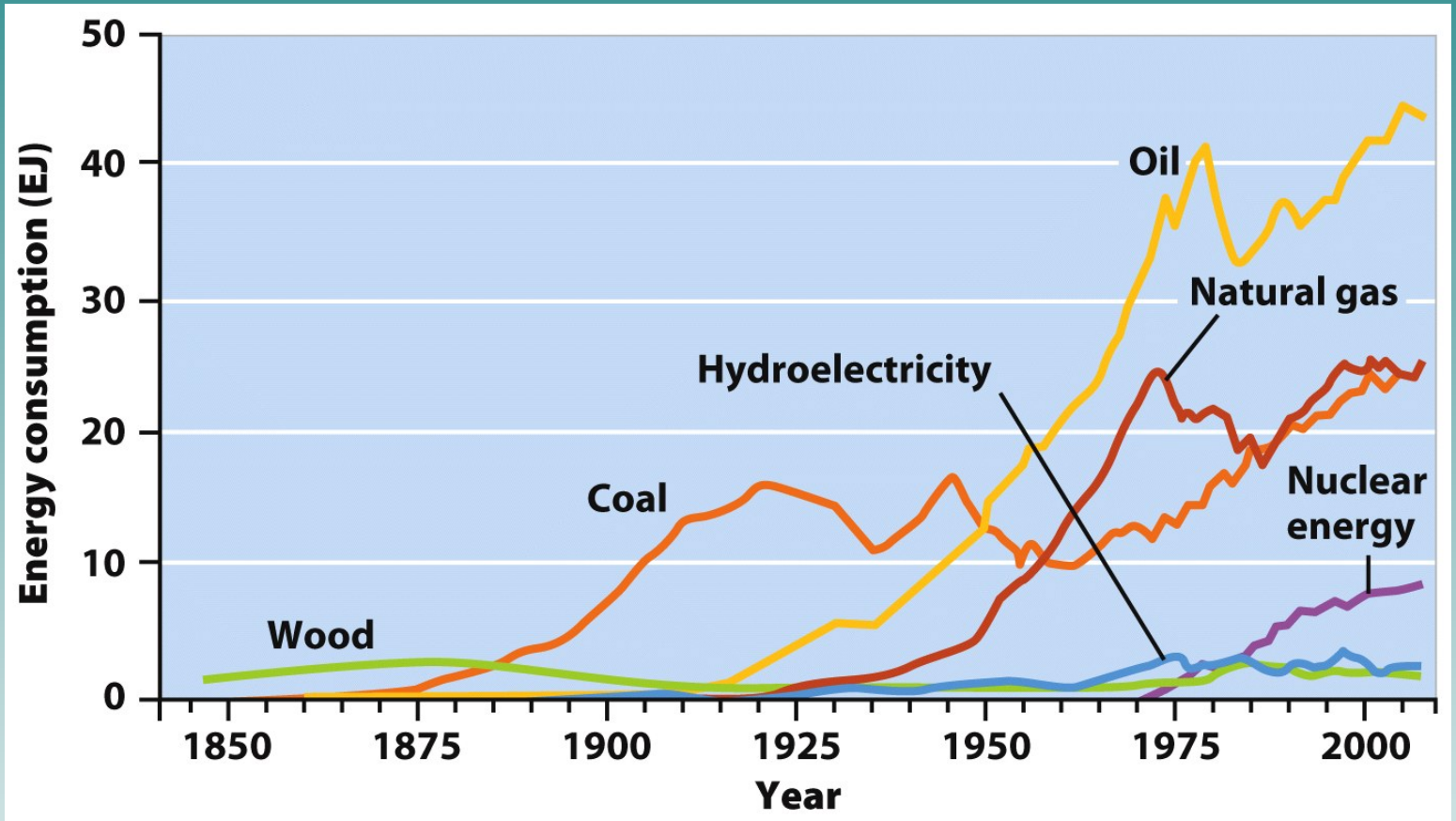
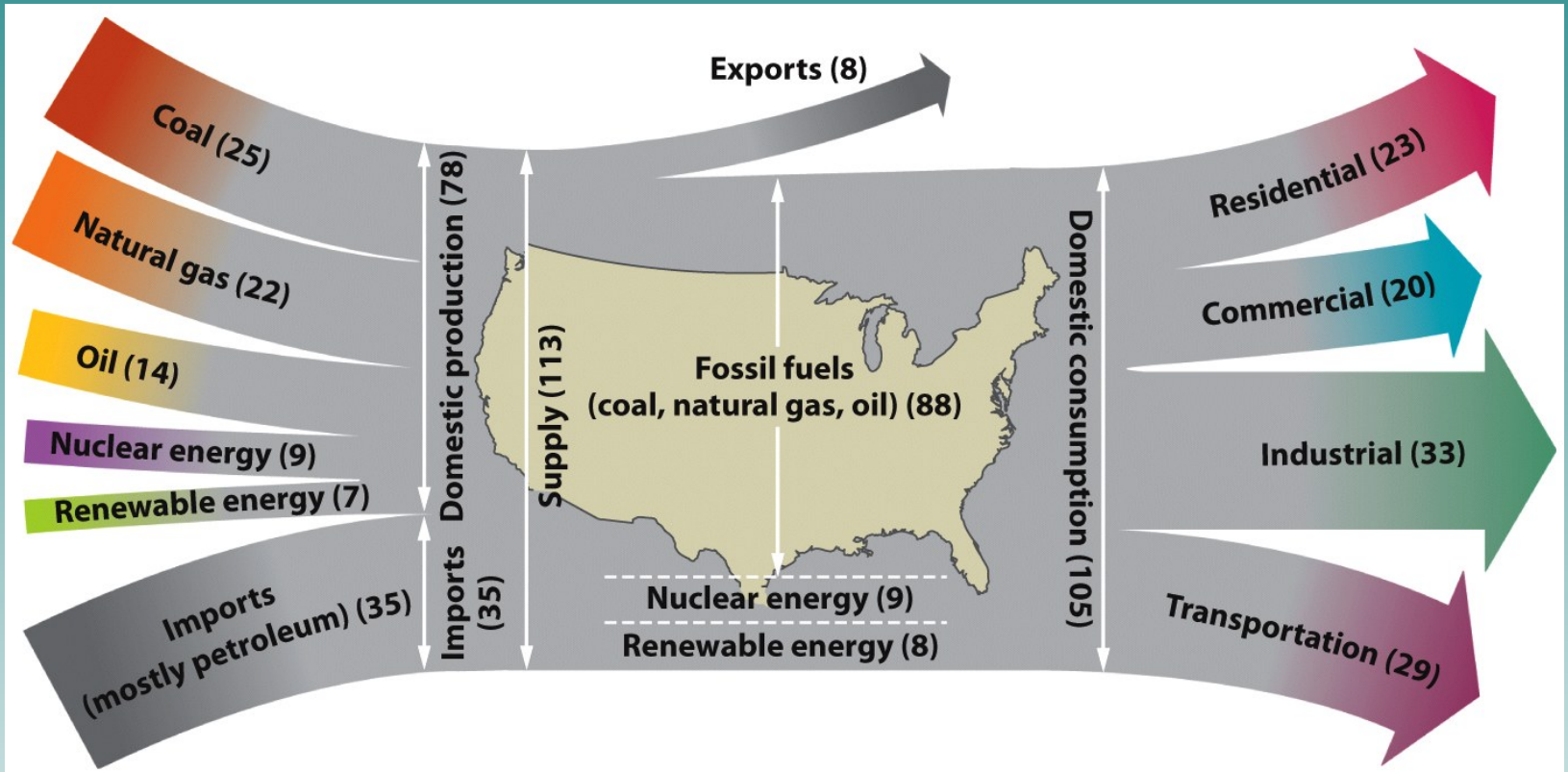


Figure 12.3
Environmental Science

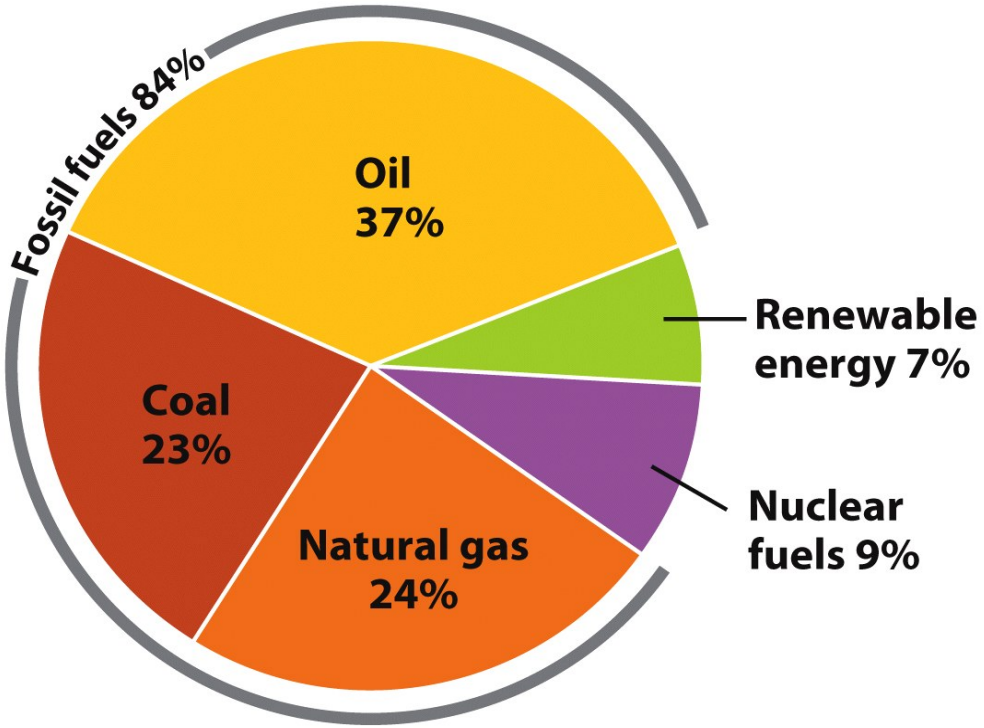
Energy Types and Uses



Energy flowchart for the United States (exajoules)

Figure 12.4a
Environmental Science

US Energy Consumption
Recall: 1 Quad =1quadrillion Btu



Total = 105 EJ (99.3 quads) per year

(b) U.S. energy consumption

Figure 12.4b
Environmental Science

EROEI

Energy Return on Energy Investment

Comparing Fuel Types

- **Coal = 100J/5J = 20 (14?)**
- **Oil = 100J/25J = 4**
- **Natural Gas = 8**
- **Nuclear = 8**

- **For Renewables:**
- **Wind = 100J/5.5J = 18**

- **Ethanol from Corn =**
- **100J /77J = 1.3**

Finding the Right Energy

Eastern USA: Coal

North USA: more Energy in winter

W and NW USA: Larger % hydroE

NE USA: larger % Nuclear power

TABLE 12.1 Energy expended for different modes of transportation in the United States

Mode	MJ per passenger-kilometer
Air	2.1
Passenger car (driver alone)	3.6
Motorcycle	1.1
Train (Amtrak)	1.1
Bus	1.7

Source: All data are from Bureau of Transportation Statistics, U.S. Department of Transportation, except for the passenger car, which was determined by assuming one occupant per vehicle obtaining average fuel efficiency of 22 mpg (9.4 km per liter).

Table 12.1
Environmental Science

Best way to improve efficiency of car travel?
More passengers!! 4 riders = .9MJ/PassKm

Overall Fuel Efficiency of U.S. Automobiles

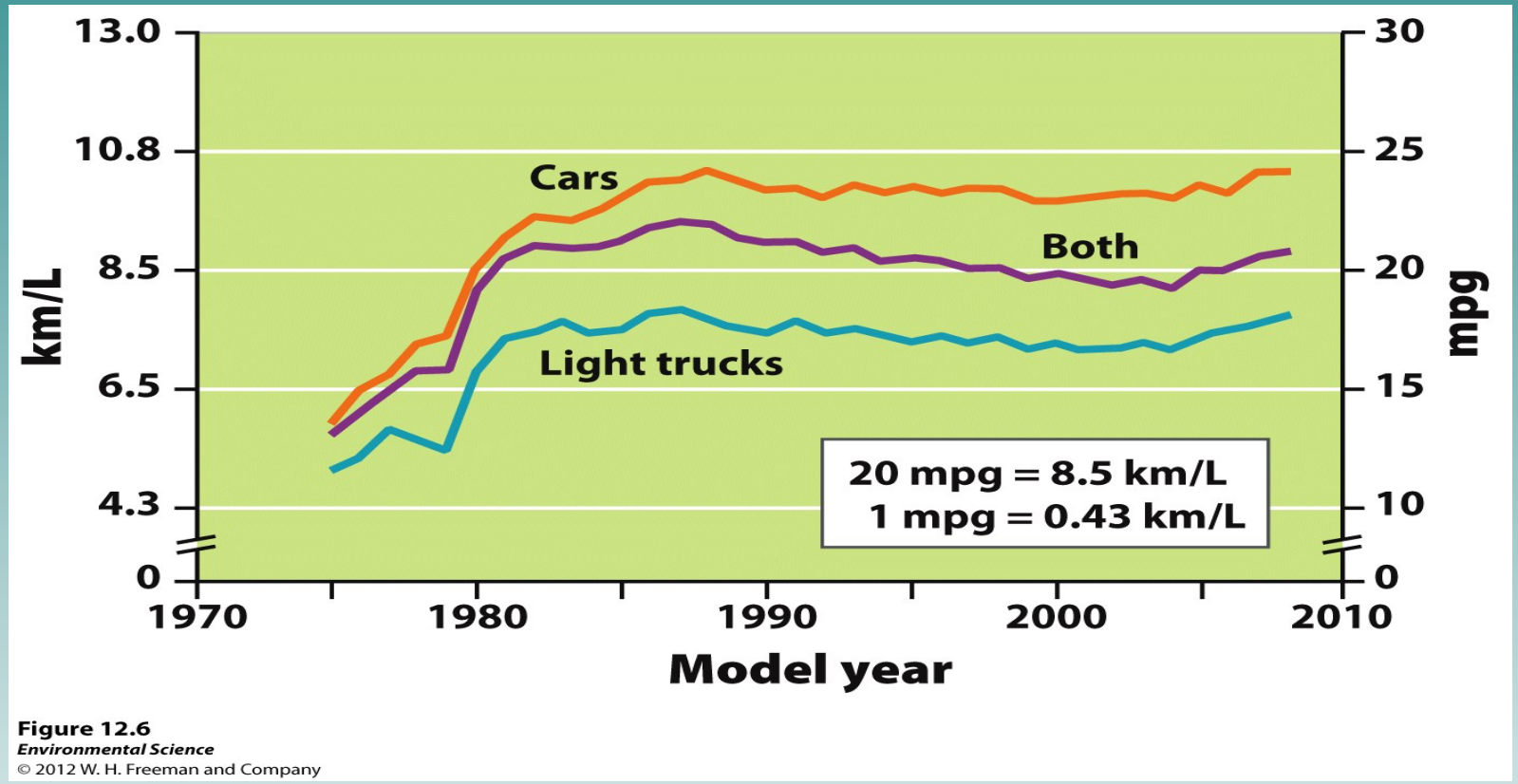


Figure 12.6
Environmental Science

Move from cars to light trucks, SUV's, minivans led to decline in 80-90's.

Electricity Generation… feeding the electrical grid

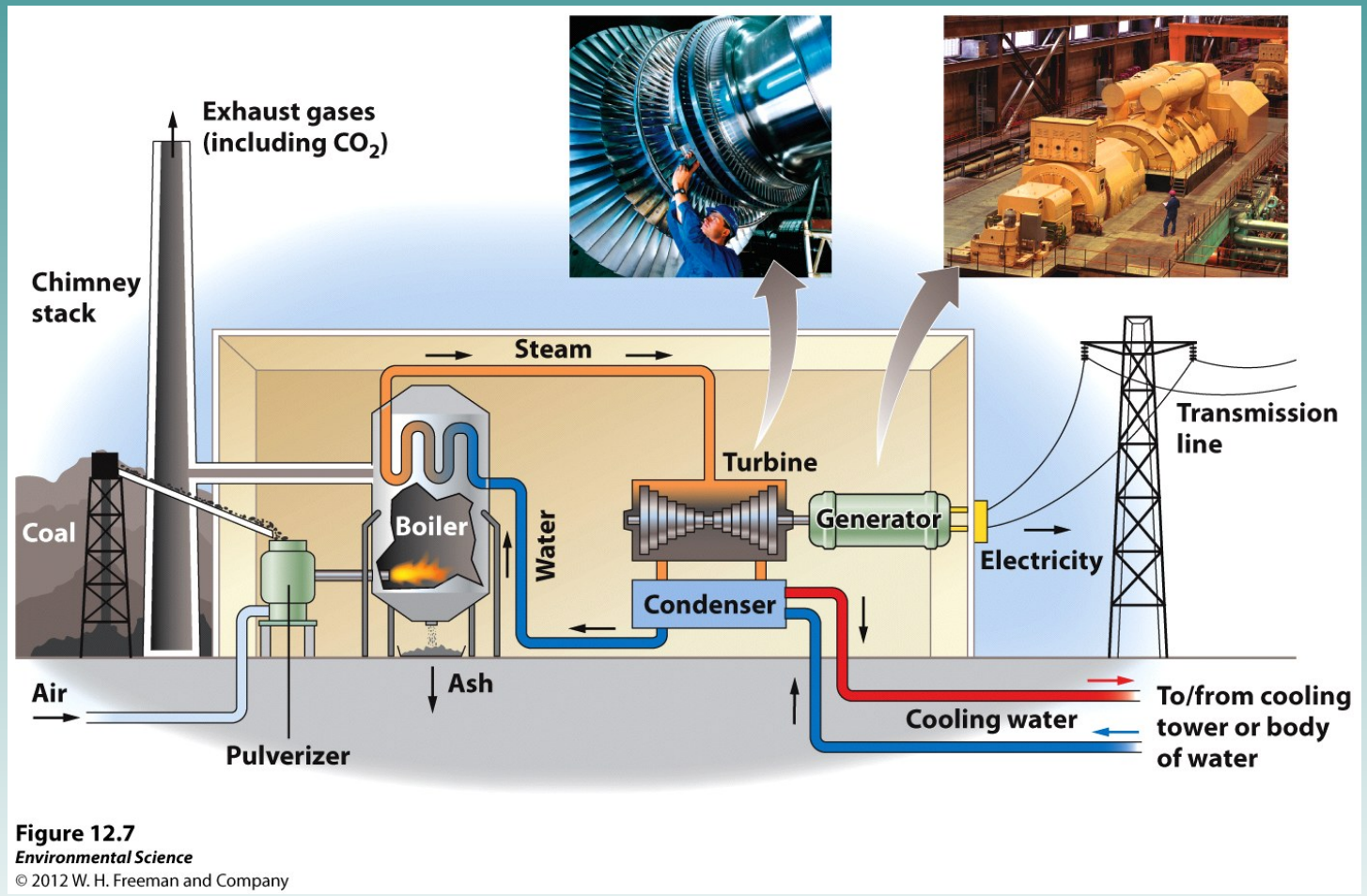


Figure 12.7
Environmental Science

Electricity Generation

- Coal (energy carrier) to Heat
- to Water to Steam.
- The kinetic energy of Steam to Mechanical Energy of Turbine.
- Turbine turns the Generator (copper coils in magnetic field).
- This mechanical motion generates electrical energy.

Electricity Generation in US.

- Efficiency of Coal
- = 35%
- Losses:
- Extraction,
- Processing,
- Building plant,
- Disposal of Coal
- Ash,
- Transmission

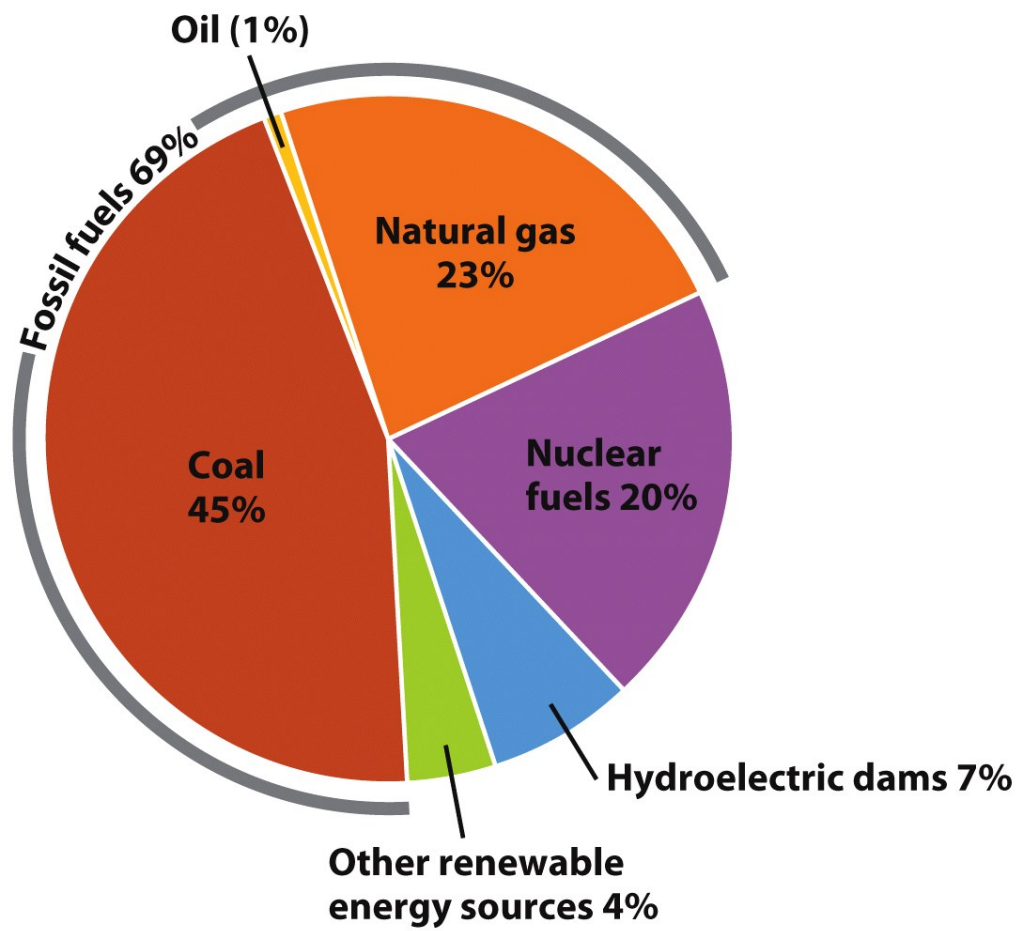


Figure 12.8
Environmental Science

Power Plants Capacity in MW

Typical Plant:

500MW x 24 hrs/day

= 12,000 MWh

=12,000,000 KWh

Home electricity:

In KWh

If home uses 1000KWh per month, a plant could supply 12,000 homes.

Cogeneration

- Cogeneration- using a fuel to generate electricity and to produce heat.
- Example- If steam is used for industrial purposes or to heat buildings it is diverted to turn a turbine first.
- This improves the efficiency to as high as 90%.

Coal

- Coal- a solid fuel formed primarily from the remains of trees, ferns, and other plant materials that were preserved 280-360 million years ago.
- Four types of coal ranked from lesser to greater age, exposure to pressure, and energy content.
- These four types are: lignite, sub-bituminous, bituminous, and anthracite.
- The largest coal reserves are in the United States, Russia, China, and India.

Coal – largest provider of electricity in US (45%)

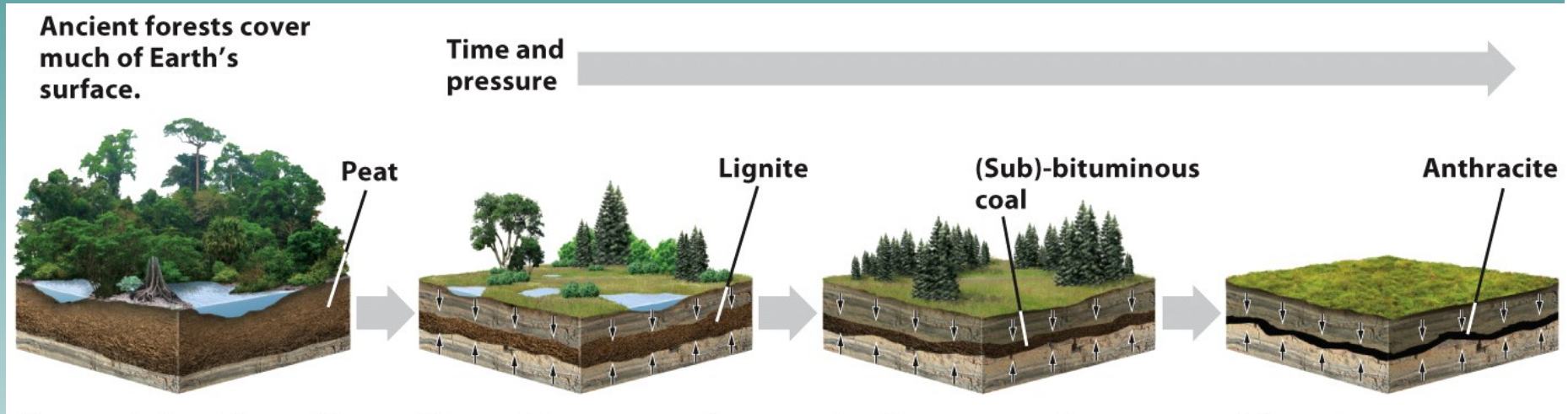
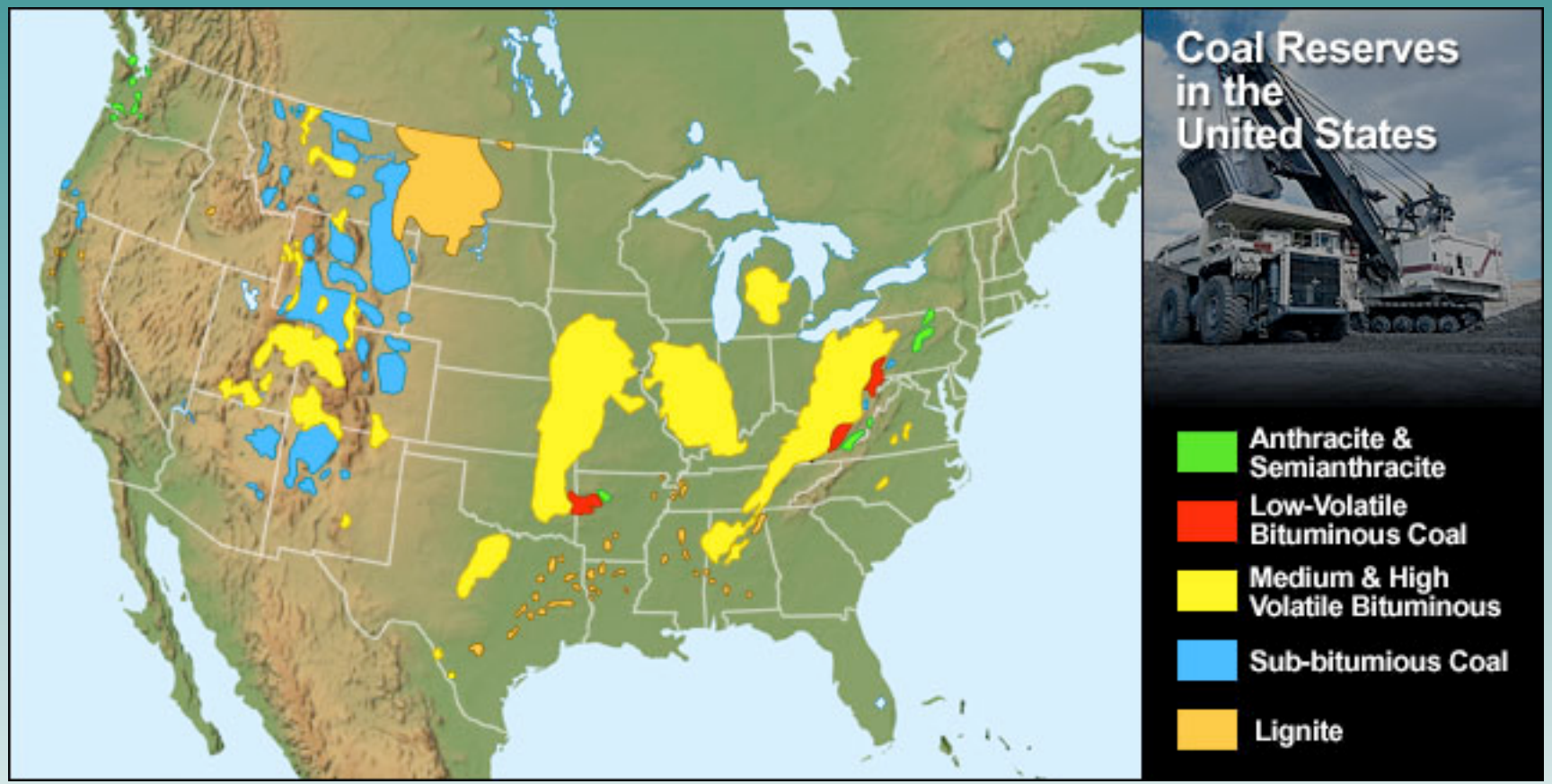


Figure 12.9
Environmental Science

Coal Mining- recall negative externalities.

Coal Deposits in the US



Advantages and Disadvantages of Coal

Advantages	Disadvantages
Energy-dense	Contains impurities
Plentiful	Release impurities into air when burned
Easy to exploit by surface mining	Trace metals like mercury, lead, and arsenic are found in coal
Technological demands are small	Combustion leads to increased levels of sulfur dioxide and other air pollutants into the atmosphere.
Economic costs are low	Ash is left behind
Easy to handle and transport	Carbon is released into the atmosphere which contributes to climate change
Needs little refining	

Coal Ash – Storage and Spills

Figure 12.10
Environmental Science

Petroleum

- Petroleum- a mixture of hydrocarbons, water, and sulfur that occurs in underground deposits.
- Oil and gasoline make this ideal for mobile combustion, such as vehicles.
- Formed from the remains of ocean-dwelling phytoplankton that died 50-150 million years ago.
- Countries with the most petroleum are Saudi Arabia, Russia, the United States, Iran, China, Canada, and Mexico.

Conventional Petroleum and Natural Gas

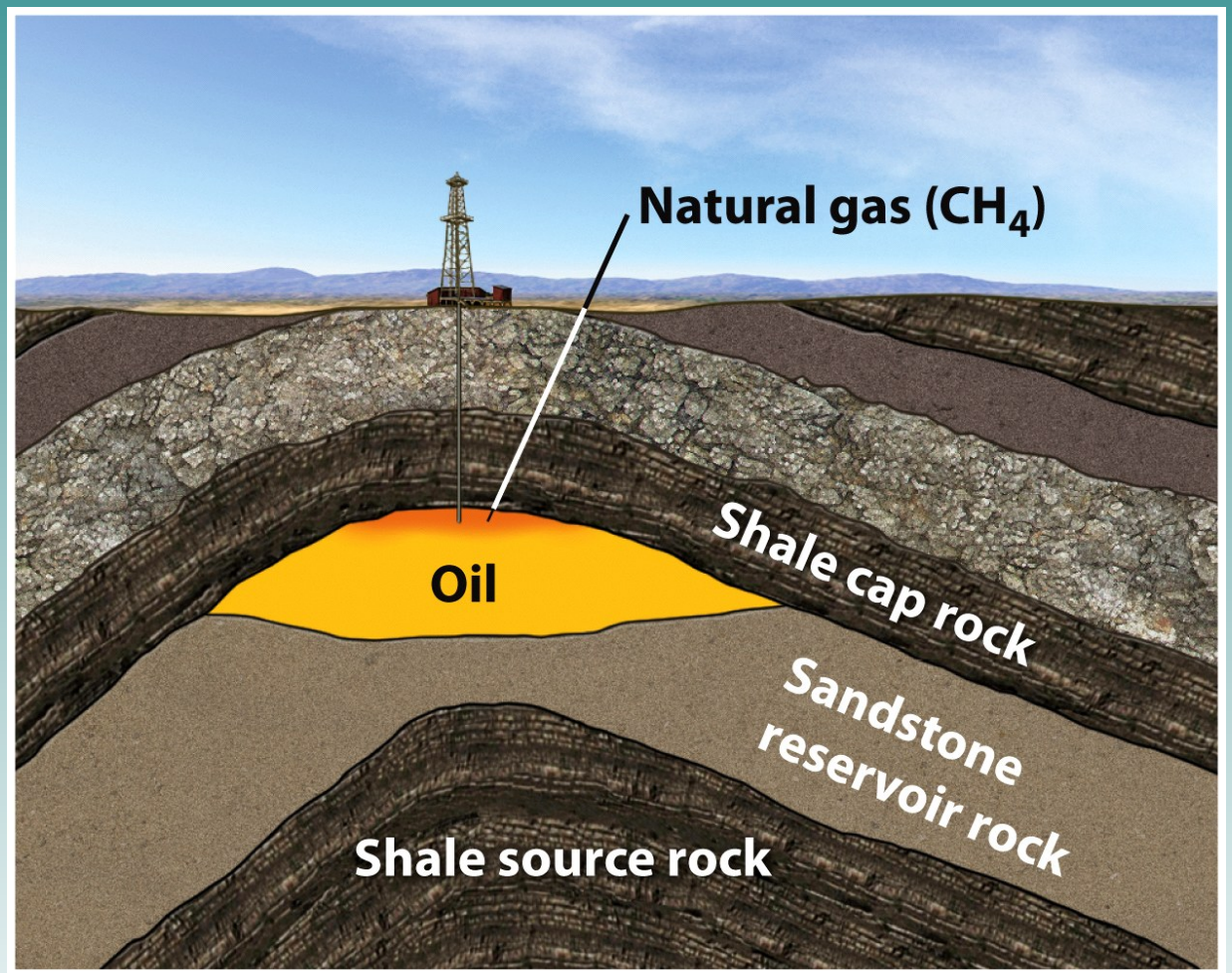


Figure 12.11
Environmental Science

Advantages and Disadvantages of Petroleum

Advantages	Disadvantages
Convenient to transport and use	Releases carbon dioxide into atmosphere
Relatively energy-dense	Possibility of leaks when extracted and transported
Cleaner-burning than coal	
Releases sulfur, mercury, lead, and arsenic into the atmosphere when burned	

Petroleum – Env. Issues

Figure 12.12
Environmental Science

Chapter 12 Opener
Environmental Science

ANWR and the North Slope

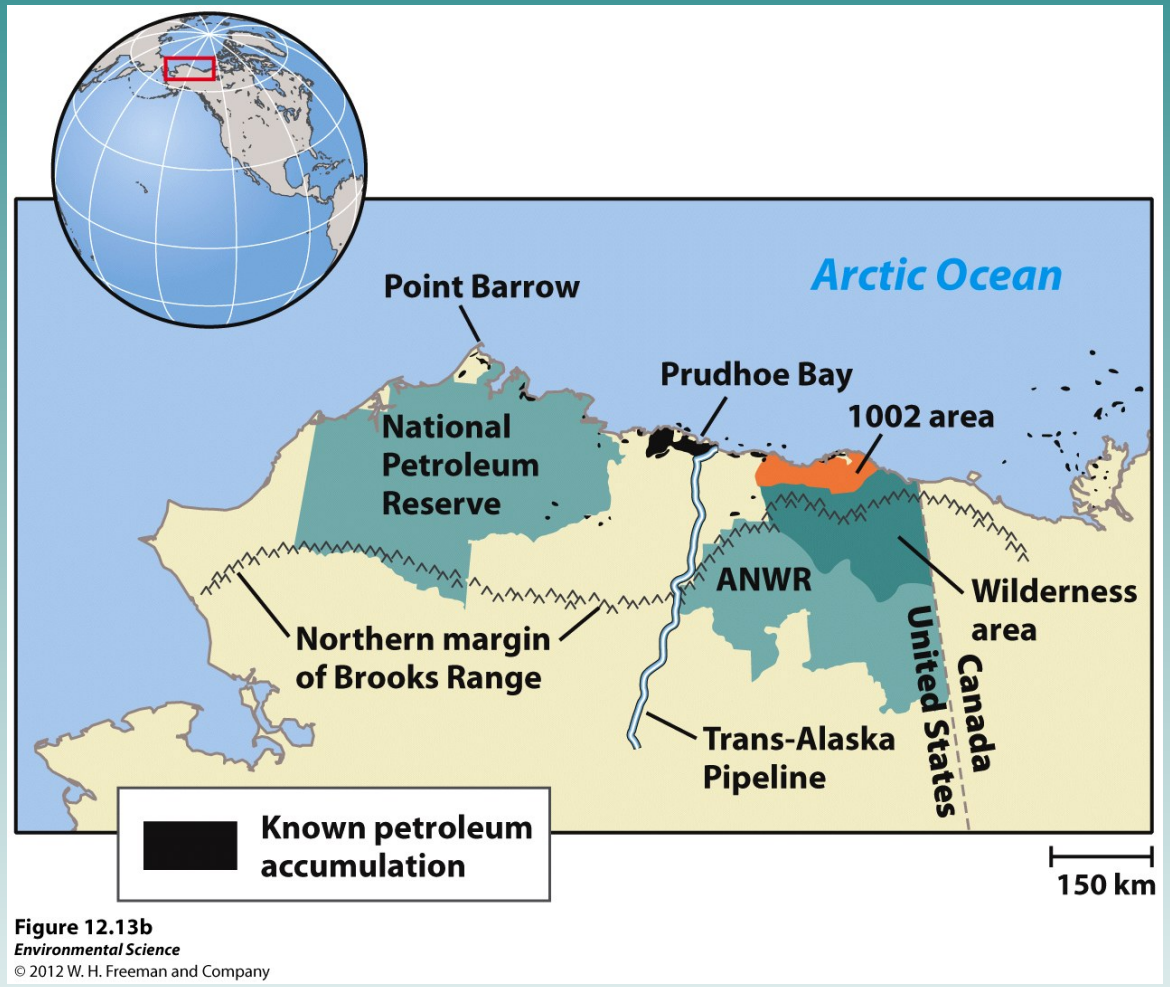


Figure 12.13b
Environmental Science

ANWR – America's Serengeti

Figure 12.13a
Environmental Science

Natural Gas

- **Natural gas- component of petroleum in the ground as well as in gaseous deposits separate from petroleum.**
- **80 – 95% Methane**
- **5 – 20% Propane, Butane, Ethane**

Conventional Petroleum and Natural Gas

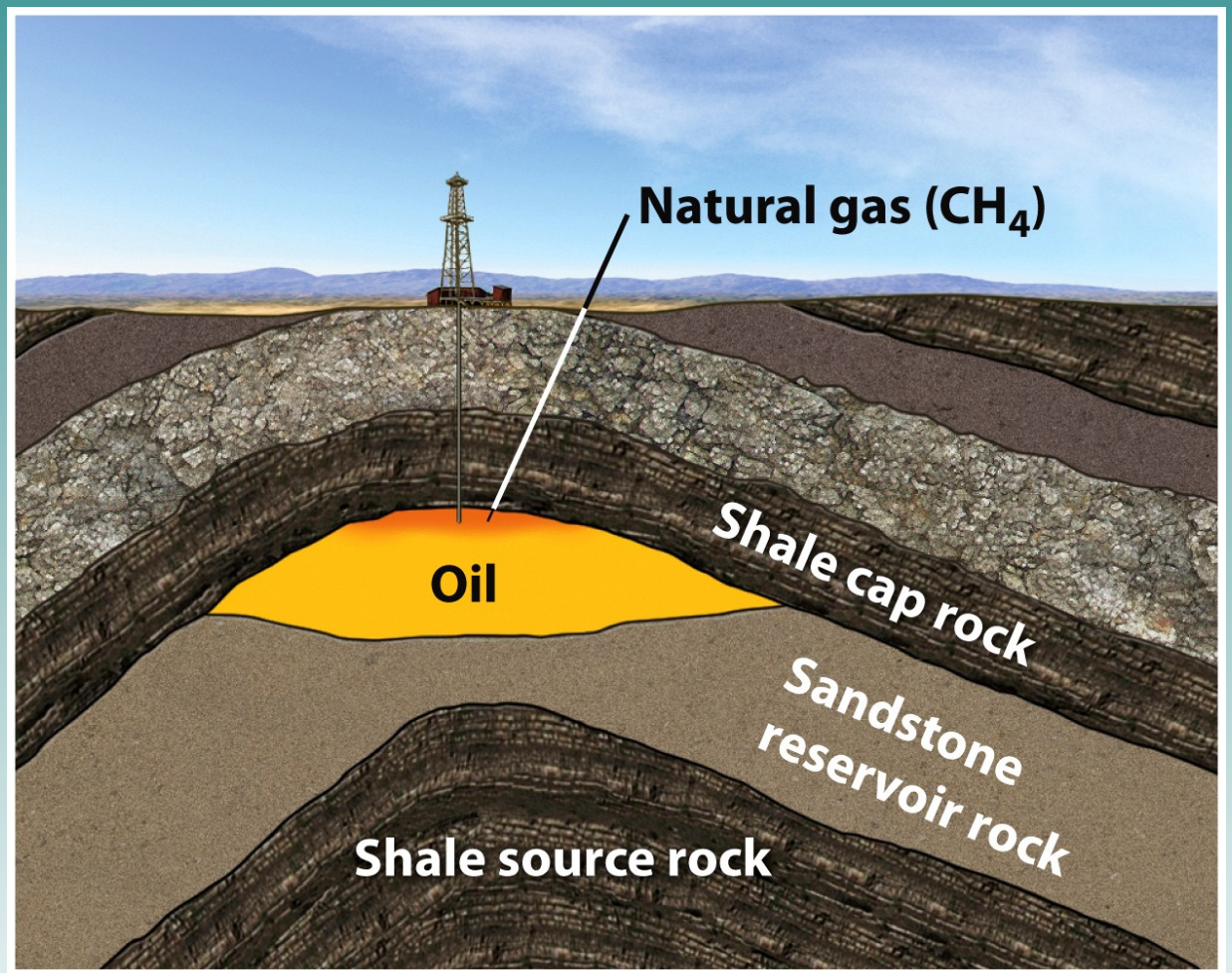
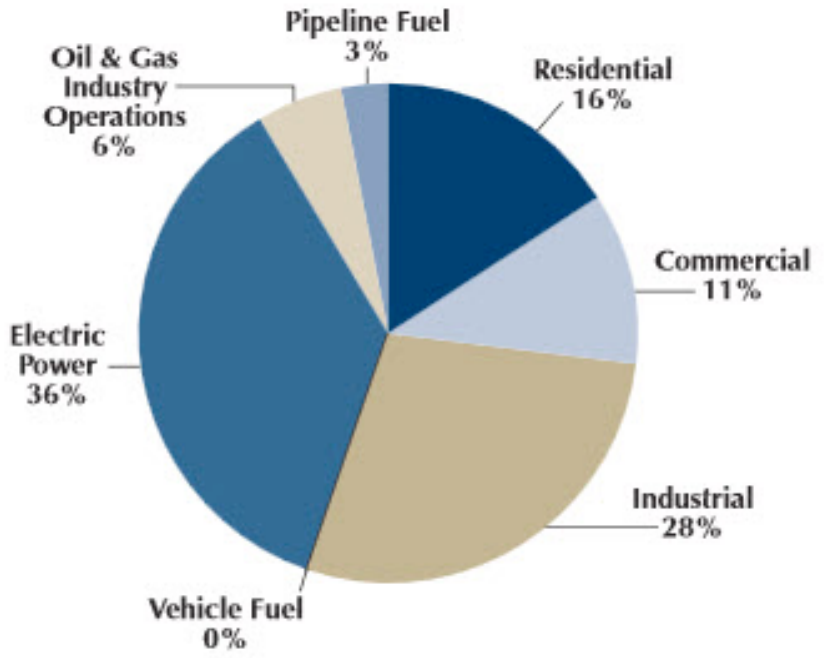


Figure 12.11
Environmental Science

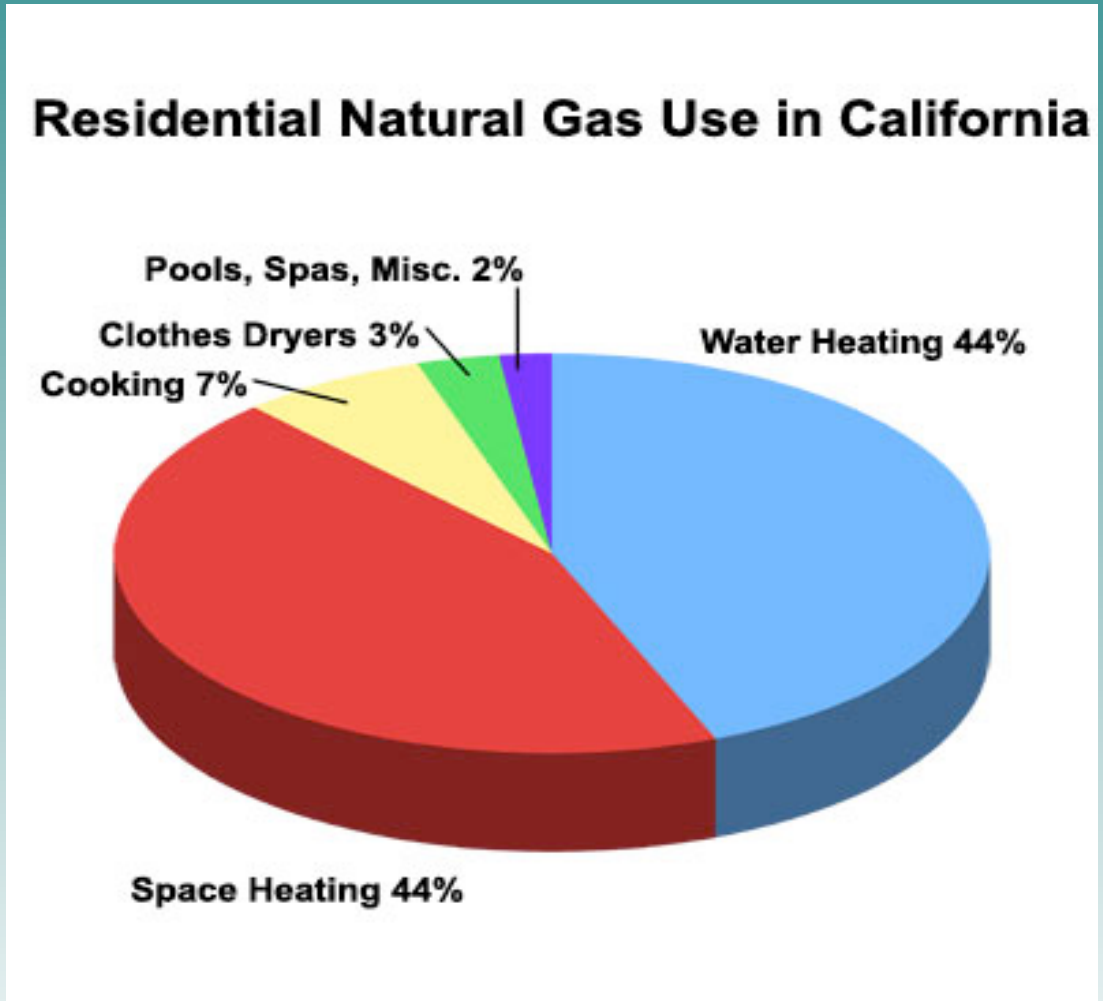
Natural Gas use in the US

FIGURE 6: U.S. Natural Gas Consumption by Sector, 2012



Source: Energy Information Administration, "Natural Gas Consumption by End Use," 2013. Available at http://www.eia.gov/dnav/ng/ng_cons_sum_dcu_nus_a.htm

Residential use of Natural Gas

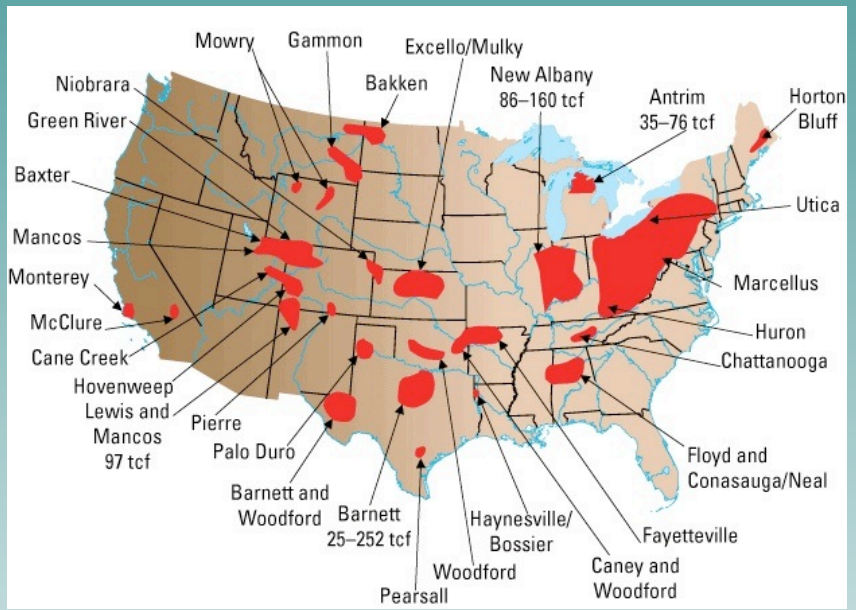


Advantages and Disadvantages Natural Gas

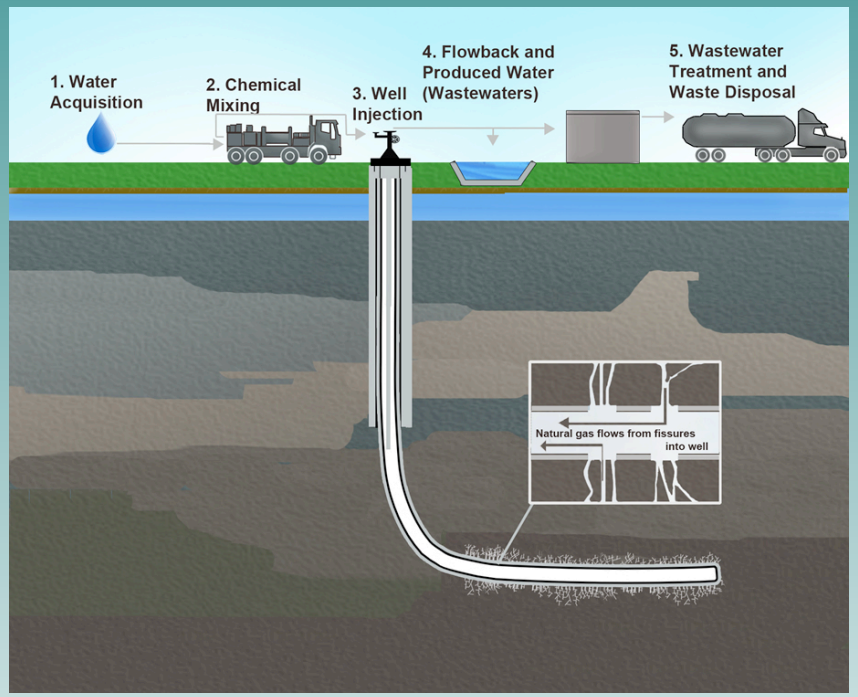
Advantages	Disadvantages
Contains fewer impurities and therefore emits almost no sulfur dioxide or particulates	When unburned, methane escapes into the atmosphere
Emits only 60% as much carbon dioxide as coal	Exploration of natural gas has the potential of contaminating groundwater

Hydraulic Fracturing

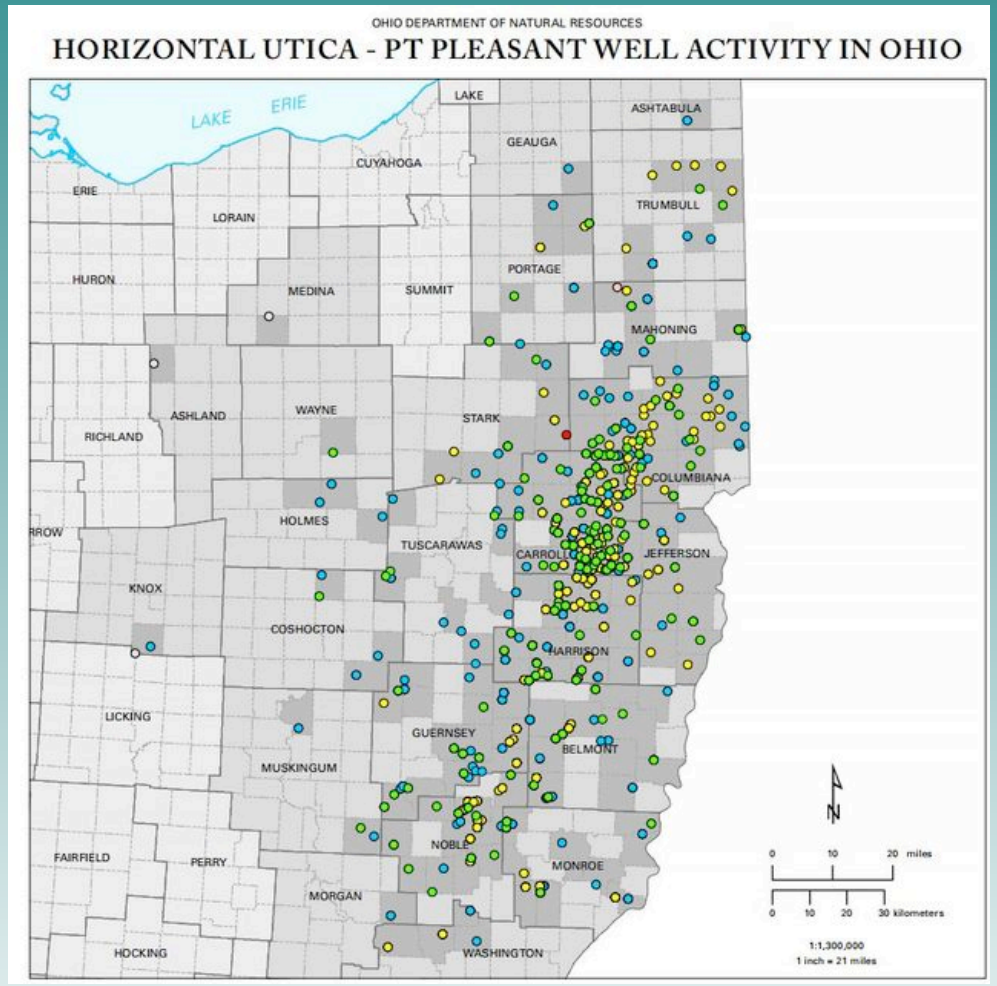
Figure 12.14
Environmental Science



The Process of Fracking



Natural Gas Drilling in Ohio



Other Fossil Fuels

- Oil sands- slow-flowing, viscous deposits of bitumen mixed with sand, water, and clay.
- Bitumen (tar or pitch)- a degraded type of petroleum that forms when a petroleum migrates close to the surface, where bacteria metabolize some of the light hydrocarbons and others evaporate.

Oil Sands and Bitumen

CTL
Coal to Liquid

As with Tar Sand…

Large H2O use, to extract and process.

Land degraded.

Trace metals.

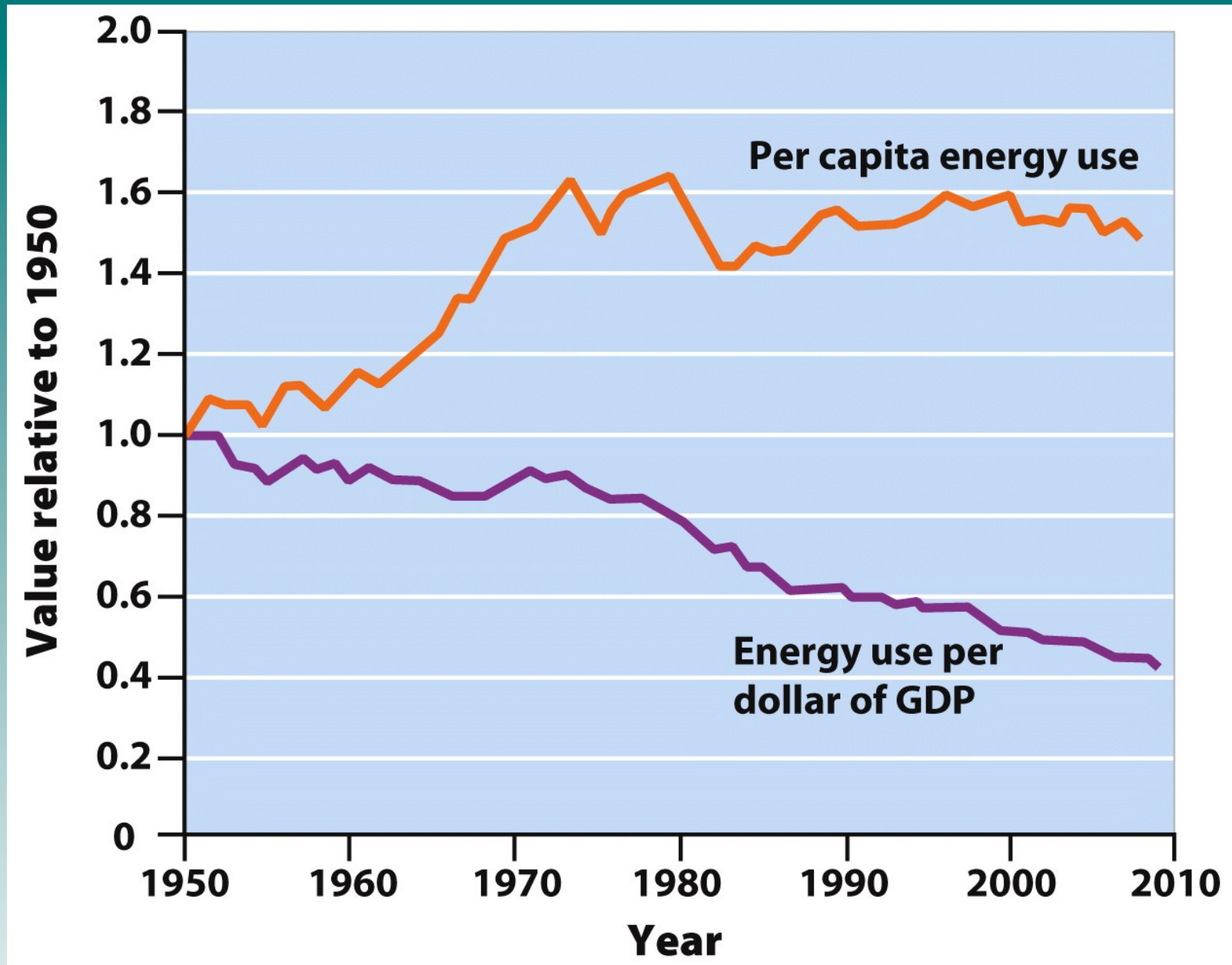


Figure 12.15
Environmental Science

The Hubbert Curve

- Note: finding more reserves will not significantly increase the amount of time before oil is used up. "Demand rises to meet Income!"

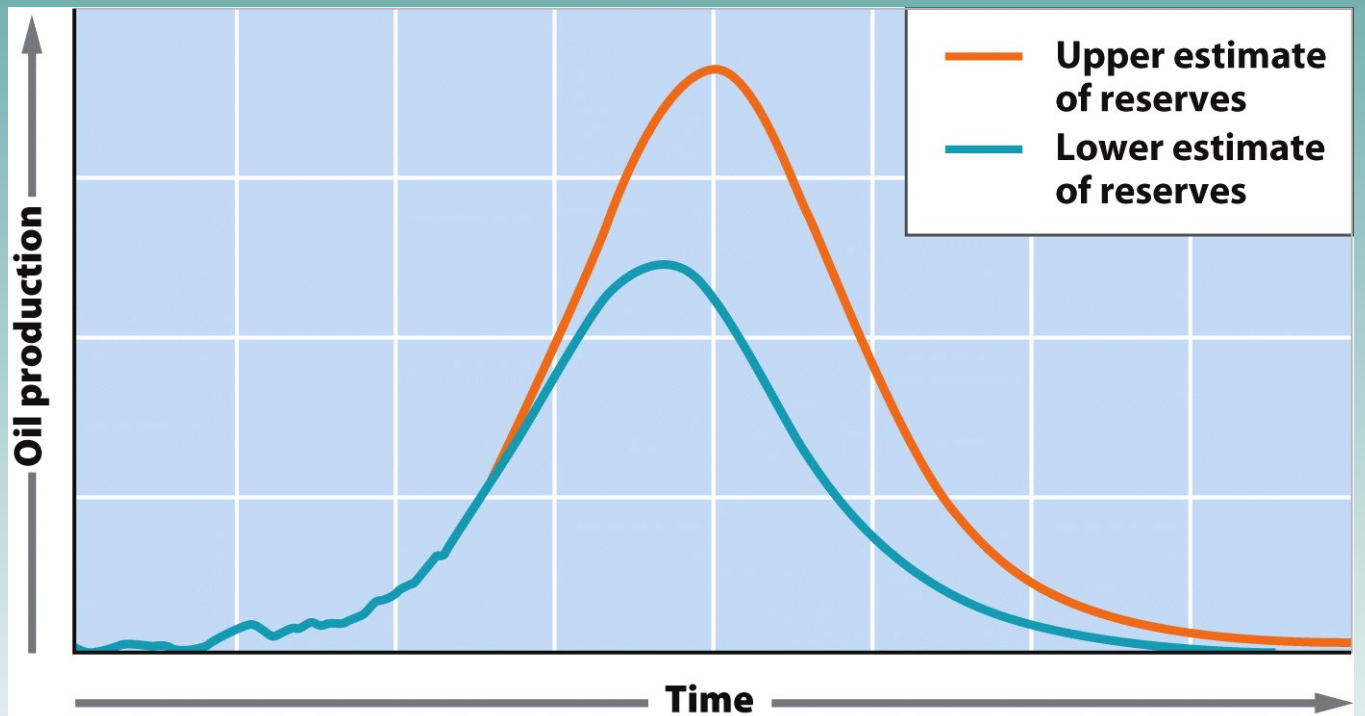


Figure 12.16
Environmental Science

The Future of Fossil Fuel Use

- If current global use continues, we will run out of conventional oil in less than 40 years.
- Coal supplies will last for at least 200 years, and probably much longer.

Nuclear Energy

- Fission- a nuclear reaction in which a neutron strikes a relatively large atomic nucleus, which then splits into two or more parts.

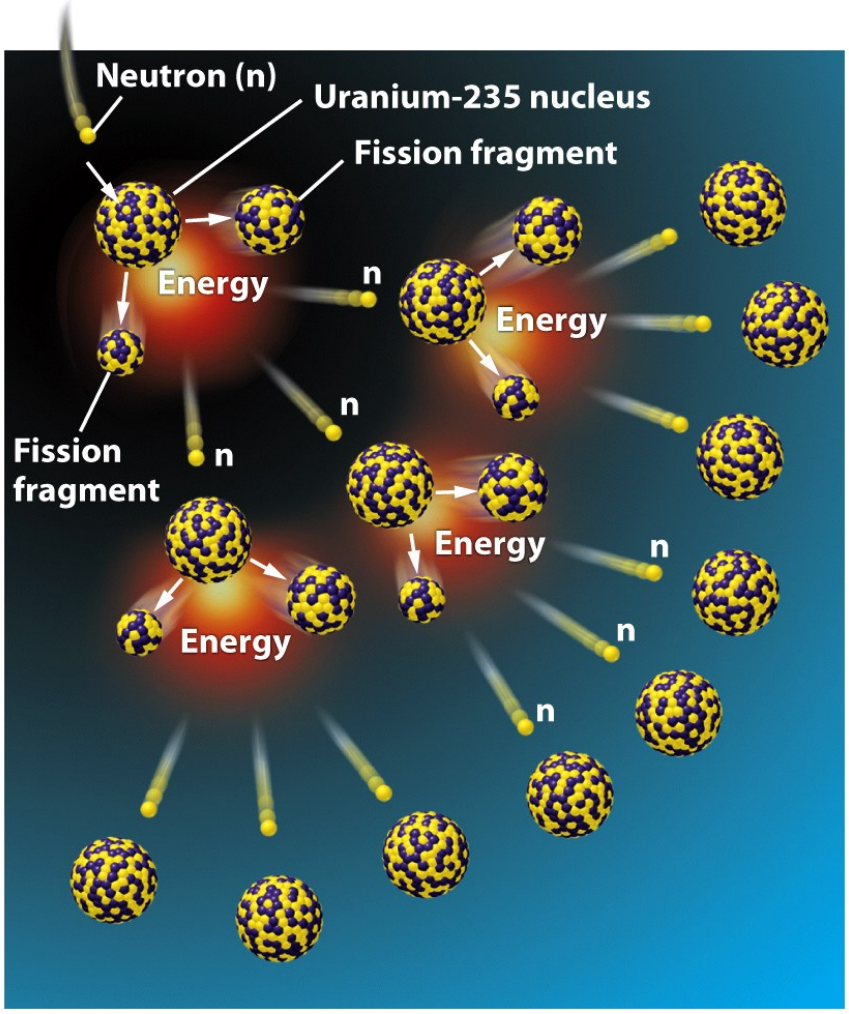


Figure 12.17
Environmental Science

Nuclear Reactors

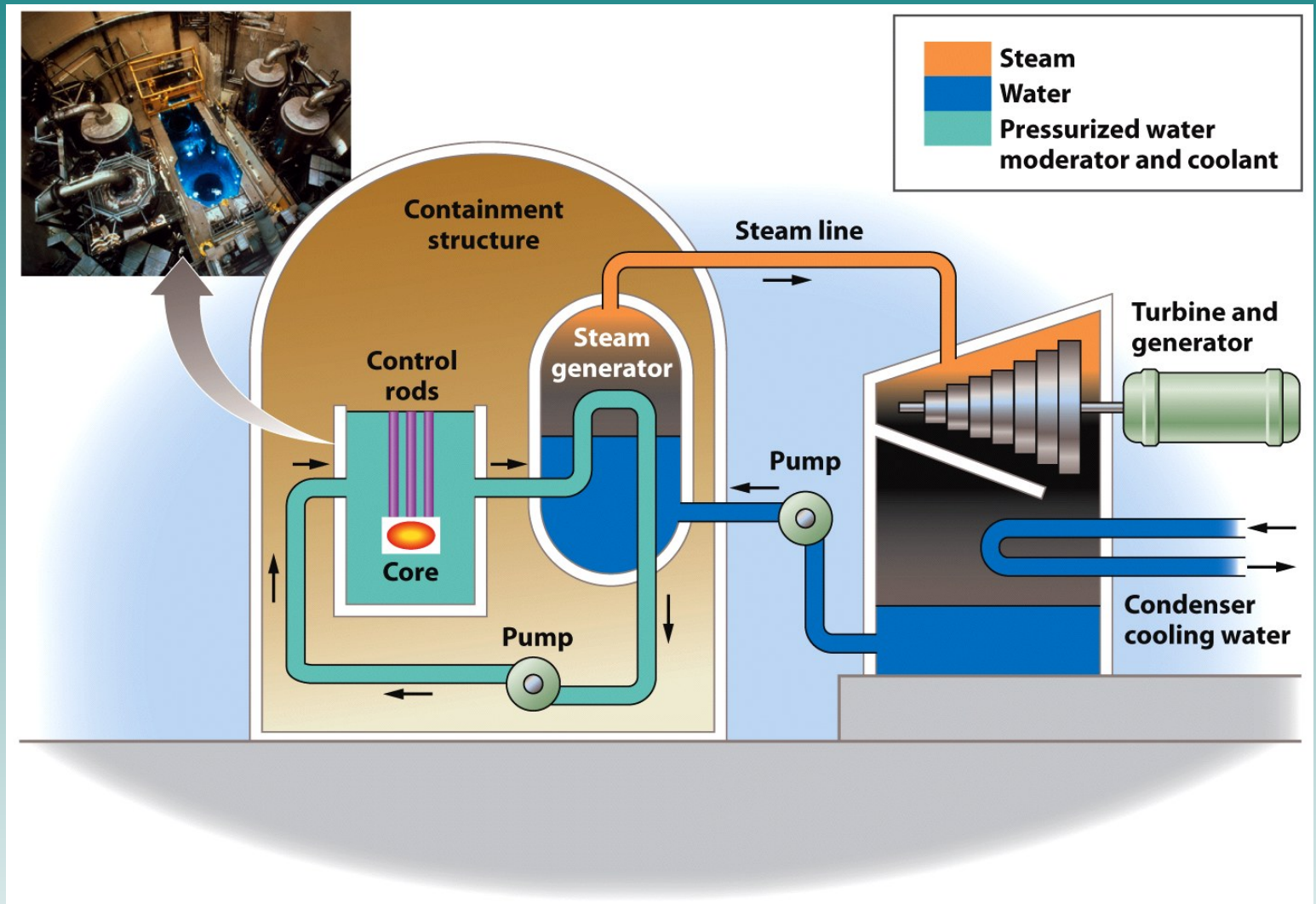


Figure 12.18
Environmental Science

Nuclear Reactors

- Fuel rods- the cylindrical tubes that house the nuclear fuel used in a nuclear power plant.
- Nuclear power plants work by using heat from nuclear fission to heat water. This water produces the steam to turn the turbine, which turns a generator.
- Control rods- cylindrical devices that can be inserted between the fuel rods to absorb excess neutrons, thus slowing or stopping the fission reaction.

Advantages and Disadvantages of Nuclear Energy

Advantages	Disadvantages
No air pollution is produced	Possibility of accidents
Countries can limit their need for imported oil	Disposal of the radioactive waste

Nuclear Accidents

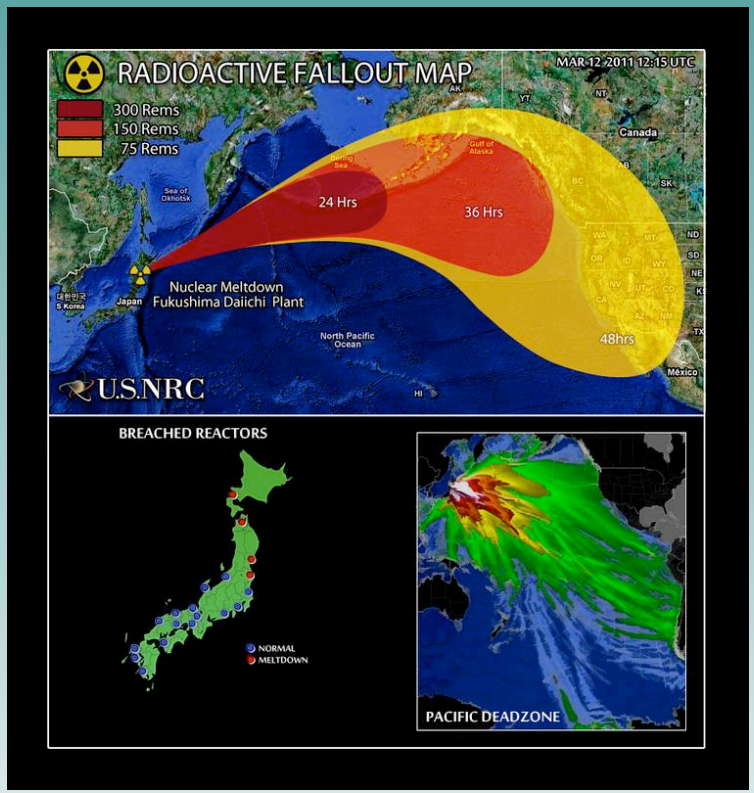
CHERNOBYL

THREE MILE ISLAND

Nuclear Accident - Tsunami

FUKUSHIMA, JAPAN

FUKUSHIMA FALLOUT



Radioactive Waste

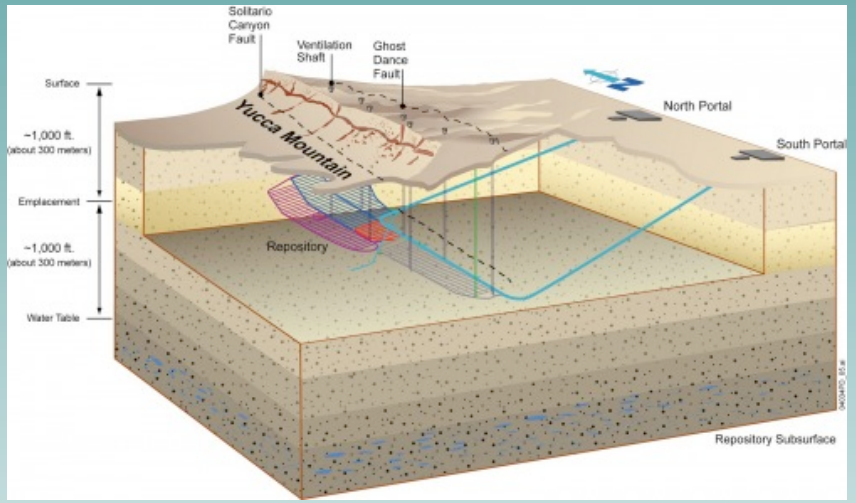
- Radioactive waste- once the nuclear fuel can not produce enough heat to be used in a power plant but it continues to emit radioactivity.
- This waste must be stored in special, highly secure locations because of the danger to living organisms.

Storage of Nuclear Waste

ON-SITE STORAGE

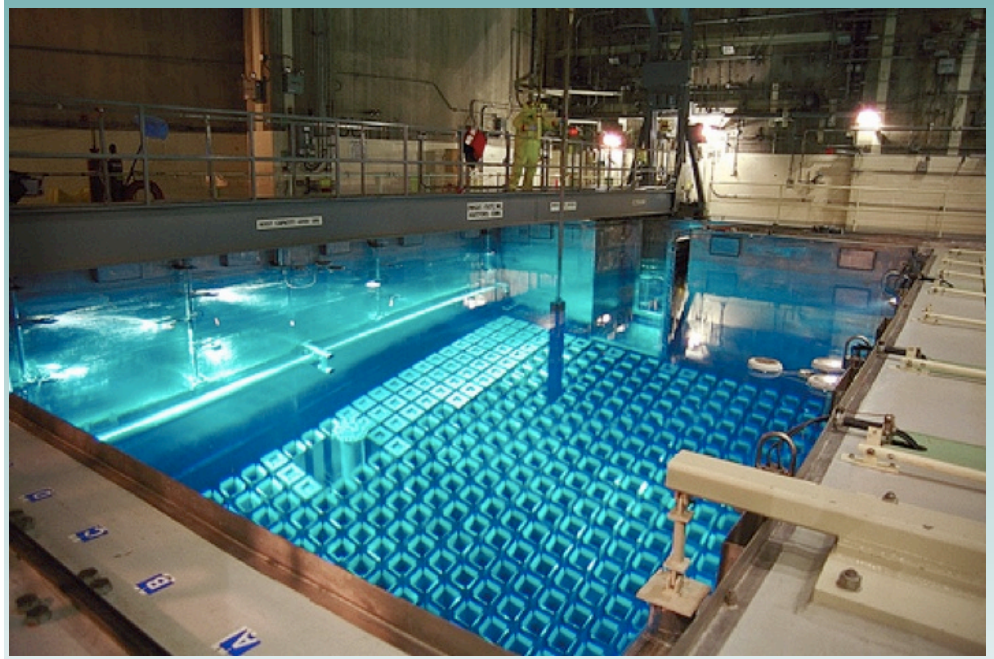
Figure 12.19
Environmental Science

YUCCA MT. - CANCELLED

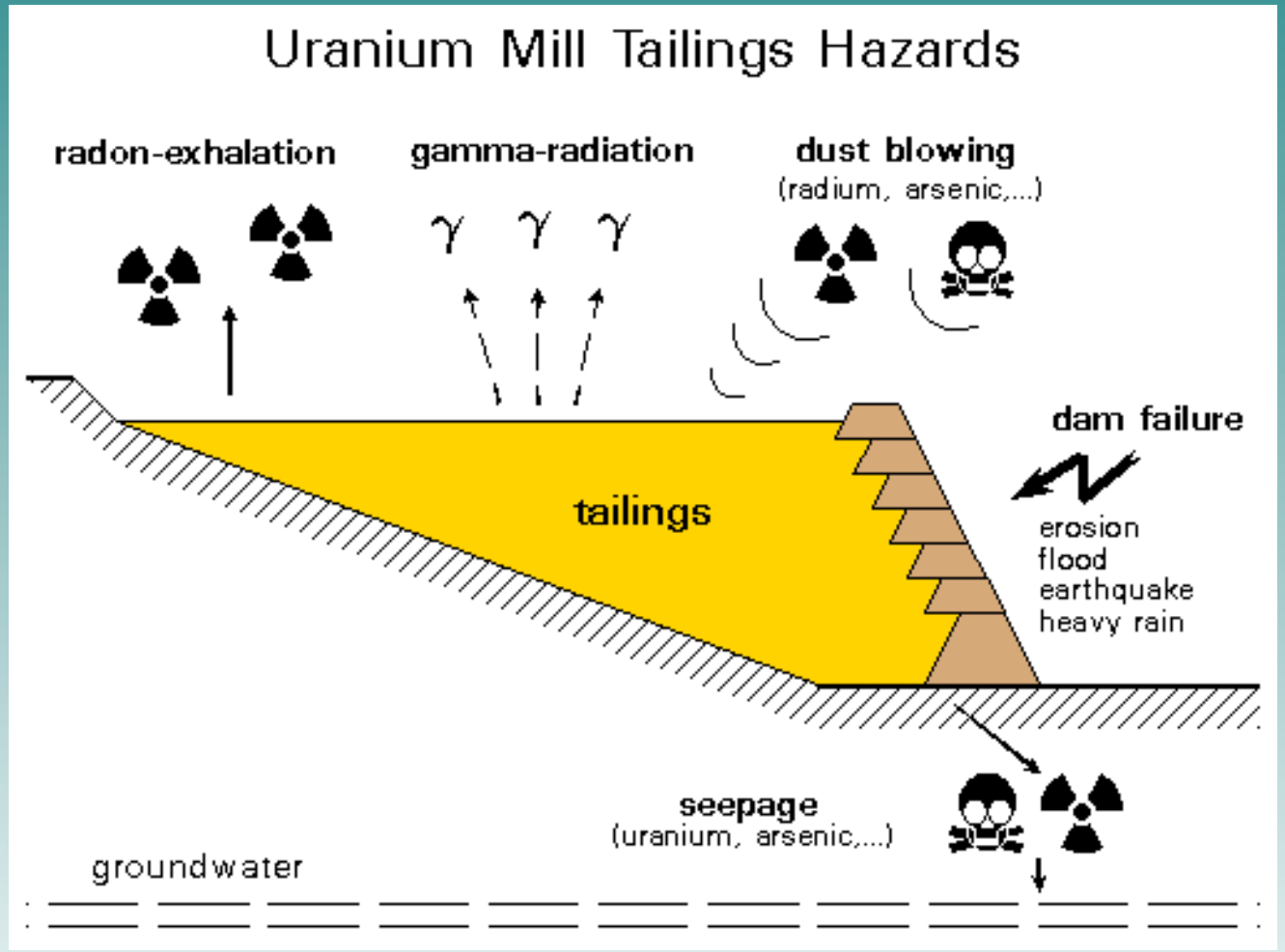


Radioactive Waste

- High-level radioactive waste- used fuel rods.
- Low-level radioactive waste- the protective clothing, tools, rags, and other items used in routine plant maintenance.



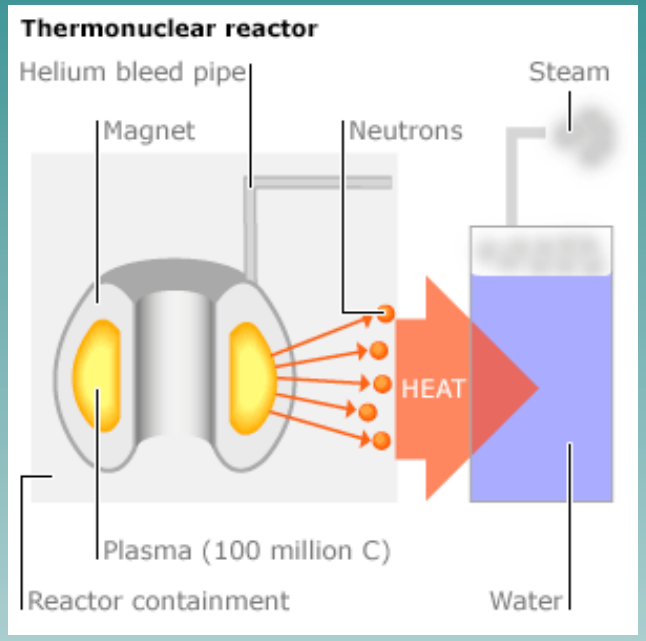
Uranium Mine Tailings



Fusion

- Nuclear fusion- the reaction that powers the Sun and other stars. This occurs when lighter nuclei are forced together to produce heavier nuclei and heat is released.
- Fusion is a promising, unlimited source of energy in the future, but so far scientists have had difficulty cotaining the heat that is produced.

Fusion Reactors –
so far, energy input exceeds energy output.



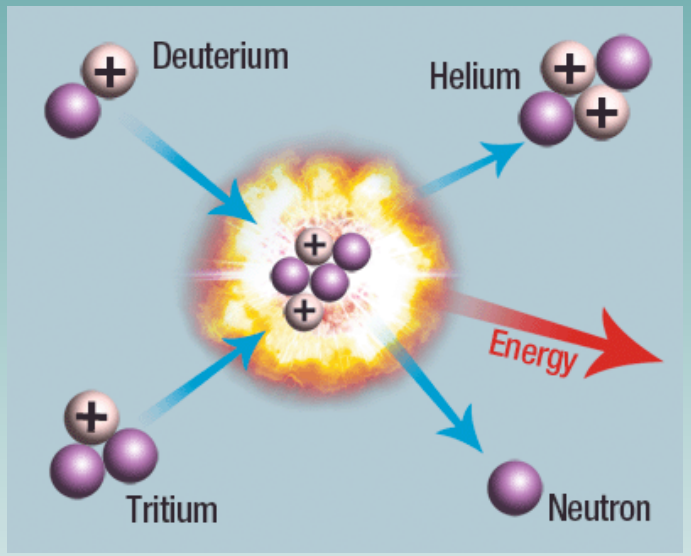


TABLE 12.2 Comparison of nonrenewable energy fuels

Energy type	Advantages	Disadvantages	Pollutant and greenhouse gas emissions	Electricity (cents/kWh)	Energy return on energy investment*
Oil/ gasoline	Ideal for mobile combustion (high energy/mass ratio) Quick ignition/turn-off capability Cleaner burning than coal	Significant refining required Oil spill potential effect on habitats near drilling sites Significant dust and emissions from fossil fuels used to power earth-moving equipment Human rights/ environmental justice issues in developing countries that export oil Will probably be much less available in the next 40 years or so	Second highest emitter of CO_2 among fossil fuels Hydrocarbons Hydrogen sulfide	Relatively little electricity is generated from oil	4.0 (gasoline) 5.7 (diesel)
Coal	Energy-dense and abundant—U.S. resources will last at least 200 years No refining necessary Easy, safe to transport Economic backbone of some small towns	Mining practices frequently risk human lives and dramatically alter natural landscapes Coal power plants are slow to reach full operating capacity A large contributing factor to acid rain in the United States	Highest emitter of CO_2 among energy sources Sulfur Trace amounts of toxic metals such as mercury	5 cents/ kWh	14

* Estimates vary widely.

Table 12.2 part 1
Environmental Science

TABLE 12.2 Comparison of nonrenewable energy fuels

Energy type	Advantages	Disadvantages	Pollutant and greenhouse gas emissions	Electricity (cents/kWh)	Energy return on energy investment*
Natural gas	Cogeneration power plants can have efficiencies up to 60 percent Efficient for cooking, home heating, etc. Fewer impurities than coal or oil	Risk of leaks/explosions Twenty-five times more effective as a greenhouse gas than CO_2 Not available everywhere because it is transported by pipelines	Methane Hydrocarbons Hydrogen sulfide	8–10 cents/kWh	8
Nuclear energy	Emits no CO_2 once plant is operational Offers independence from imported oil High energy density, ample supply	Very unpopular; generates protests Plants are very expensive to build because of legal challenges Meltdown could be catastrophic Possible target for terrorist attacks	Radioactive waste is dangerous for hundreds of thousands of years No long-term plan currently in place to manage radioactive waste No air pollution during production	12–15 cents/kWh	8

* Estimates vary widely.

Table 12.2 part 2
Environmental Science

TED: The Energy Detective

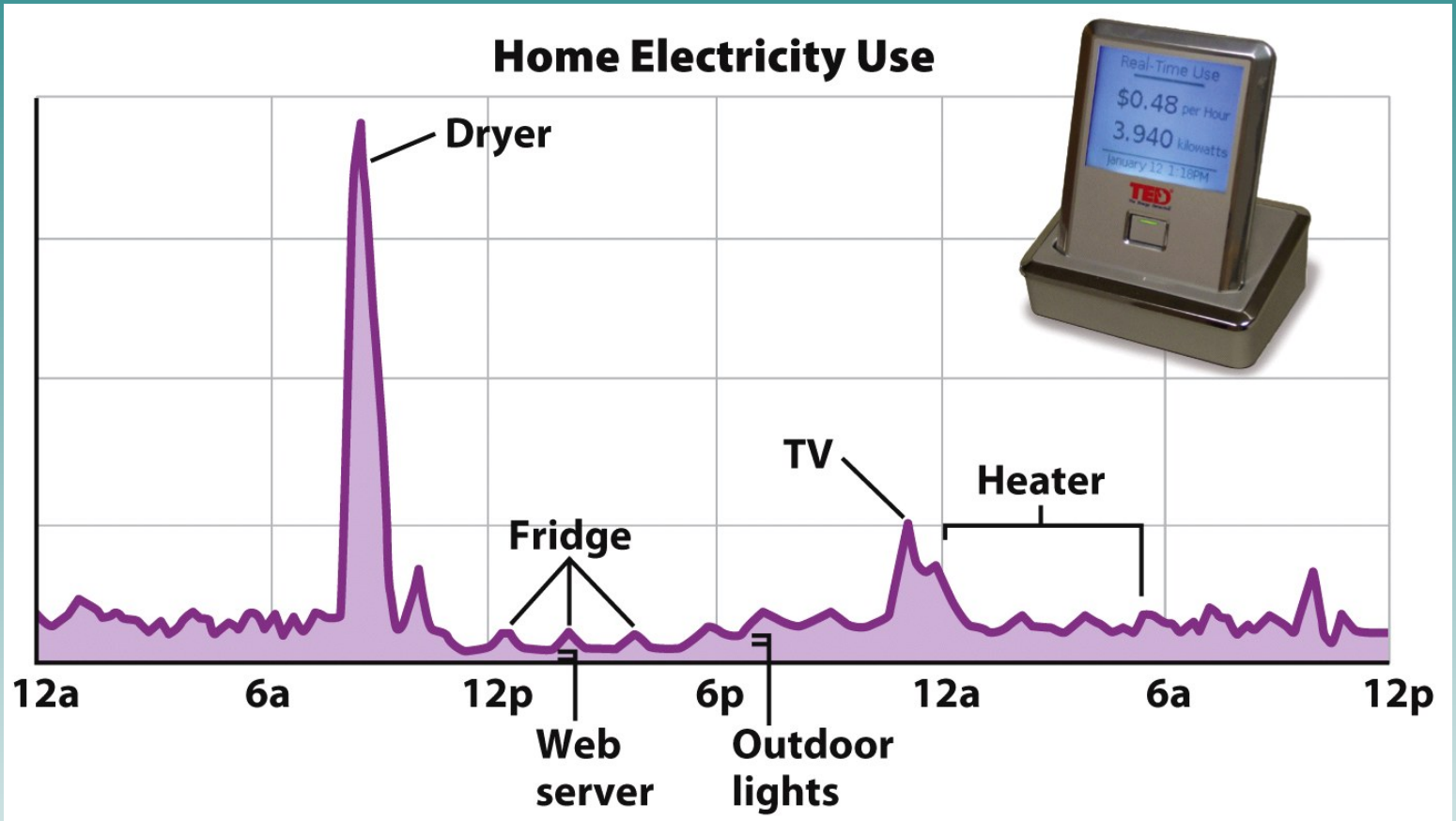


Figure 12.20
Environmental Science

Energy Vampires…chargers, TV's, computers…so called "standby energy".