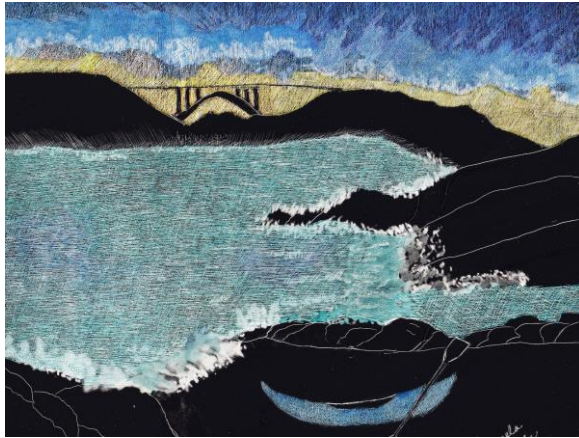
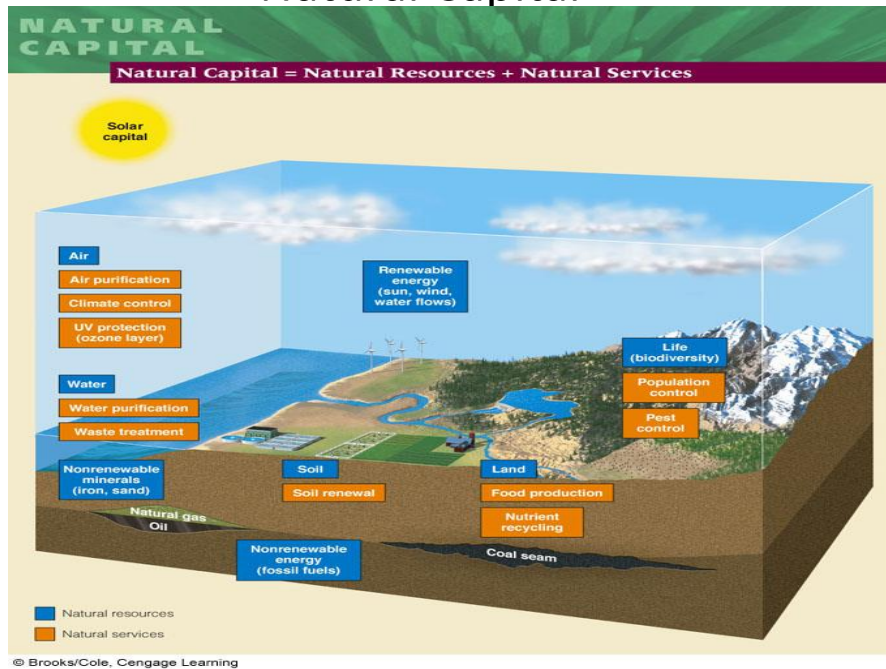


Chapter 3 Sustainability



Natural Capital

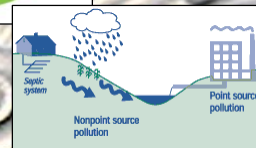


Resource Use

- Exploiting resources comfortable life
- U.S. most waste at 1642 pounds of waste per person and 33% recycling rate.
- Canada 921 lbs and recycling of 27%.

The coming 'Ecological Age'

- **Point source pollution vs. non-point source pollution**
- ***Triple Bottom Line***: cost of goods must reflect all costs, incl. transport, water, disposal
- **Recycling/downcycling**
- **Cradle to grave (C2G) vs. cradle to cradle (C2C)**
- **Biomimicry**





Renewable Sources of Energy
Wind energy, Wyoming

Prior to the Industrial Revolution humans used **renewable resources**, sun, wind, water, wood, and human and animal energy.

Non-Renewable Resources Santa Clarita, CA

- The availability of fossil fuels enabled technological advances that transformed the quality of life. While this has been a huge advantage for some humans, it was balanced by losses for other humans and the rest of the natural world. The fossil fuel dependent paradigm was based on the idea of Earth being for human's exclusive use.

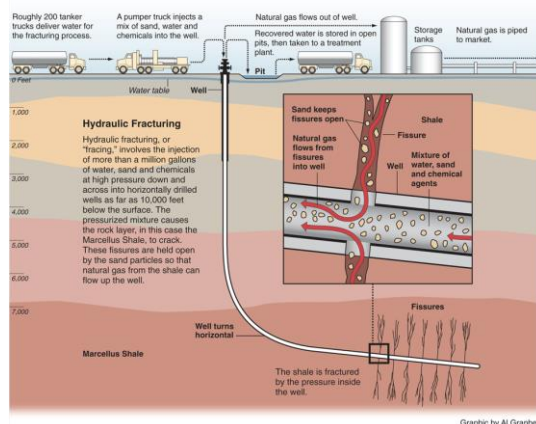
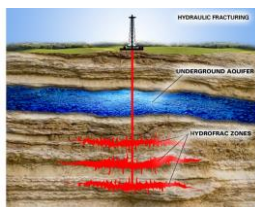


Coal Is a Plentiful but Dirty Fuel

- World's most abundant fossil fuel
 - U.S. has 25%
 - Current usage we have a 300 year supply
- Environmental costs of burning coal
 - Severe air pollution
 - Sulfur released as SO_2
 - Large amount of soot
 - CO_2
 - Trace amounts of Hg and radioactive materials
 - Dirtiest fossil fuel to burn.

Horizontal drilling and hydraulic fracturing or fracking.

- Held in shale formations
- Drill vertically and then flexible well bore drill horizontally
- Perforated tubes with explosive charges create fissures in rock.
- High pressure pumps-shoot water, sand, and chemicals.
- More cracks and sand allows cracks to remain open.
- Oil or natural gas can flow to surface.
- Repeat 7-10 times.



<http://sites.lafayette.edu/egrs251-fa11-fracking/files/2011/11/fracturing-cross-cut-diagram1.gif>

Hydraulic Fracturing: "fracking"
Northwestern, North Dakota

• Fracking Disadvantages

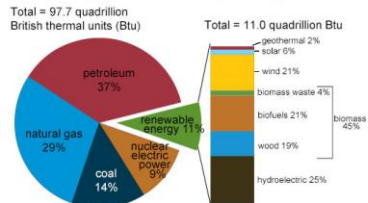
- Drinking water contaminated with natural gas can catch fire
- Using huge amounts of water, sand, and chemicals.
- Disposal of toxic wastewater
- Transportation of natural gas.



Rank Total	Country	C02 million metric tons	Metric tons per capita
1	China	9040.74	6.59
2	U.S.	4997.50	15.53
3	India	2066.01	1.58
4	Russia	1468.99	10.19
5	Japan		
6	Germany		
9	Canada	549.23	15.32

2015 Union of Concerned Scientists

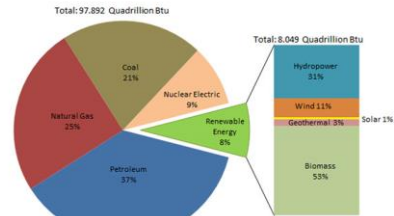
U.S. energy consumption by energy source, 2017



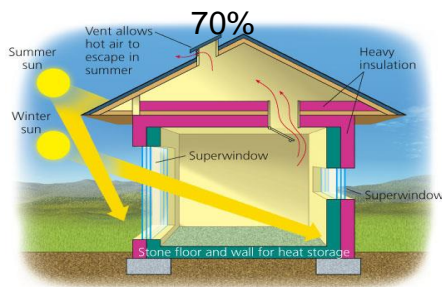
Note: Sum of components may not equal 100% because of independent rounding.
Source: U.S. Energy Information Administration, Monthly Energy Review, Table 1.3 and 10.1, April 2018, preliminary data.



U.S. Energy Consumption, 2010

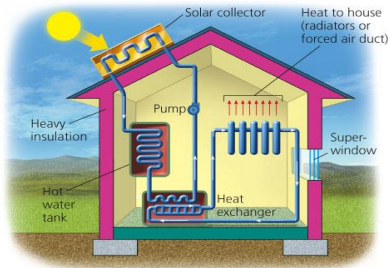


Solar



PASSIVE

© Brooks/Cole, Cengage Learning



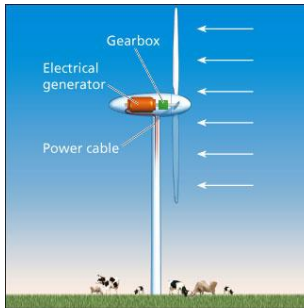
ACTIVE

Photovoltaic cells



Wind

- Wind: indirect form of solar energy
 - Captured by turbines
 - Converted into electrical energy



Wind turbine
© Brooks/Cole, Cengage Learning



Wind farm



Wind farm (offshore)

Wind Energy

- Advantages of wind energy
 - High net energy yield
 - Little or no Co2.
 - Widely available
 - Easy to build.
- Drawbacks
 - Winds die down; need back-up energy
 - Kills migratory birds if not designed properly.
 - “Not in my backyard”

Case Study: Is Ethanol the Answer?

- **Cellulosic ethanol**: alternative to corn ethanol
- Sources
 - Switchgrass
 - Crop residues
 - Municipal wastes



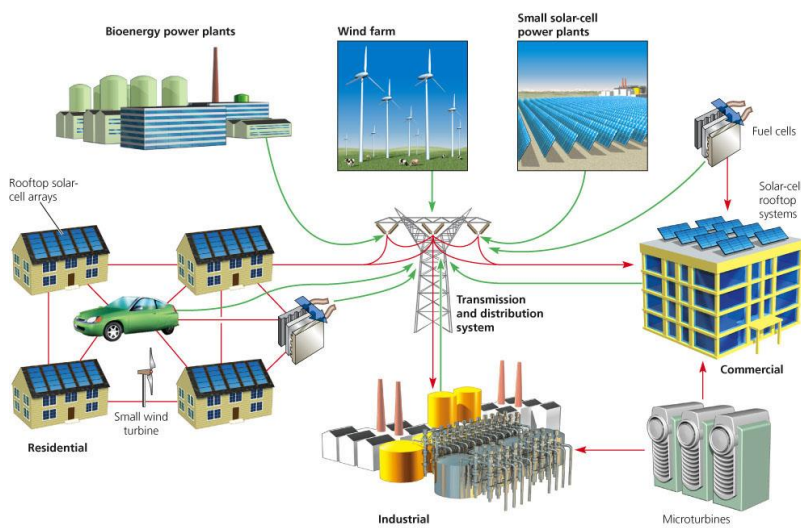
Biofuels

- | Pros | Cons |
|---|---|
| <ul style="list-style-type: none">– Reduce co2 from some crops.– Medium net energy yield | <ul style="list-style-type: none">– Decrease biodiversity– Increase soil degrading, erosion, and nutrient leaching– Push farmers off their land– Raise food prices |

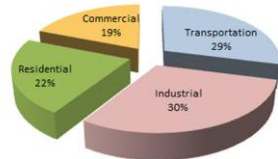
Three Big Ideas

- Making the transition to a more sustainable energy future will require:
 - Sharply increasing energy efficiency
 - Using a mix of environmentally friendly renewable energy resources
 - Including the harmful environmental and health costs of energy resources in their market prices

Solutions: Decentralized Power System

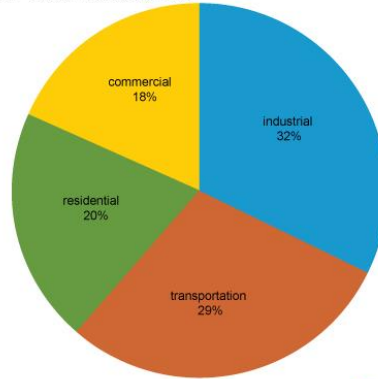


Share of Energy Consumed by Major Sectors of the Economy, 2009



Shares of total U.S. energy consumption by end-use sectors, 2017

Total = 97.7 quadrillion British thermal units



Note: Sum of individual percentages may not equal 100 because of independent rounding.
Source: U.S. Energy Information Administration, Monthly Energy Review, Table 2.1, April 2018, preliminary data.



Transit-oriented developments (TODs) near Seattle, Washington

- Sustainable development
- Sprawl vs. New Urbanism
- Transit-oriented dev. (TODs)



Leadership in Energy and Environmental Design (LEED)

The LEED rating system addresses six sustainable issues:

- Sustainable site development
- Water savings
- Energy efficiency
- Materials selection (favoring recycled materials)
- Indoor air quality
- Design innovation



LEED insignia in Berea, Kentucky



Ecological Footprint

The ecological footprint approximates how much productive land and water are needed to provide for a population. The ecological footprint can be measured at any scale, from individuals to global. If everyone on Earth were to consume at the American rate there would need to be 5.3 Earths, to consume as the average Canadian would require 4 Earths.

Kyoto Protocol

- Western Europe emits less than the per capita CO₂ emissions.
- Kyoto Protocol
 - 169 countries signed reverse GHG 1990 levels by 2012
 - India and China “fledgling” exempt
 - U.S. never signed-economy; 500 mayors pledged
 - Canada signed but reneged in 2007

Paris Agreement

- December 2015
- 195 countries including U.S.
- Trump withdrew but legally cannot.
- [European Commission](#)

Sustainable World Summary

A sustainable world includes the following elements:

- Minimizing non-renewable resource consumption
- Maximizing resource and energy efficiency
- Minimizing polluting toxins
- Respecting and working with the natural environment rather than against it
- Cradle to cradle industry
- Ecological balance and integrating ecosystems
- Including humans aligned with nature as part of the many ecosystems
- Living with sustainable agricultural practices
- Controlling population growth
- Reducing material consumption
- Taxing of environmental pollution through shifting the tax burden or cap and trade.
- Reducing poverty
- Educating holistically