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10

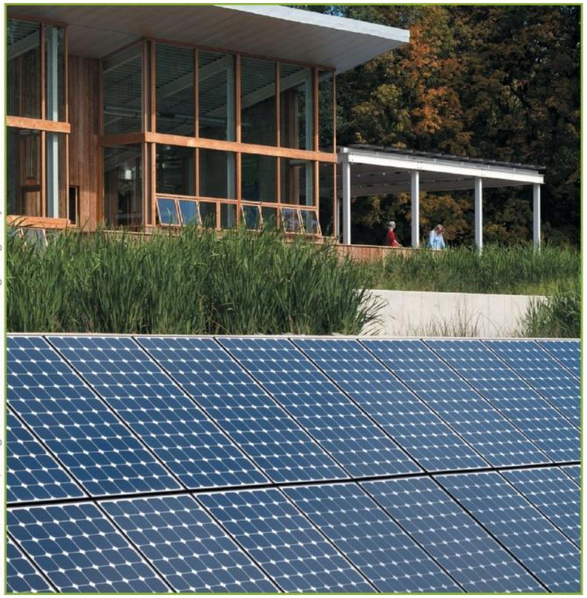
Energy Consumption

Overview of Chapter 10

- Energy Consumption and Policy
- Energy Efficiency and Conservation
- Electricity, Hydrogen, and Energy Storage
- Energy Policy

Using Energy Sustainably

- Energy mainly used for: transportation, industry, buildings
- Buildings that use zero energy
- Omega Center, NY
  - 5 years with zero net energy use
- LEED certification and U.S. Green Building Council
  - Often higher upfront costs



Energy Consumption and Policy

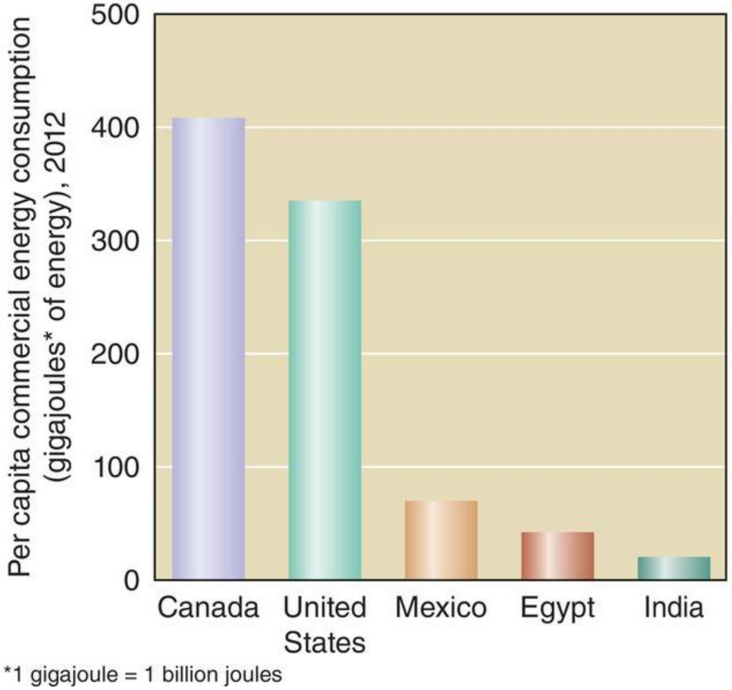
- No energy sources are truly clean
- All humans activities require energy
  - Heat & cool buildings
  - Illuminate buildings and streets
  - Plant, harvest, & ship food
- 100 years ago energy sources were local
  - Wood, peat, dung
- Now they are worldwide
  - Fossil fuels, nuclear energy, electricity

Energy Consumption and Policy

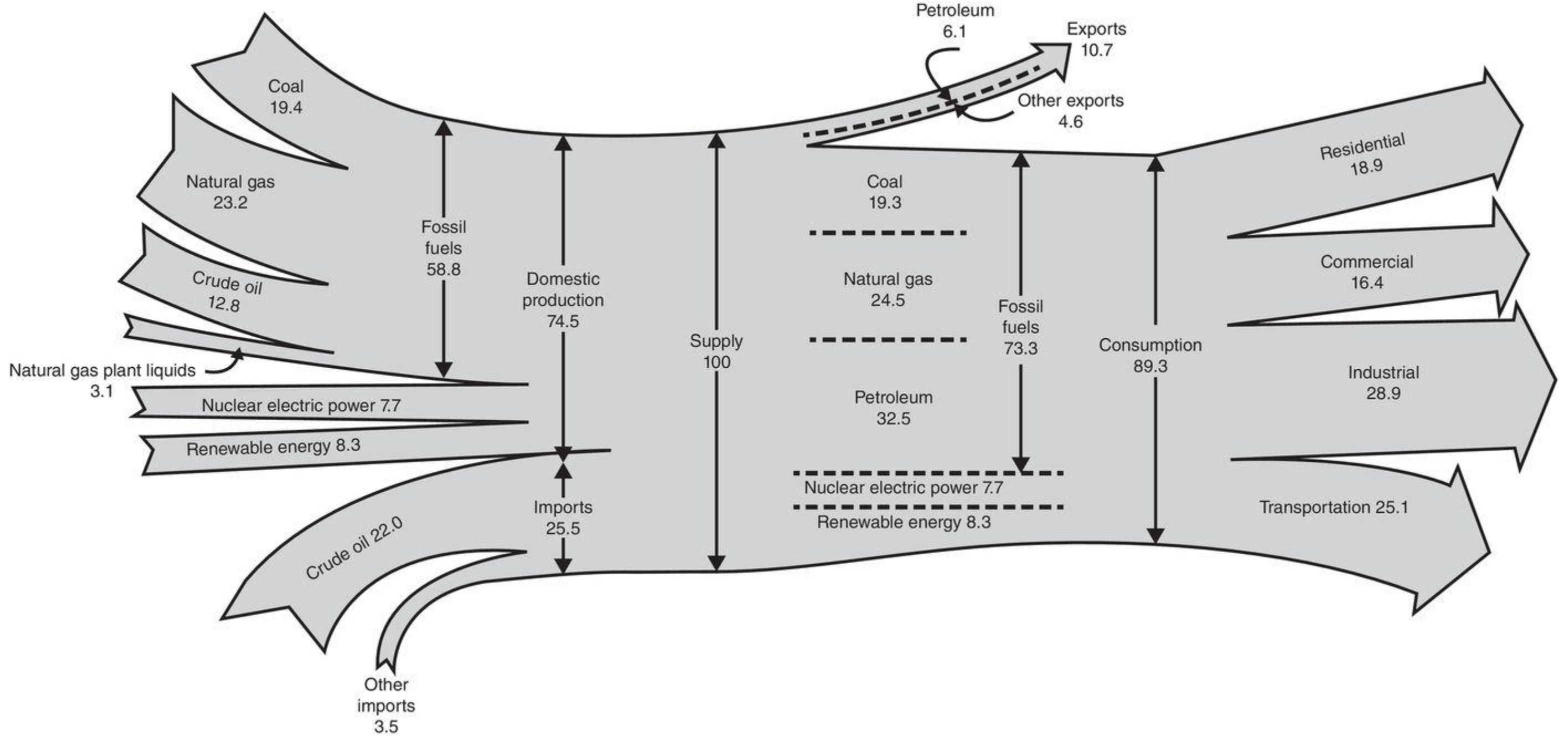
- Advantages of energy source
  - How concentrated it is
  - Versatility
  - Safety
  - Availability
- Disadvantages of energy source
  - Hazard potential
  - Environmental damage
  - Cost
- See Table 10.1 in text for details

Energy Consumption Worldwide

- Differs between developing and developed nations
  - <20% of world's population use 60% of the world's energy sources

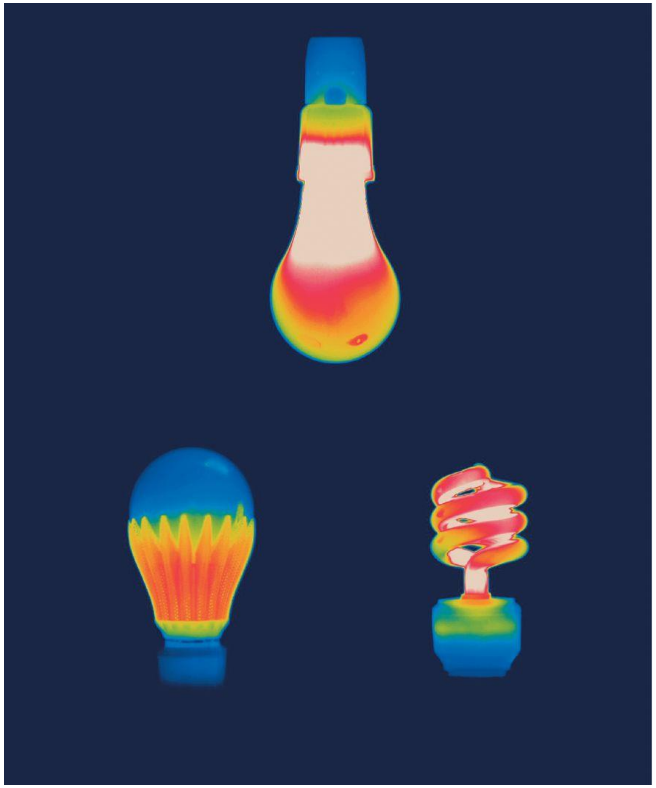


Energy Consumption in US



Energy Efficiency

- Amount of available energy in a source that is transformed into useful work
- Ranges from 0–100%
  - Natural gas (cooking) ~100%
  - Natural gas (electricity) ~60
  - Incandescent bulbs ~2-3%
  - Fluorescent bulbs ~10%
  - Light-emitting diodes ~20%
    - Pictured here



Tyrone Turner/National Geographic Image Creative

Energy Intensity

Table 10.2 **Comparison of 1980, 2006, and 2012 Energy Intensities for Selected Countries**

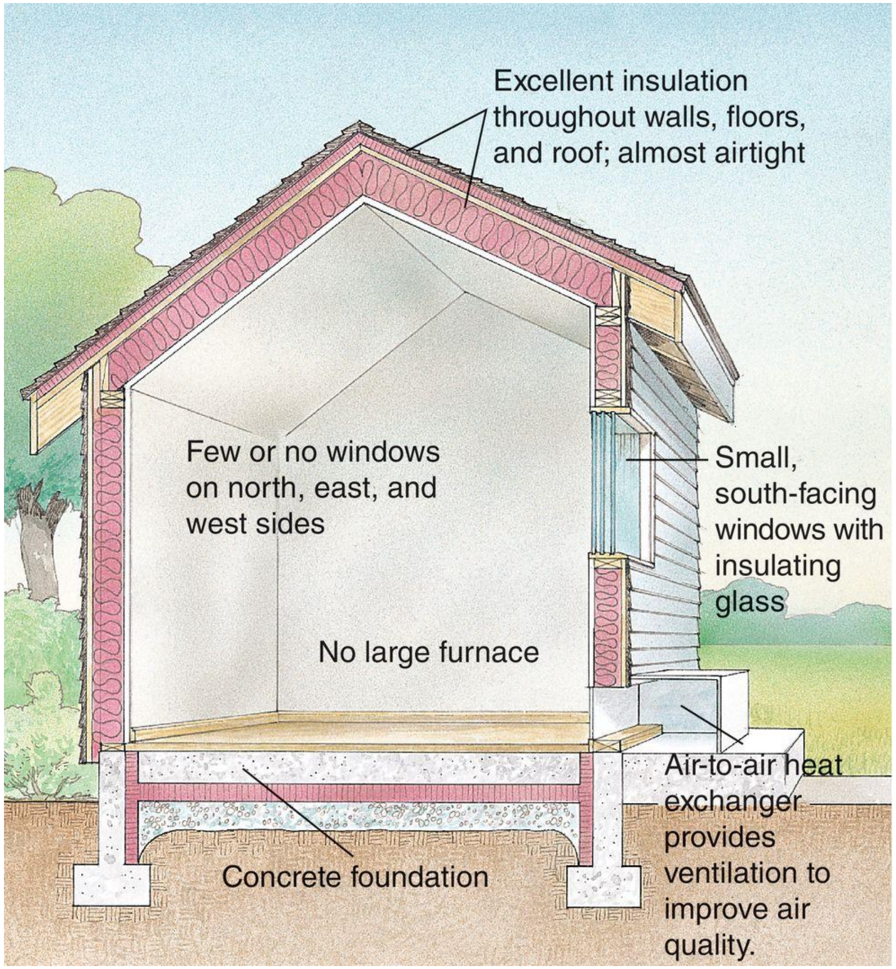
	*Energy Intensity**		
Country	*1980*	*2006*	*2012*
Kenya	4,473	3,393	2,695
India	7,870	7,477	5,860
Japan	7,834	6,492	5,313
Mexico	6,052	6,116	5,209
France	8,684	6,596	5,385
China	37,279	13,780	10,872
United States	15,135	8,841	7,329
Canada	18,701	13,097	10,661

*In Btu per 2000 U.S. dollars of GDP.
Source: Energy Information Administration.

- Energy Intensity- energy use per $ of GDP

Energy Efficiency

- Super-insulated buildings use 70-90% less energy
- NAECA sets national standards for appliances
  - By 2010, energy use saved equal to 51 coal-fired power plants



Energy Efficiency

- Super insulated office building
- South facing windows
- Insulating glass
- No furnace
- New push for zero net energy buildings
  - Produce as much or more energy than they consume

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Energy Efficiency - Commercial Buildings

- High-performing buildings pay for themselves
  - Energy costs = 30% of budget

Table 10.3 Energy-Efficiency Upgrades in Selected Commercial Buildings

Project	*Energy Payback Time**	*Unexpected Benefits Attributed to Project***
Energy-efficient lighting (post office in Nevada)	6 years	6% increase in mail-sorting productivity
Energy-efficient (metal-halide) lighting (aircraft assembly plant in Washington)	2 years	Up to 20% better quality control
Energy-efficient lighting (drafting area of utility company in Pennsylvania)	About 4 years	25% lower absenteeism; 12% increase in drawing productivity
Energy-efficient lighting and air conditioning (office building in Wisconsin)	0 years (paid for by utility rebates); energy savings estimated at 40%	16% increase in worker productivity
Energy-saving daylighting, passive solar heating, heat recovery system (bank in Amsterdam)	3 months	15% lower absenteeism

*How long it takes for energy savings to cover the cost of the project.
**Lighting quality as well as lighting efficiency is improved, resulting in greater worker comfort.
Source: Rocky Mountain Institute.

Energy Efficiency- Power Company

- Demand-side Management
  - Decreases demand for electricity
  - Cash rewards/incentives to customers who install energy-efficient technologies
  - Energy companies may give away free energy-efficient appliances, light bulbs, etc.
  - Benefits both customer and electric company

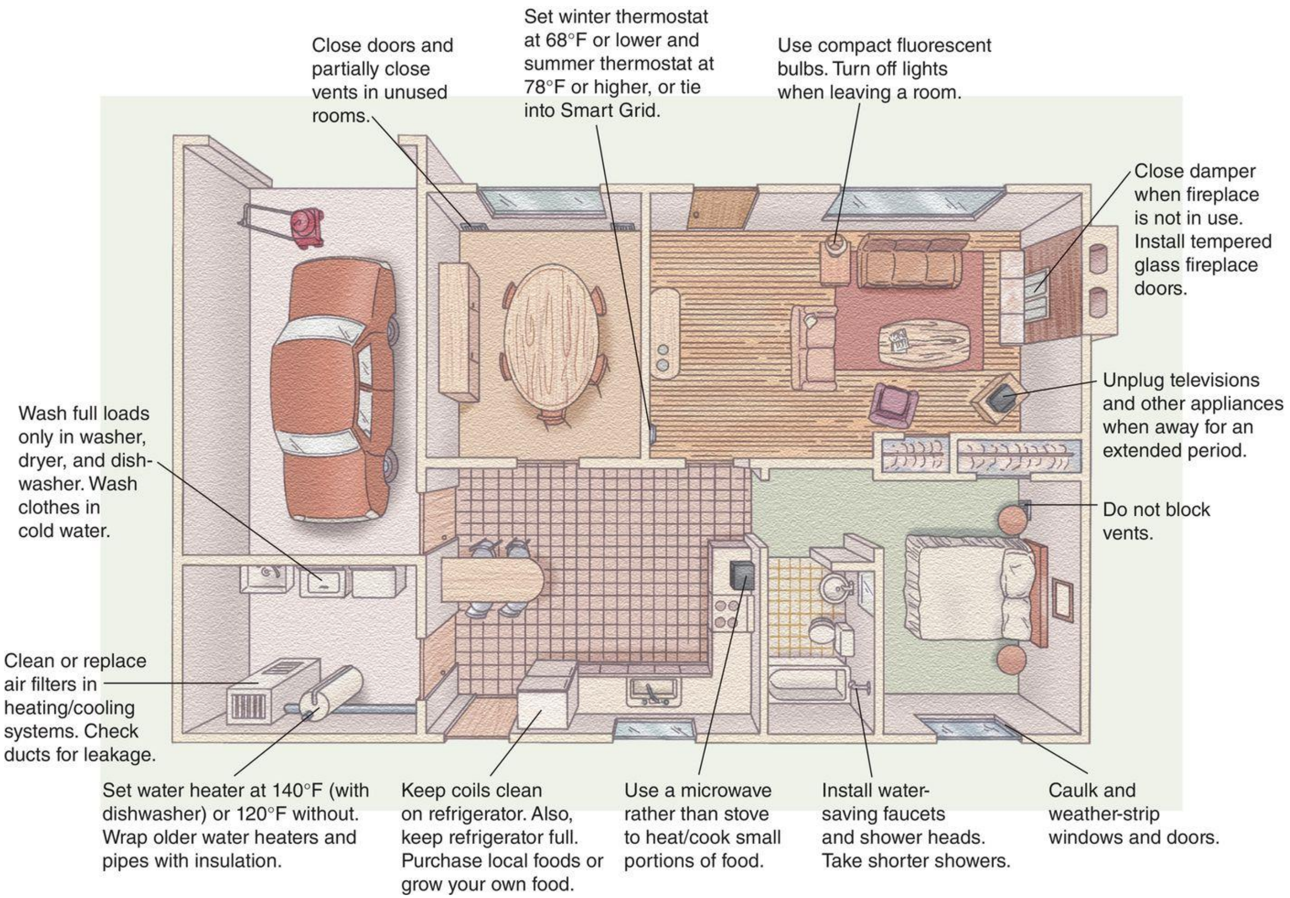
Energy Efficiency - Transportation

- Most energy in gasoline is wasted
  - Energy lost in combustion to heat
  - Energy lost in braking, idling
  - Energy lost in friction with road
  - Energy lost in moving weight of car (not passengers)
  - Bad driving habits waste gas

Energy Efficiency - Transportation

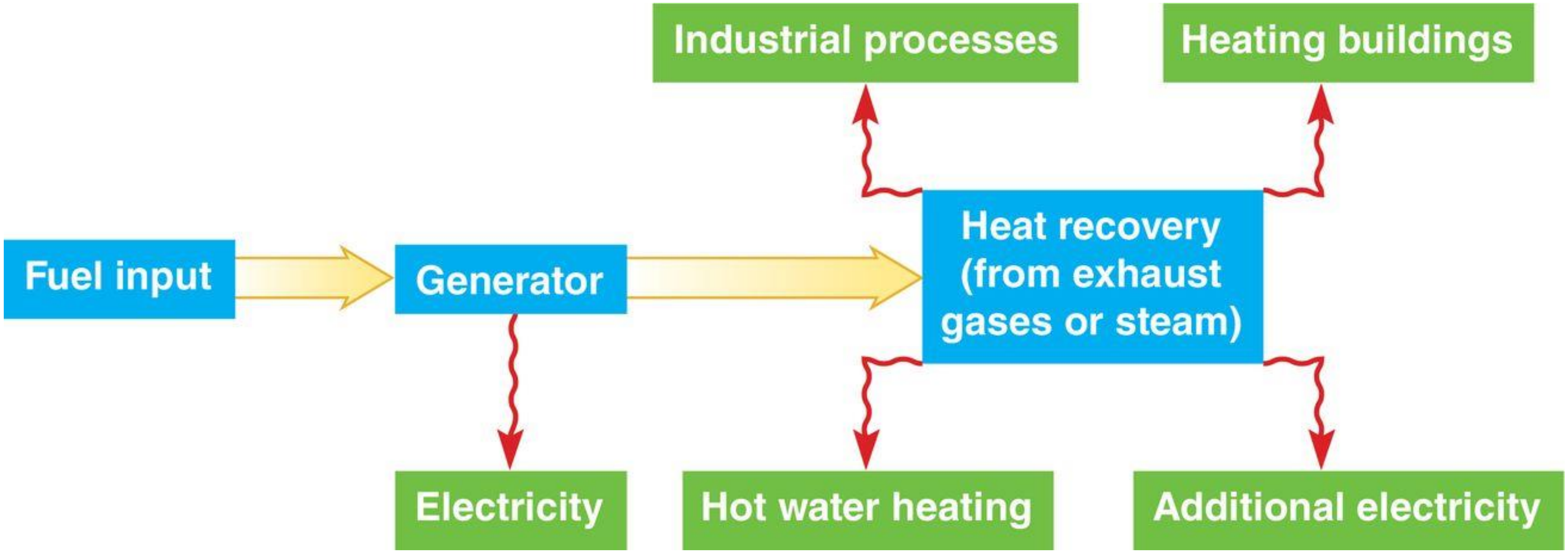
- Modern Vehicle Design
  - Use of Kevlar and plastics to reduce weight
  - Gasoline-electric hybrid engines (Prius)
    - Regenerative braking recaptures lost energy
    - Operate at lower temperatures
- New Laws
  - By 2020, all passenger vehicles must have average fuel efficiency of 35 mpg
    - Including minivans, light trucks and SUVs

Saving Energy at Home



Energy Efficiency - Industry

- Cogeneration- production of two useful forms of energy from the same fuel
  - Most effective on small scale



Energy Conservation

- Requires a change in behaviors and practices
  - Reduce commute length
  - Use public transportation or bike to work
  - Turn off lights when not in use
  - Reduce temperature on thermostat at night
- Some changes would be difficult - e.g., removing subsidies
  - Allow product prices to reflect true cost of production (including energy costs)
  - Increase price of gasoline to represent true price

Energy Conservation

Table 10.4 A Comparison of Gasoline Prices in Selected Countries (Including Taxes)

	Regular Gasoline Price (Dollars per Gallon)		
Country	*2001*	*2008*	*2013*
United States	$1.51	$3.37	3.82
Canada	1.78	4.34	4.76
Mexico	2.46	3.04	3.22
Turkey	3.05	9.35	9.89
France	3.58	7.70	7.76

**Source:* Energy Information Administration.

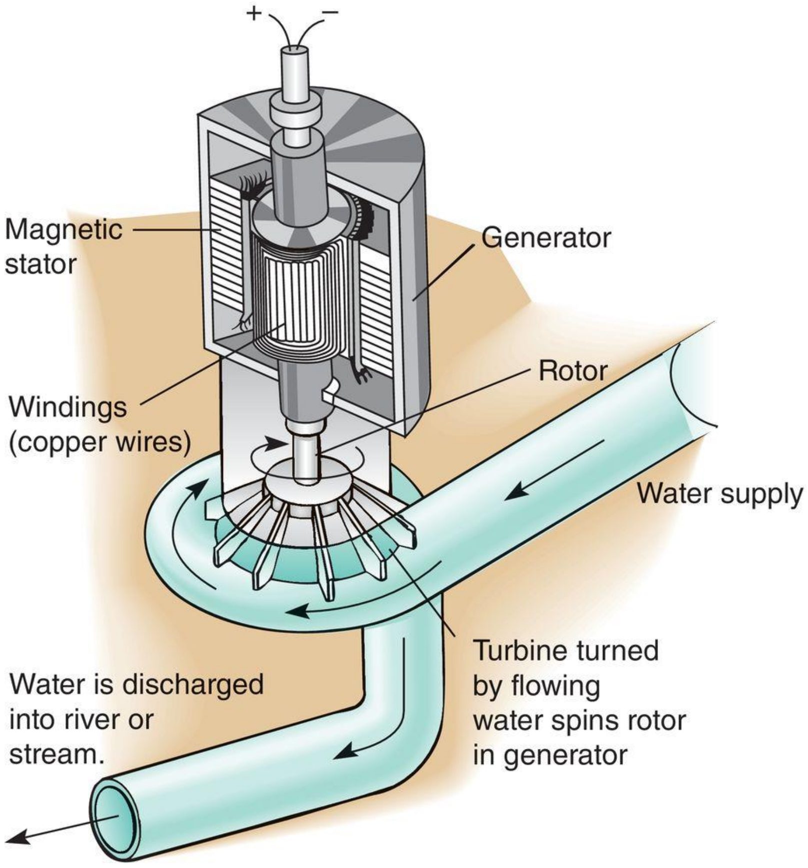
Table 10.5 A Comparison of Energy Input for Different Kinds of Transportation

Method of Transportation	*Energy Input (in BTUs)* per Person, per Mile*
Automobile (driver only)	6530
Rail	3534
Carpool	2230
Vanpool	1094
Bus	939

*BTU stands for *British thermal unit*, an energy unit equivalent to 252 calories or 1054 joules.

Electricity

- The flow of electrons in a wire
- Can be generated from almost any energy source
  - Energy source spins a turbine
  - Turbine turns a generator
    - Bundle of wires spin around a magnet or vice versa
  - Spinning causes electrons to move in a wire = electricity

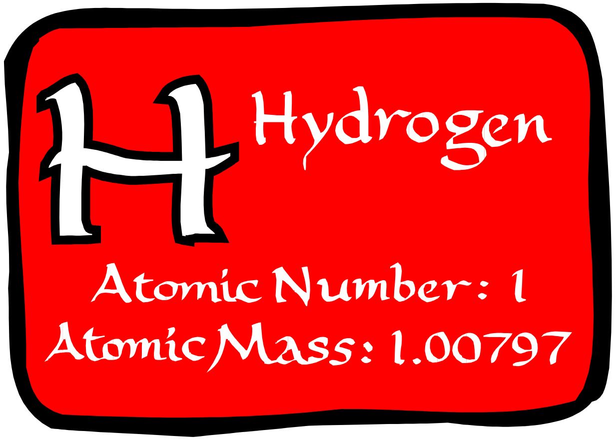


Electricity

- Source of electricity can be hundreds of miles away
  - Environmental impacts are far away from those who use the energy

Hydrogen and Fuel Cells

- Hydrogen gas (H_2)
  - Comprised of two hydrogen molecules
  - Large amounts of available energy
  - Explodes when combined with oxygen releasing energy and forming water

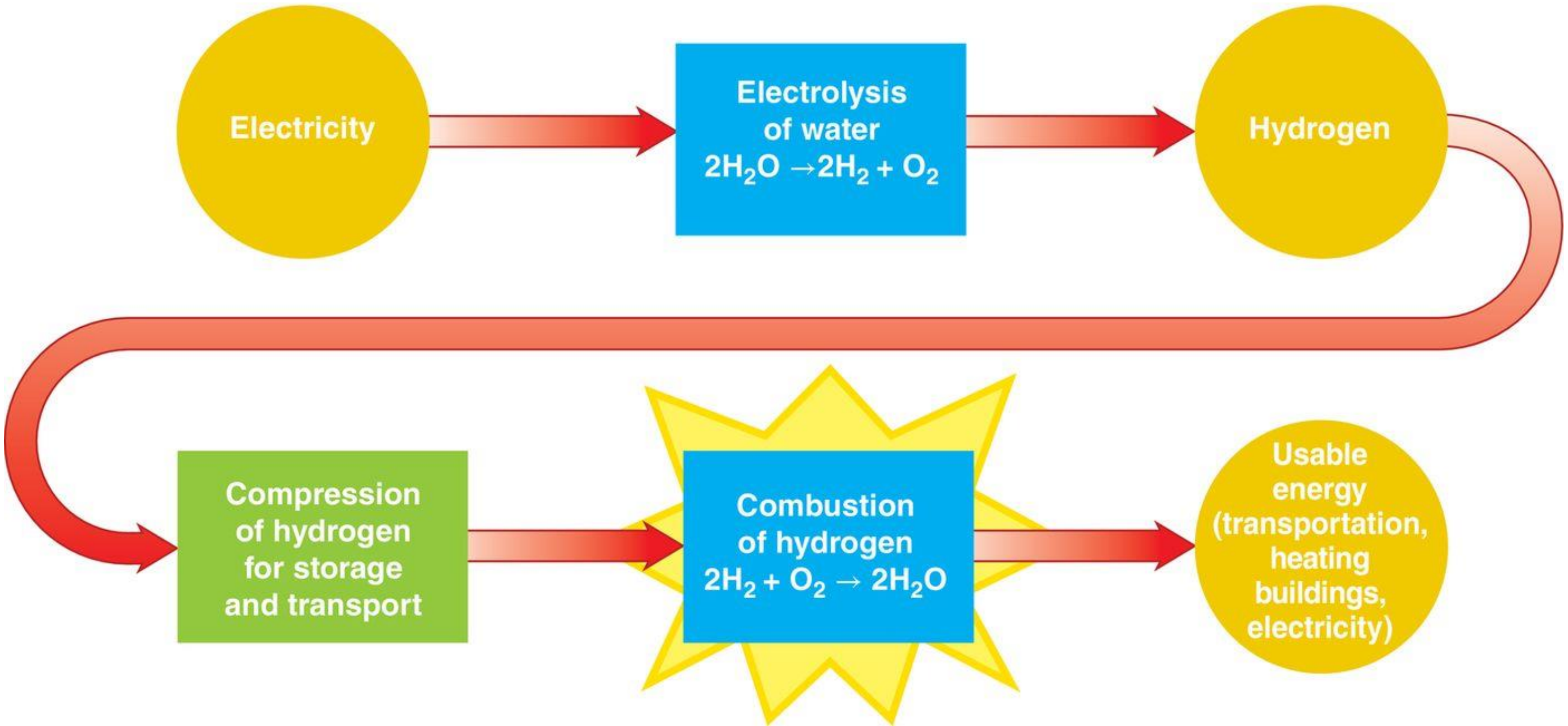


Hydrogen as a Fuel Source

- Advantages
  - Very high energy density
  - Can be produced from any electrical source
    - Electrolysis (see illustration on next slide)
  - No greenhouse gases and few other pollutants
  - Can be use in vehicles
- Disadvantages
  - Highly volatile (requires special storage)
  - Relatively inefficient

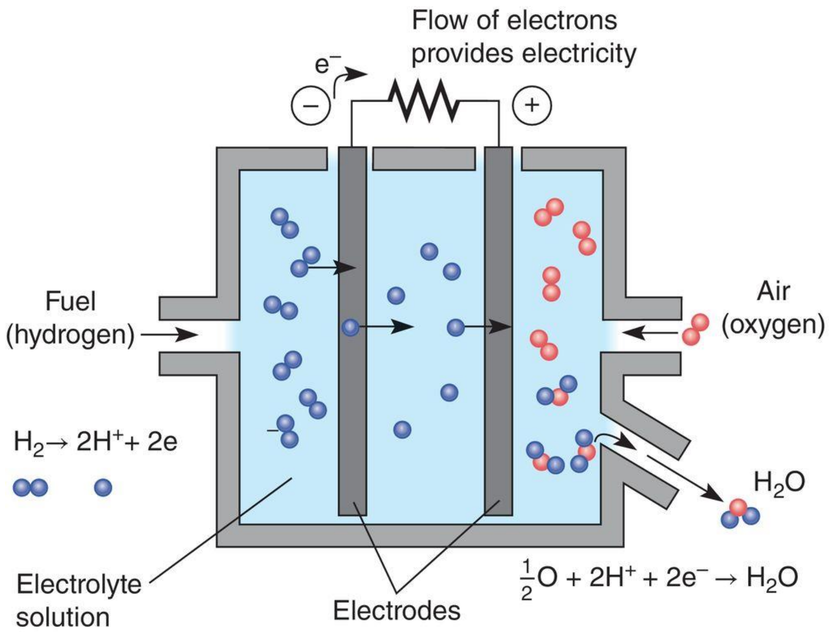
Electrolysis

Process of using electricity to separate water into O_2 and H_2



Hydrogen Fuel Cell

- Fuel cell
  - Device that directly converts chemical energy into electricity
  - Requires hydrogen from a tank and oxygen from the air
  - Similar to a battery, but reactants are supplied from outside source



Future Applications of Fuel Cells

- Hydrogen Fuel Cells Vehicles
  - H not yet readily available as fuel source
  - >100 H fueling stations in U.S. (2013)
- Pure electric vehicles
- Plug-in hybrid electric vehicles
  - Short ranges
- Flexible fuel vehicles
- These still use electricity

CHROMORANGE/Klaus Willig/picture alliance/Newscom

Orange County Register /ZUMAPRESS.com

Energy Storage

- Many energy resources are not available when we want them
  - Too little: Solar and wind can be intermittent
  - Too much: Large coal and nuclear plants are most efficient with constant energy output
- Solution = storage of unused energy
  - Less than 100% efficient
  - With each conversion, less energy is available

Energy Storage

- Superconducting Magnetic Energy Storage
- Compressed Air Energy Storage
- Electrochemical Energy Storage (Batteries)
- Pumped Hydroelectric Storage
- Thermal Energy Storage
- Kinetic Energy Storage (Flywheel)

Courtesy American Electric Power

US Energy Policy

- Objective 1: Increase Energy Efficiency and Conservation
  - Requires many unpopular decisions
  - Examples
    - Decrease speed limit to conserve fuel
    - Eliminate government subsidies
- Objective 2: Secure Future Fossil Fuel Energy Supplies
  - 2 oppositions: environmental and economic

US Energy Policy

- Objective 3: Develop Alternative Energy Sources
  - Who should pay for this? Gas taxes?
- Objective 4: Meet the First Three Objectives Without Further Damage to the Environment
  - Tax per barrel?