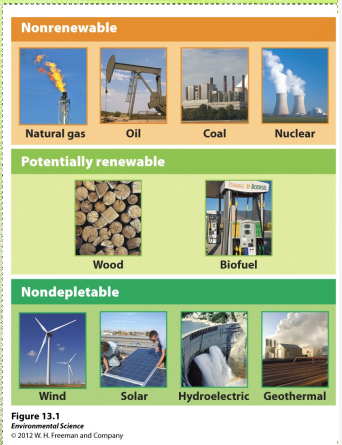

Figure 13.1
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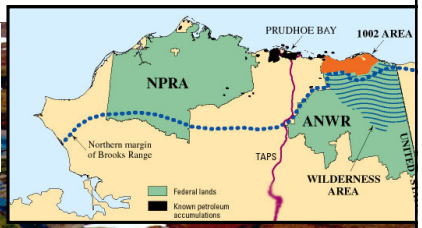
Energy

Chapters 19-21

Fossil Fuels Video

Artic National Wildlife Refuge (ANWR)

- Federal land set aside for wildlife and to preserve pristine ecosystems
- Pristine wilderness to some and untapped oil riches to others
- Debate over whether the "1002 Area" should be opened to drilling
- Opponents fear that drilling will sacrifice the nation's national heritage for little gain
  - 4.3 – 11.8 billion barrels recovered
  - -Enough for 1 year

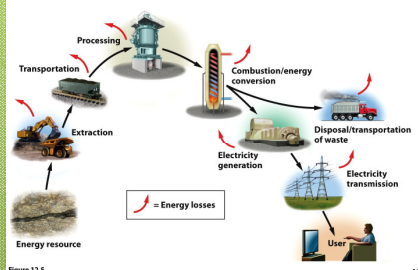


The first Earthday

- April 22, 1970
  - Several events in the 60's prompted the creation.
    - Well explosion off the coast of Santa Barbara CA in January, 1969. 3 million gallons of crudes oil dumped.
- Spills can happen during any part of the process: leaks, explosions, extraction, transport.
  - March, 1989: Exxon Valdez super tanker crash into Prince William Sound, Alaska. 53 million gallons.
  - 2005: BP oil refinery in Texas. 15 workers killed.
  - April, 2010: Coal mine explosion in West Virginia. 29 miners killed.
  - April, 2010: BP Deepwater Horizon oil well in the Gulf of Mexico. Killed 11 workers, injured 17, 206 million gallons of oil dumped.

EROEI (Energy Return ON Energy Investment

$$\text{EROEI} = \frac{\text{Energy obtained from the fuel}}{\text{Energy invested to obtain the fuel}}$$



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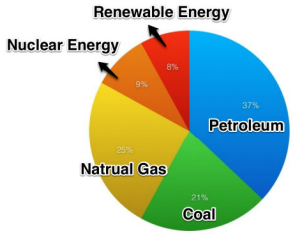
**The bigger the EROEI, the better.

Nonrenewable Energy

- Nonrenewable energy resources- fossil fuels (coal, oil, natural gas) and nuclear fuels.
  - Two main categories: Fossil fuels and Nuclear fuels

- Today (U.S. and worldwide): in order of increasing importance:
- 1. oil
- 2. coal
- 3. natural gas.



Energy sources for US power

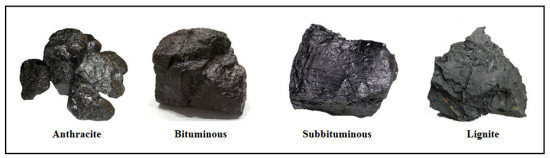
Fossil Fuel Video

Coal-Non Renewable

- World's most abundant fossil fuel
  - US, Russia, China and India
- What is this energy source used for?
  - Electricity and industry
- How is power generated?
  - Coal burned, steam spins turbines
- Environmental Problems
  - Gray smog: SO_2, PM, CO
  - CO_2
  - Acid Rain
  - Mercury emissions (Tuna)
  - Mining
- Worst health problems
  - #1 China
  - #2 USA

Coal

- Four types of coal ranked from lesser to greater age, exposure to pressure, and energy content.
- These four types are:
  1. Anthracite – highest ranked –high energy –oldest
  2. Bituminous – 2nd ranked in energy (MOST USED)
  3. Sub-bituminous – 3rd ranked in energy
  4. Lignite- Lowest energy –youngest



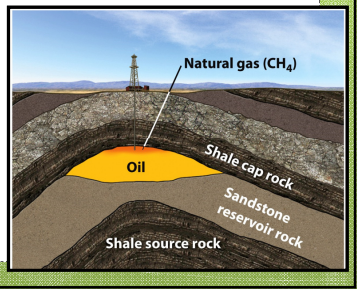
- Peat = organic material that is broken down anaerobically but remains wet, near the surface and not well compressed

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	

Oil/Gasoline—non renewable

- What is this energy source used for?
  - Transportation, plastics, some electricity
- How is power generated?
  - Internal combustion engine in cars
- Environmental Problems:
  - Brown smog: NOx, Ozone, VOCs
  - Roads to drilling
  - CO_2



Lego Clip

Oil continued

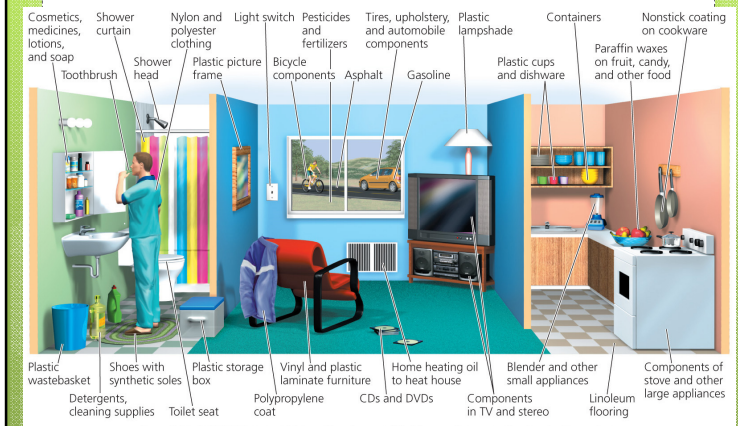
- Human Health Problems:
  - Respiratory problems such as Asthma
- Which Countries?
  - Russia and Saudi Arabia produce the most
  - US uses most, but oil economy is global.

- OPEC (Organization of Petroleum Exporting Countries

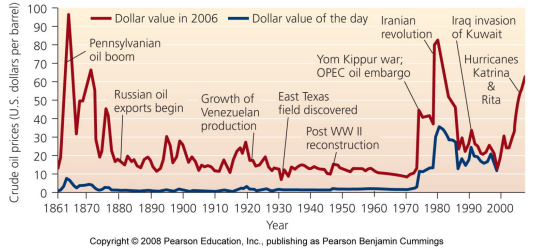
-Is a permanent, intergovernmental Organization, created at the Baghdad Conference on September 10–14, 1960, by Iran, Iraq, Kuwait, Saudi Arabia and Venezuela.

Petroleum products have many uses

Extracted oil is refined to create many products



- Oil embargo caused widespread panic and skyrocketing prices

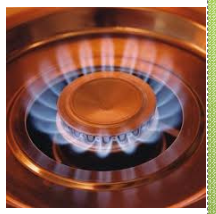


Advantages and Disadvantages of Petroleum

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	Deliberate and accidental releases of waste oil
	Possible that it might melt permafrost and interfere with the calving of caribou along pipelines
	Releases sulfur, mercury, lead, and arsenic into the atmosphere when burned

Natural Gas—non renewable

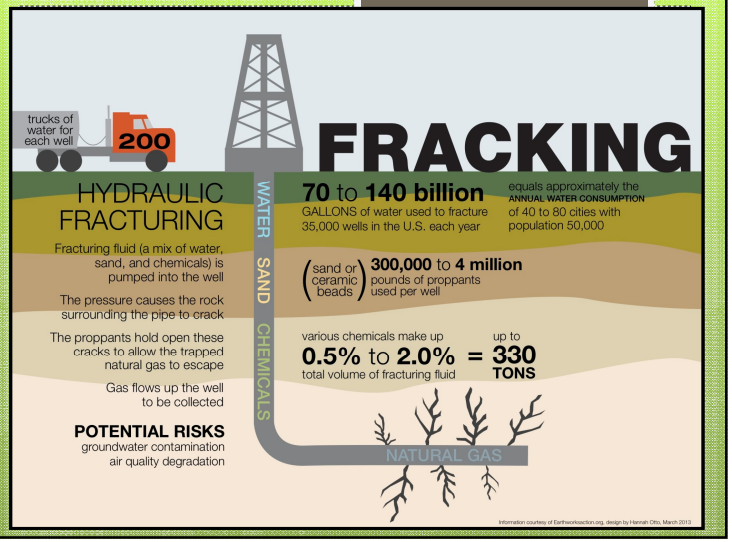
- Natural gas- exists as a component of petroleum in the ground as well as in gaseous deposits separate from petroleum.
- Mostly methane and some ethane, propane, and butane.
  - What is this energy source used for?
    - Cooking, heating, electricity and transportation
  - How is power generated?
    - Turbines
    - Combustion



Song Clip

Natural Gas continued

- Human Health Problems:
  - Toxic gas
- Which Countries?
  - Russia and the U.S lead in production and consumption
- Environmental Problems:
  - Some CO_2
  - Fracking can damage aquifers
  - Pipelines can explode



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 (potent greenhouse gas)
Emits only 60% as much carbon dioxide as coal	Exploration of natural gas has the potential of contaminating groundwater
	Large quantities of water used during extraction

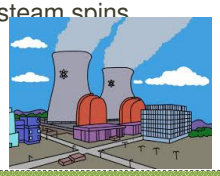
Oil sands- Nonrenewable

- **Oil sands (tar sands)** = sand deposits with 1 - 20% **bitumen**, a thick form of petroleum
- Degraded and chemically altered crude oil deposits
  - Removed by strip mining
- Requires special extraction and refining processes to become useful
- Primarily found in Venezuela and Alberta, Canada

Nuclear—non renewable

- The reaction that drives the release of nuclear energy in power plants is **nuclear fission** = the splitting apart of atomic nuclei
- Fuel is Uranium

- What is this energy source used for?
  - Electricity and weapons
- How is power generated?
  - Nuclear fission-energy heats water, steam spins turbines



Nuclear continued

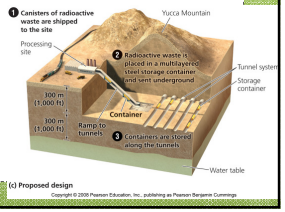
- Human Health Problems:
  - Accidents cause thyroid cancer, birth defects, radiation poisoning, death
- Which Countries?
  - France-highest % of own electricity
  - U.S.-most MW power
- Environmental Problems:
  - No emission (good), but accidents a problem.
  - Disposal problems
  - Thermal pollution in water

Nuclear continued

Nuclear power poses small risks

- **Three Mile Island** was the most serious accident in the U.S. Meltdown
- **Chernobyl** was the worst accident in the world.
  - 1986 in Ukraine
- **Fukushima** was caused by tsunami that was triggered by an earthquake.
  - 2011 in Japan

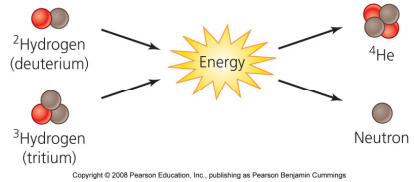
- Radioactive waste storage at Yucca Mountain, Nevada
- 125 sites in over 39 states



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 Fusion remains a dream



- **Nuclear fusion =** the process that drives our Sun's vast output of energy
  - The force behind hydrogen (thermonuclear) bombs
  - Involves forcing together the small nuclei of lightweight elements under extremely high temperature and pressure
  - If we could control fusion, we could produce vast amounts of energy from water

Biomass-renewable, but has to grow back

- Organic material that makes up living organisms

- What is this energy source used for?
  - Cooking/heating (wood), electri
    ethanol (cars)
- How is power generated?
  - combustion
  - Turbines
  - Combustion engine

Biomass continued

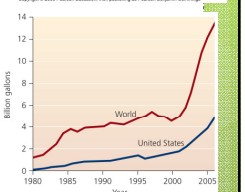
- Human Health Problems:
  - Respiratory problems such as asthma
- Which Countries?
  - Developing countries for cooking
  - U.S. (corn) and Brazil (sugarcane) for ethanol
- Environmental Problems:
  - Deforestation (wood)
  - Fertilizers, pesticides (crops for ethanol)
  - CO_2 , CO, PM

Biofuels

- Ethanol = produces as a biofuel by fermenting carbohydrate-rich crops
  - Ethanol is widely added to U.S. gasoline to reduce emissions
  - Any vehicle will run well on a 10% ethanol mix
- **Flexible fuel vehicles** = run on 85% ethanol

But, very few gas stations offer this fuel

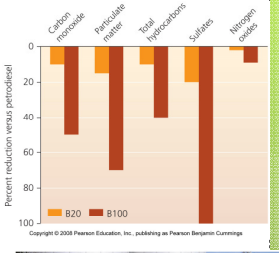
(a) Corn grown for ethanol



(b) Ethanol production, 1980–2006

Biodiesel

- U.S. biodiesel producers use soybean oil
  - Animal fats, used grease, and cooking oil can also be used
  - Vehicles can run on 100% biodiesel, but the engine needs to be modified
  - Biodiesel cuts down on emissions; its fuel economy is almost as good and costs slightly more than gasoline



Modern Carbon vs. Fossil Carbon

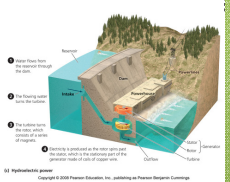
- Many people are confused how burning biomass such as wood is better then burning coal.

- The carbon found in biomass was in the atmosphere as carbon dioxide, taken in by the tree, and by burning it we put it back into the atmosphere (it was taken out more recently)
- **Carbon neutral = No net increase in Carbon**

- Burning coal is carbon that has been buried for millions of years and was out of circulation until we began to use it.
- This results in a rapid increase in the concentration of carbon dioxide in the atmosphere

Hydroelectric—Renewable if good rainfall

- What is this energy source used for?
  - Electricity (efficient)
- How is power generated?
  - Water spins turbines in dams
- Environmental Problems:
  - Evaporation and sediments behind dam
  - Habitat alteration for river species



Hydroelectric continued

- Human Health Problems:
  - Reservoirs of water can breed mosquitos in tropical countries
- Which Countries?
  - Norway—highest % of own electricity
  - Canada—most MW of power from hydroelectric
  - China—largest dam

- 2.2 % of world energy supply

Solar --renewable

- What is this energy source used for?
  - PV cells—electricty
  - Active and Passive—cooking and heating
- How is power generated?
  - PV cells—silicon + light
  - Active/passive—direct heat
- Environmental Problems:
  - PV Cells—production makes toxins
  - Active/Passive-- none

Solar continued

- Human Health Problems:
  - none
- Which Countries?
  - Germany leads the world

Passive Solar Energy

Using passive solar energy can lower your electricity bill without the need for pumps or other mechanical devices.

Building the house with windows along a south-facing wall which allows the Sun's rays to warm the house would be an example.

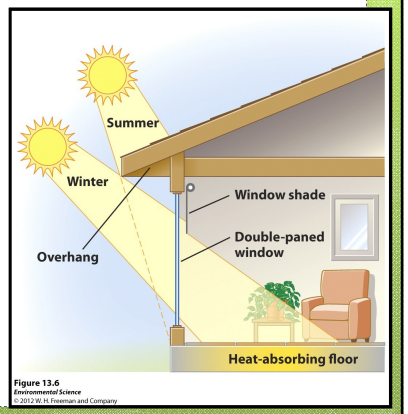


Figure 13.6
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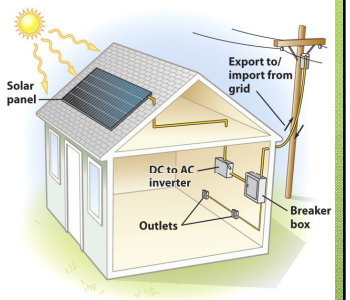
Active solar energy

- Uses technology to focus, move, or store solar energy
- Solar water heating systems, photovoltaic systems (PV)

Photovoltaic System (PV)

- Silicon plates

In this domestic photovoltaic system, photovoltaic solar panels convert sunlight into direct current (DC). An inverter converts DC into alternating current (AC), which supplies electricity to the house. Any electricity not used in the house is exported to the electrical grid.



Schematic of photovoltaic (PV) system

Figure 13.18a
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Photovoltaic Systems

Benefits and Drawbacks

- No air pollution
- No water pollution
- No CO_2 production
- Produce electricity when it is needed most: hot sunny days.

- Initial cost to set up
- PV panels are expensive
- Manufacturing PV requires a great deal of energy and water and involves a variety of toxic metals and industrial chemicals.
- End-of-life reclamation of PV solar cells is a source of environmental contamination
- Life span <20-30 years

Wind--renewable

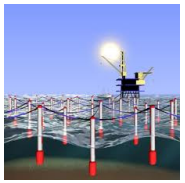
- Fastest growing source of electricity worldwide.
- What is this energy source used for?
  - electricity
- How is power generated?
  - Wind spins turbines
- Environmental Problems:
  - Birds hit blades
  - Bird/bat migration and flying paths

Wind continued

- Human Health Problems:
  - none
- Which Countries?
  - Historically and currently highest % of own power-Denmark
  - U.S.-most MW
  - Germany

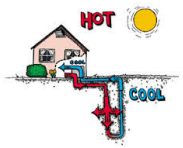
Waves/Tidal--renewable

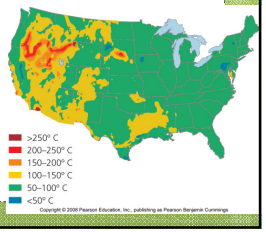
- What is this energy source used for?
  - electricity
- How is power generated?
  - Force of water spins turbines
- Environmental Problems:
  - Disruption of marine habitat
- Human Health Problems:
  - none
- Which Countries?
  - Experimental in U.S. and Japan



Geothermal—renewable if no over-pumping of groundwater

- What is this energy source used for?
  - Electricity
  - Heating
- How is power generated?
  - Steam from aquifers spins turbines
  - Hot water through pipes in homes/buildings
- Environmental Problems:
  - Ground water depletion





Geothermal continued

- Human Health Problems:
  - Natural sulfur becomes airborne
- Which Countries?
  - Iceland

Hydrogen--renewable

- What is this energy source used for?
  - Transportation
- How is power generated?
  - Fuel cells split water into H_2 and O_2 gas. H_2 is combustable
- Environmental Problems:
  - Use fossil fuels to split water
- Human Health Problems:
  - none
- Which Countries?
  - experimental

Smart grid

- Efficient, self-regulating electricity generating distribution source.
  - Coordinates energy use with availability.
- Some experts maintain that a better system would consist of a large number of small scale electricity generating “parks” that rely on a mix of fossil fuel and renewable energy.
  - Would save money because it would transfer energy over shorter distances leading to less loss (2nd law of thermodynamics) and they would be safer from breakdown and sabotage. They would also cause less large scale outages.

Smart grid