ENERGY RESOURCES

EM&SD lecture

Energy Resources

- Supplementing free solar energy
  - 99% of heat comes from the sun
  - Without the sun, the earth would be –240 ^{0}C (-400 ^{0}F)
- We supplement the other 1% with primarily non-renewable energy sources

Energy Resources

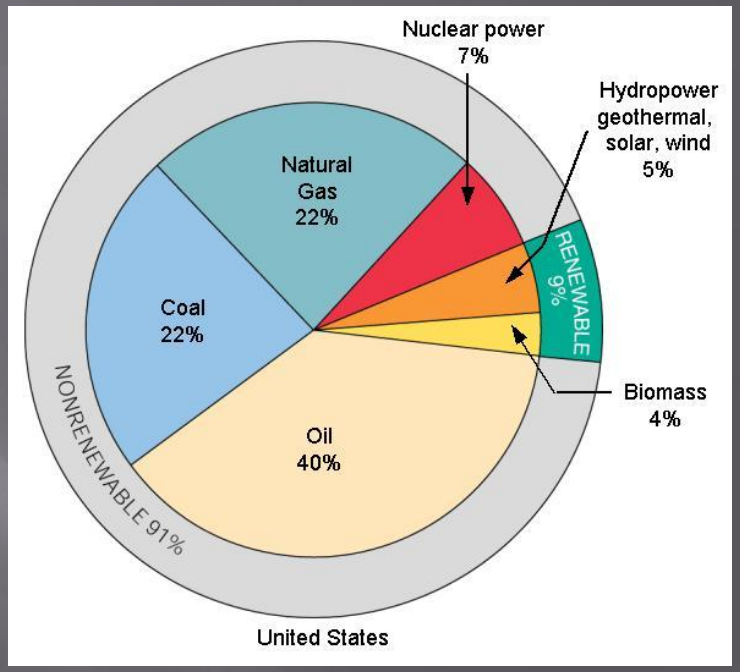
- Renewable (16%)
  - Solar
  - Wind
  - Falling, flowing water
  - Biomass
- Non-renewable (84%)
  - Oil
  - Natural gas
  - Coal
  - Nuclear power

Energy sources and uses

- Energy uses in developed countries
  - industrial
  - domestic
  - transportation
- Note: Electricity is not an energy source, converted from another source (coal, hydro, nuclear, etc.).
- 1st Law of Thermodynamics - You can't get more energy out of something than you put in
- 2ond Law – In any conversion of heat energy to useful work, some energy is always degraded to a lower quality energy

Evaluating Energy Resources

- Renewable
- Future availability
- Net energy yield
  - It takes energy to get energy
- Habitat degradation
- Cost (initial and ongoing)
- Community disruption
- Political or international issues
- Suitability in different locations
- Polluting (air, water, noise, visual)



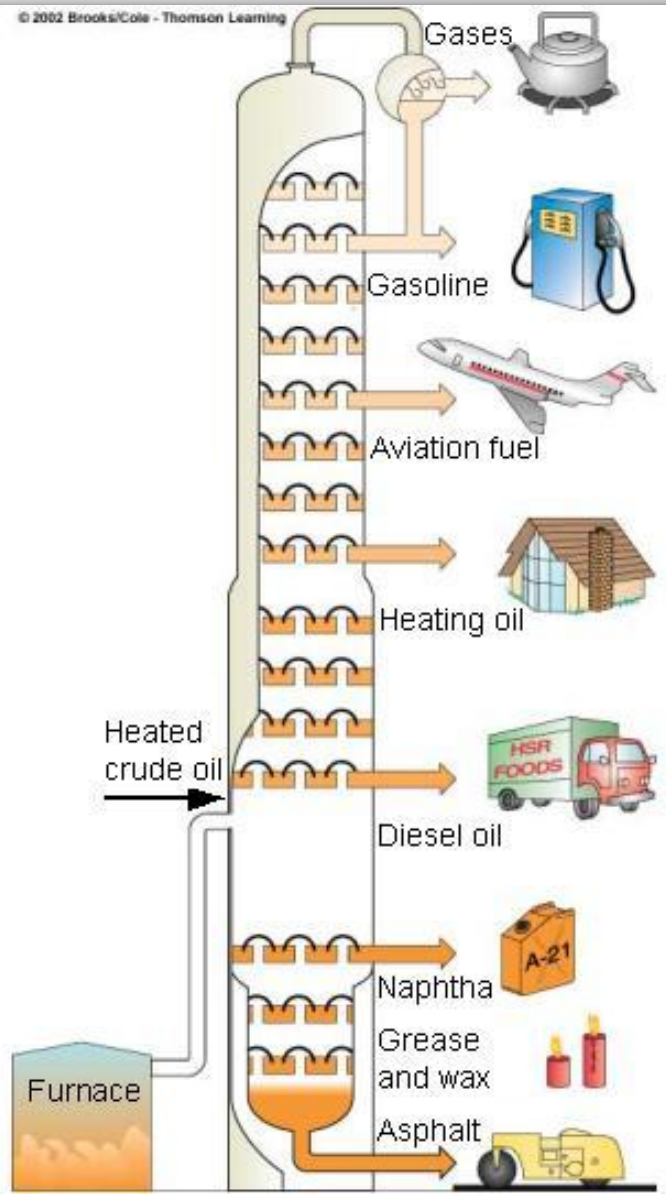
OIL and NATURAL GAS

- Accumulations of dead marine organisms on the ocean floor were covered by sediments.
- Muddy rock gradually formed rock (shale) containing dispersed oil.
- Sandstone formed on top of shale, thus oil pools began to form.
- Natural gas often forms on top of oil.
  - Primary component of natural gas is methane

Oil

Based on boiling points

- Petroleum (crude oil)
- Costs:
  - Recovery
  - Refining
  - Transporting
  - Environmental
    - Highest risks are in transportation
- Refining yields many products
  - Asphalt
  - Heating oil
  - Diesel
  - Petrochemicals
  - Gasoline
  - …



Conventional Oil

Advantages

- Relatively low cost
- High net energy yield
- Efficient distribution system

Disadvantages

- Running out
  - 42-93 years
- Low prices encourage waste
- Air pollution and greenhouse gases
- Water pollution

Oil Shale and Tar Sands

Tar Sand:

Mixture of clay, sand water and *bitumen* - a thick and sticky heavy oil.

Extracted by large electric shovels, mixed with hot water and steam to extract the bitumen.

Bitumen heated to

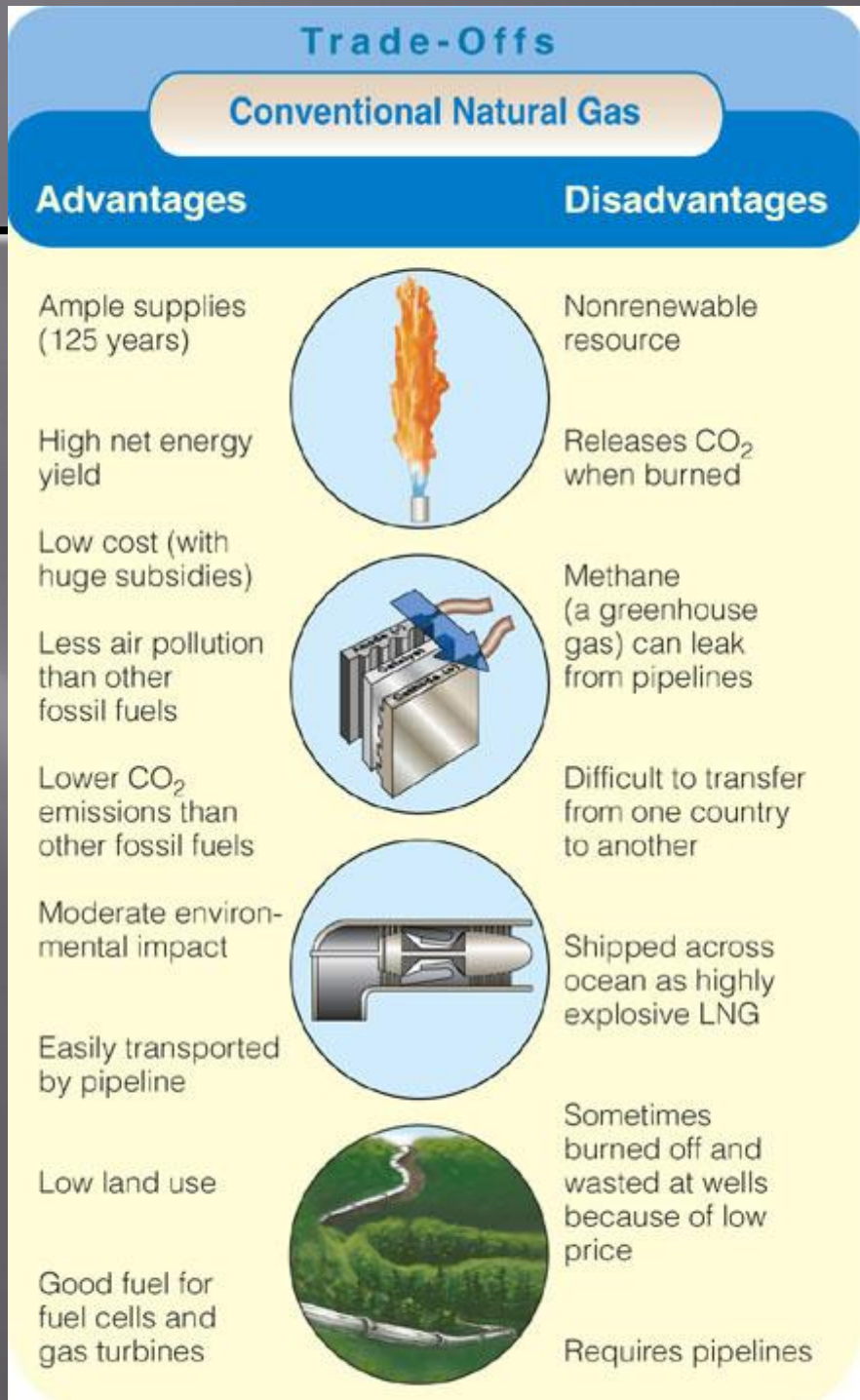
Oil Shale:

Oily rocks that contain a solid mix of hydro-carbons.

Global supplies ~ 240 times conventional oil supplies.

Natural Gas

- 50-90% methane
- Cleanest of fossil fuels
- Approximate 200 year supply
- Advantages and disadvantages



Coal – What is it?

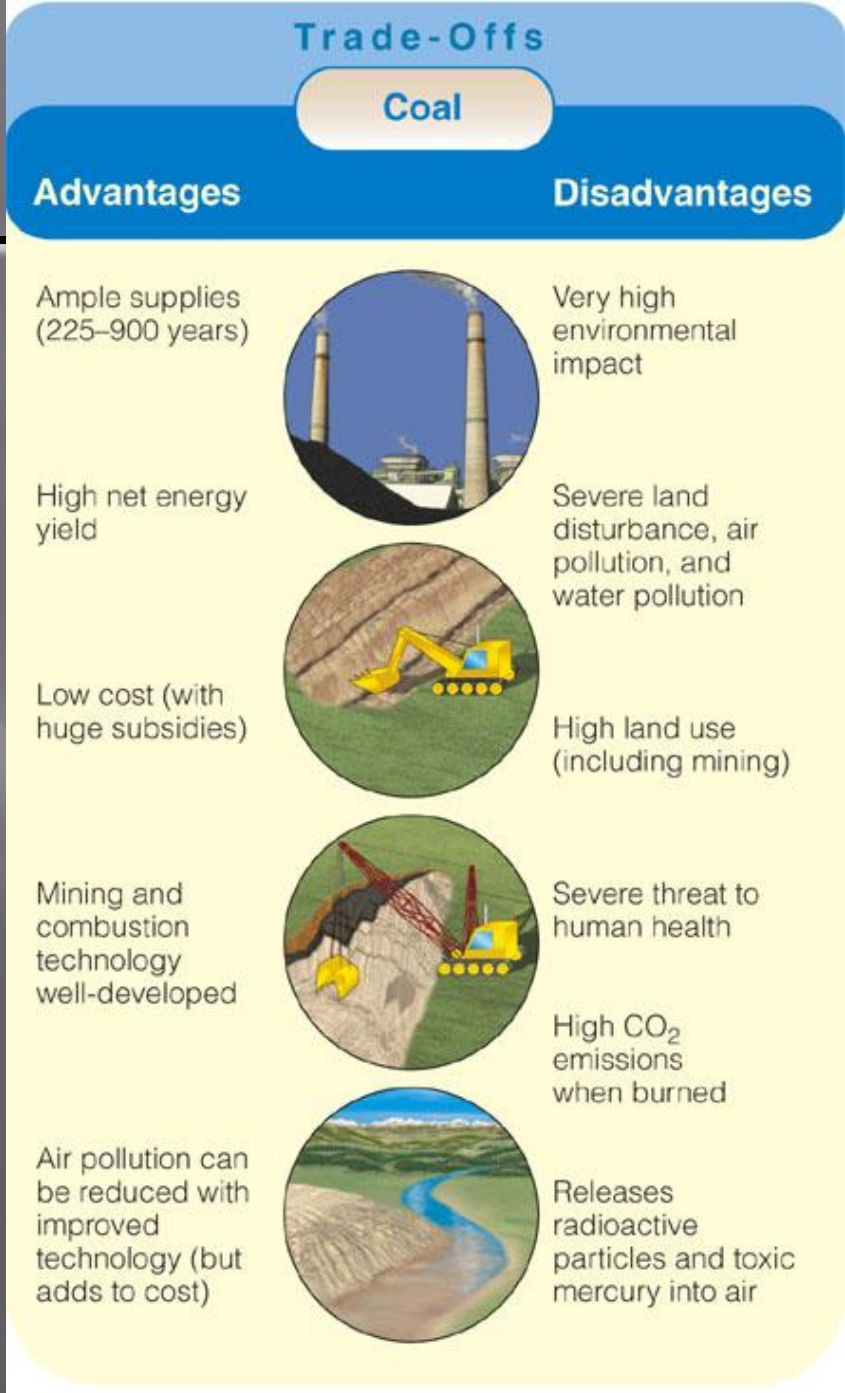
- Solid fossil fuel formed in several stages
- Land plants that lived 300-400 million years ago
- Subjected to intense heat and pressure over many millions of years
- Mostly carbon, small amounts of sulfur

Coal – what do we use it for?

- Stages of coal formation
  - 300 million year old forests
  - peat > lignite > bituminous > anthracite
  - Primarily strip-mined
- Used mostly for generating electricity
  - Used to generate 62% of the world's electricity
  - Used to generate 52% of the U.S. electricity
- Enough coal for about 200-1000 years
  - U.S. has 25% of world's reserves
- High environmental impact
- Coal gasification and liquefaction

Coal: Trade-offs

World's most abundant fossil fuel
Mining and burning coal has a severe environmental impact
Accounts for over 1/3 of the world's CO_2 emissions



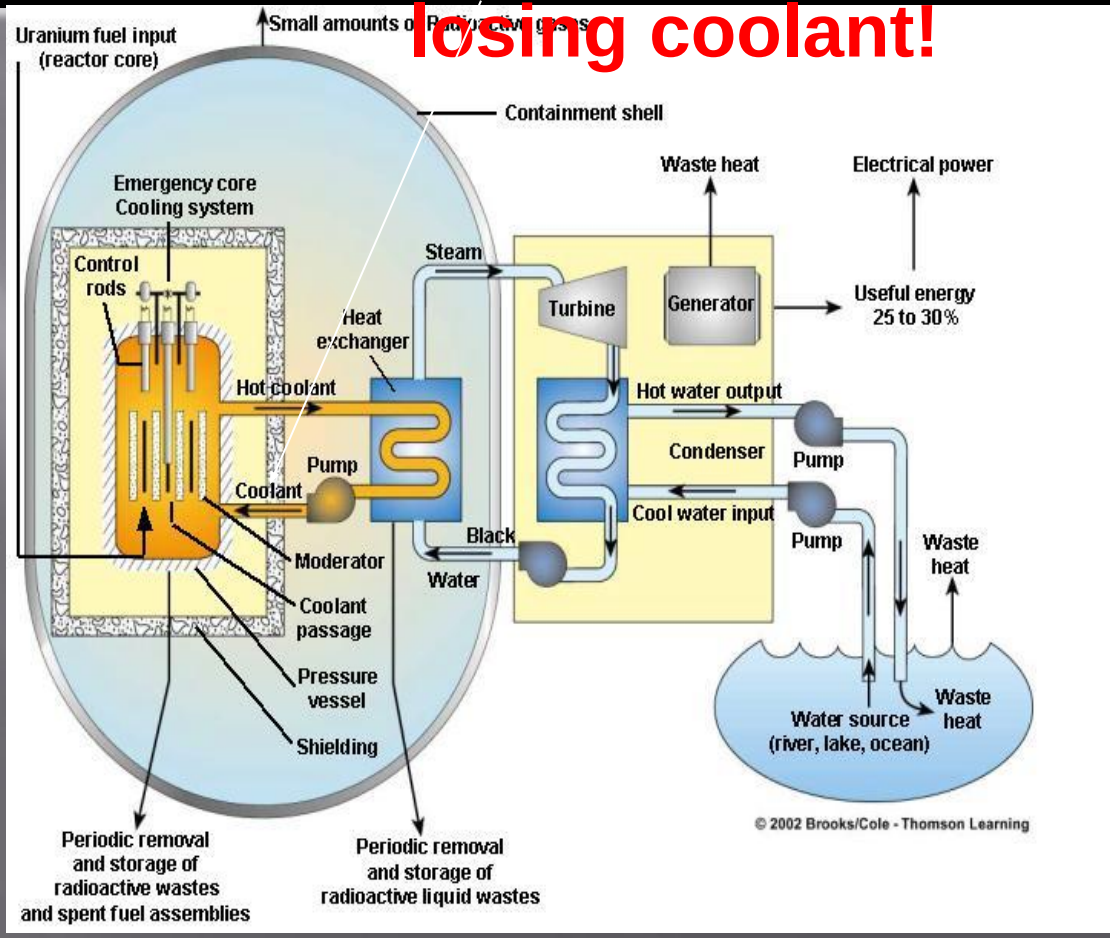
Nuclear Energy – What is it?

- A nuclear change in which nuclei of certain isotopes with large mass numbers are split apart into lighter nuclei when struck by neutrons.
  - Nuclei – center of an atom, making up most of the atom's mass
  - Isotopes – two or more forms of a chemical element that have the same number of protons but different mass numbers because they have different numbers of neutrons in their nuclei.
  - Neutron – elementary particle in all atoms.
  - Radioactivity – Unstable nuclei of atoms shoot out "chunks" of mass and energy.

Nuclear Energy

- Fission reactors
- Uranium-235
- Fission
  - Resulting heat used to produce steam that spins turbines to generate electricity
  - Produces radioactive fission fragments

Great danger of losing coolant!



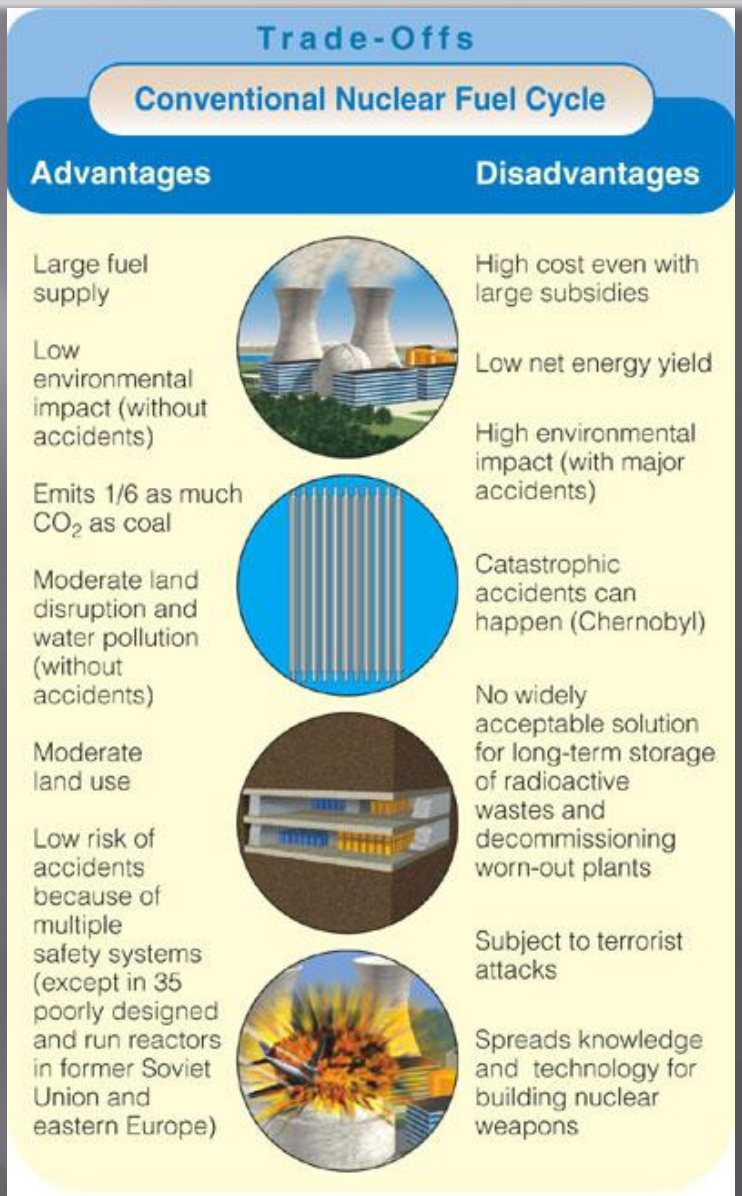
Light water generator – used in all U.S. and 85% world wide.

Conventional Nuclear Power: Trade-offs

No new plants in U.S.
since 1978 and
in Germany as well

All 120 plants ordered
in 1973 have been cancelled.

Cost over-runs
High operating costs



Chernobyl – Ukraine (Former USSR)

- April 26, 1986
- One of four reactors explodes.
- 31 immediate deaths.
- 116,000 people evacuated.
- 24,000 evacuees received high doses of radiation.
- Thyroid cancer in children.
- Damaged reactor entombed in concrete, other reactors returned to service within months.
- Eventually, remaining reactors out of service.

Dealing with Nuclear Waste

- High- and low-level wastes
- Terrorist threats – storage casks hold 5-10 X more long-lived radioactivity than the nuclear power plant
- Disposal proposals
  - Underground burial
  - Disposal in space (illegal under international law)
  - Burial in ice sheets
  - Dumping into subduction zones
  - Burial in ocean mud
  - Conversion into harmless materials (no way to do this with current technology)

Low - Level Waste – (materials other than the radioactive isotopes)

- Includes cooling water from nuclear reactors, material from decommissioned reactors, protective clothing, and like materials.
  - Prior to 1970, US alone placed 50,000 barrels of low-level radioactive waste on the ocean floor.
  - Moratorium in 1970, Ban in 1983.

Energy Efficiency and Renewable Energy

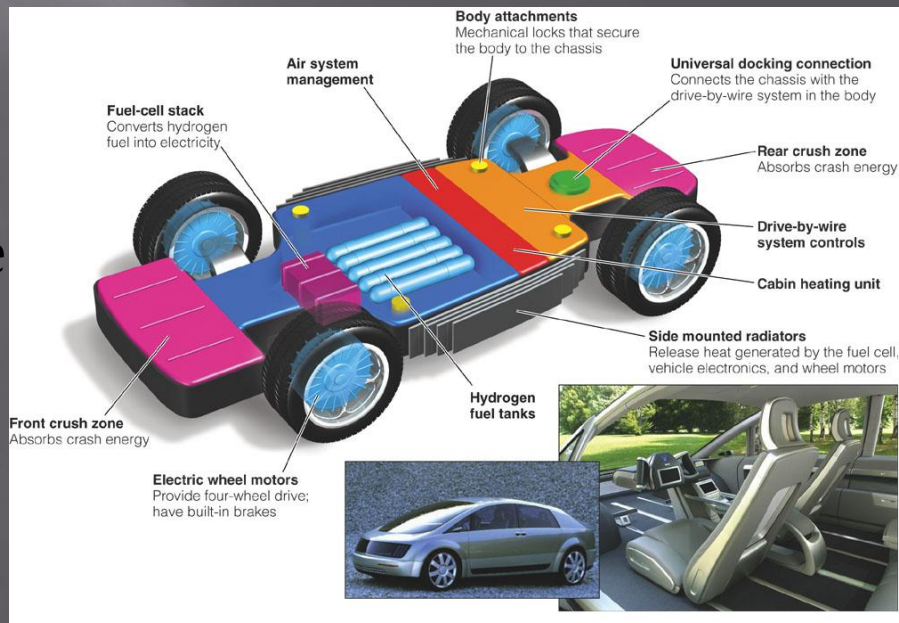
- 84% of energy is wasted in the United States
  - 41% degradation (2nd law of Thermodynamics)
  - 43% unnecessary
    - Fuel wasting vehicles
    - Furnaces
    - Poorly insulated buildings
- U.S. unnecessarily wastes 2/3 of the energy that the rest of the world's population consumes!

Ways to Improve Energy Efficiency

- Cogeneration – combines heat and power
  - Two forms of energy (ex. steam and electricity) are provided from the same fuel source. Used in Western Europe, U.S. produces 9% of electricity using cogeneration plants)
- Efficient electric motors
- High-efficiency lighting
- Increasing fuel economy
- Alternative vehicles
- Insulation
- Plug leaks

Hybrid and Fuel Cell Cars

- Hybrid cars still use traditional fossil fuels
  - Energy otherwise wasted charges battery which assists acceleration and hill climbing
  - More efficient than internal combustion engine alone, but still uses non-renewable resources
- Fuel cell cars not yet available
  - Hydrogen gas is fuel
  - Very efficient
  - Low pollution
  - Major infrastructure change needed for fueling stations



Renewable energy sources

- Solar
- Flowing water
- Wind
- Biomass
- Geothermal
- Hydrogen

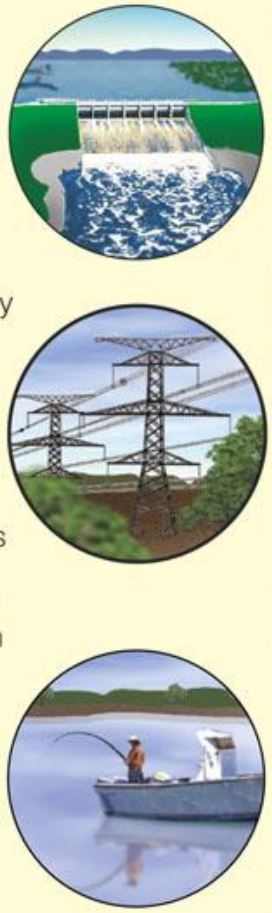
Producing Electricity from Moving Water

- Large-scale hydropower
- Small-scale hydropower
- Tidal power plant
- Wave power plant

Trade-Offs

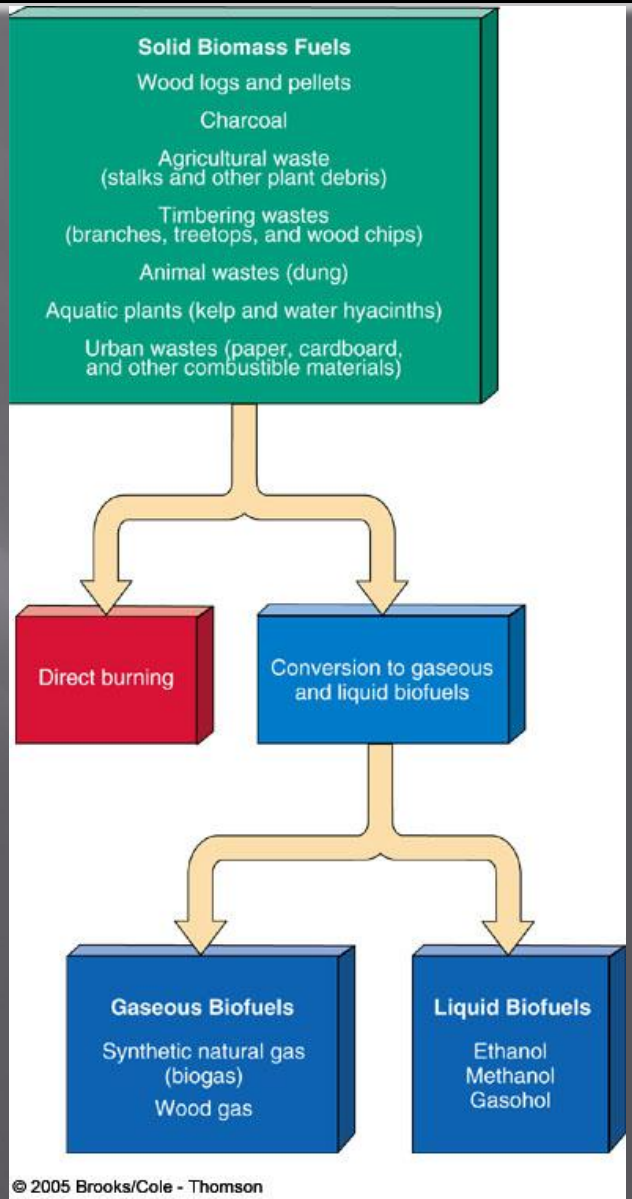
Large-Scale Hydropower

Advantages	Disadvantages
Moderate to high net energy	High construction costs
High efficiency (80%)	High environmental impact from flooding land to form a reservoir
Large untapped potential	High CO_2 emissions from biomass decay in shallow tropical reservoirs
Low-cost electricity	Floods natural areas behind dam
Long life span	Converts land habitat to lake habitat
No CO_2 emissions during operation in temperate areas	Danger of collapse
May provide flood control below dam	Uproots people
Provides water for year-round irrigation of cropland	Decreases fish harvest below dam
Reservoir is useful for fishing and recreation	Decreases flow of natural fertilizer (silt) to land below dam



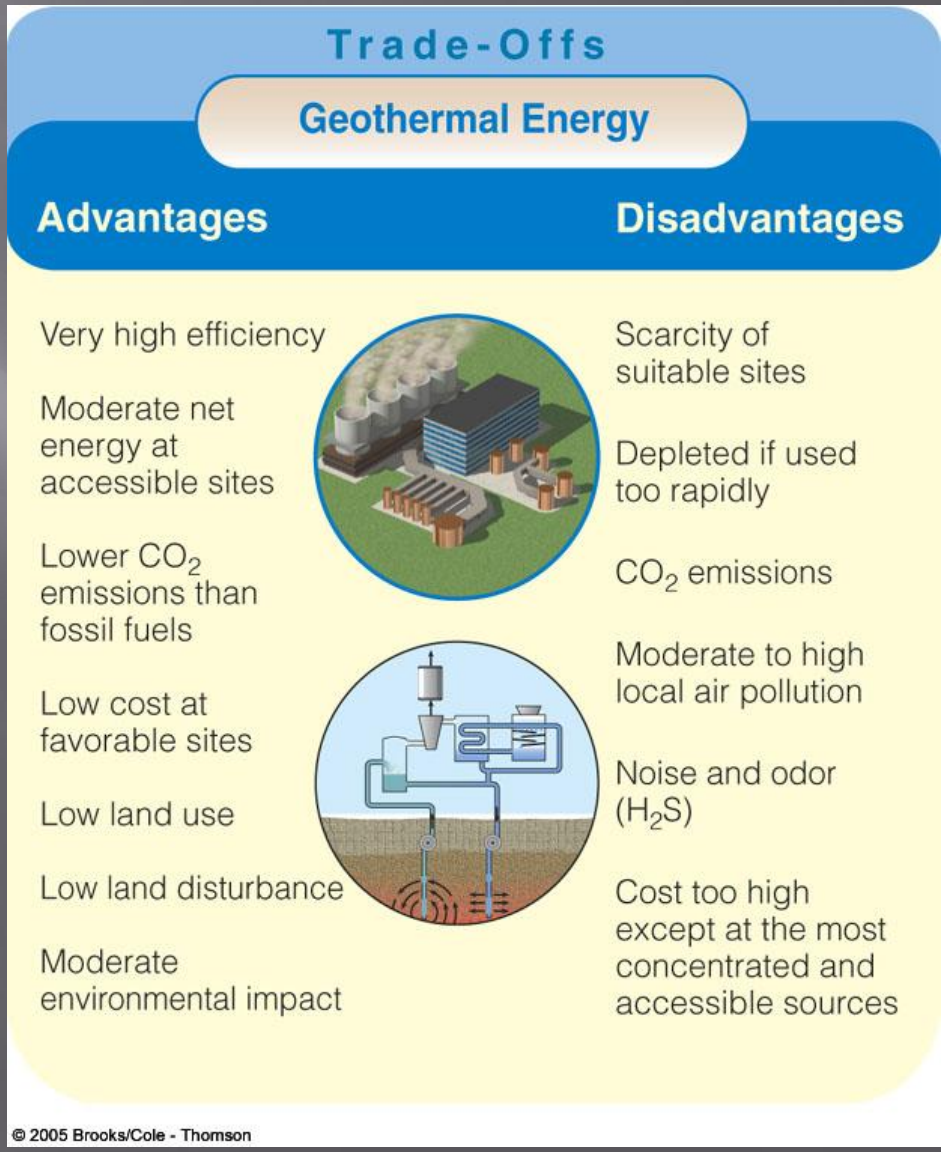
Producing Energy from Biomass

- Biomass and biofuels
- Biomass plantations
- Crop residues
- Animal manure
- Biogas
- Ethanol
- Methanol



Geothermal Energy

- Geothermal heat pumps
- Geothermal exchange
- Dry and wet steam
- Hot water
- Molten rock (magma)
- Hot dry-rock zones



The Hydrogen Revolution

- Environmentally friendly
- Extracting hydrogen efficiently
- Storing hydrogen
- Fuel cells