Lecture Topic 5

Part 2: Renewable Energy and Alternative Fuels

(Chapter 8)

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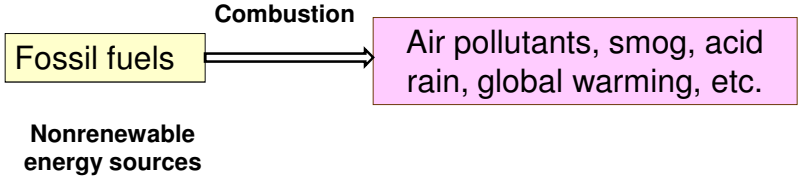
Energy Use and Pollution

From Chapters 3-5:



Solution:

- Switch to **renewable energy** (e.g. solar, wind) and **alternative fuel** (e.g. H_2)

  Goal: To reduce air pollution

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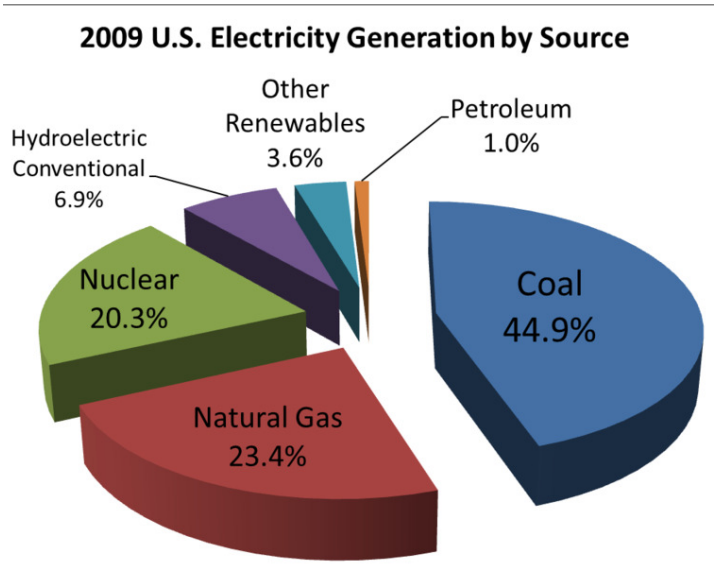

Sources of electricity in the USA 2009. Data from http://www.eia.doe.gov/cneaf/electricity/epm/table1_1.html. Image available at http://commons.wikimedia.org/wiki/File:Sources_of_electricity_in_the_USA_2009.png

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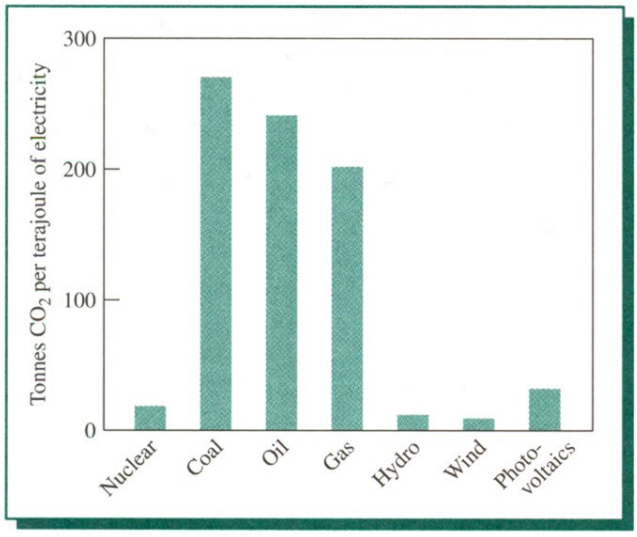

Figure 8-4. CO_2 emissions associated with different energy sources

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Renewable Energy

- Hydropower
- Wind
- Solar
- Geothermal
- Biomass

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1. Hydroelectric power

- Utilizes the kinetic energy of flowing water to turn the blades of a turbine, thus generating electricity
- Most large-scale facilities utilize **dams** and **waterfalls**
  - Higher water pressure, more power yield (see diagram in the next slide)
- Current worldwide usage is ***only 20 % of potential usage***
- With 80,000 megawatts of generating capacity, hydropower is the nation's ***largest renewable electricity source***

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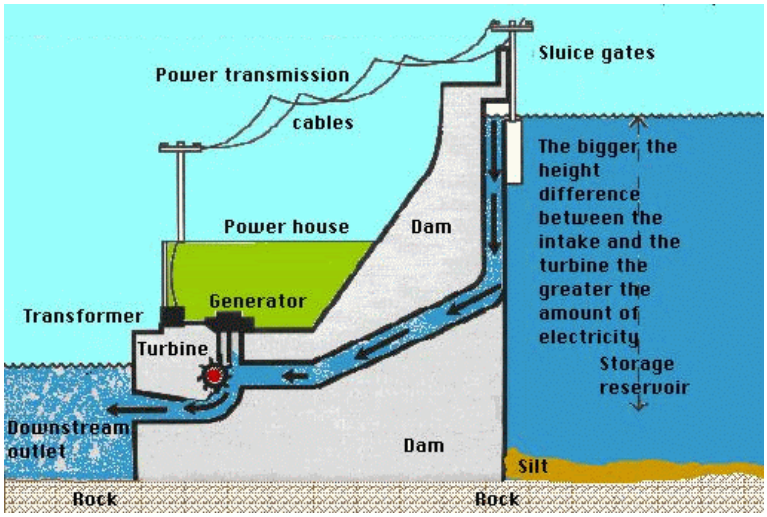
Hydroelectric Power: How It Works



Source: Canada. Environment Canada. Freshwater: Instream uses - Hydroelectric power generation. Ottawa, 1999.
http://atlas.gc.ca/site/english/maps/freshwater/consumption/hydro_generation.jpg/image_view

Hydroelectric Power (Cont.)

Drawbacks:

- Not entirely emissions-free
  - Recall that methane emissions result from flooding of vegetation on land to create dams
    - CH_4 emissions cancel out CO_2 emissions savings
- Eutrophication of flooded waterways
- Devastation to fish population
  - Building of dams block spawning routes of migrating fish like salmon

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2. Wind Power

- The world's fastest-growing energy technology.
- Today, the U.S. has more than 35,000 megawatts of wind generating capacity. (http://www.eere.energy.gov/windandhydro/)

U.S. wind power:

- Started in the ***1980s*** in CA (tax incentives)
  - Many failures due to lack of testing prior to construction
    - Marred industry's reputation
  - Higher initial costs
- Today ***reliability***, ***performance*** and ***cost*** have been improved

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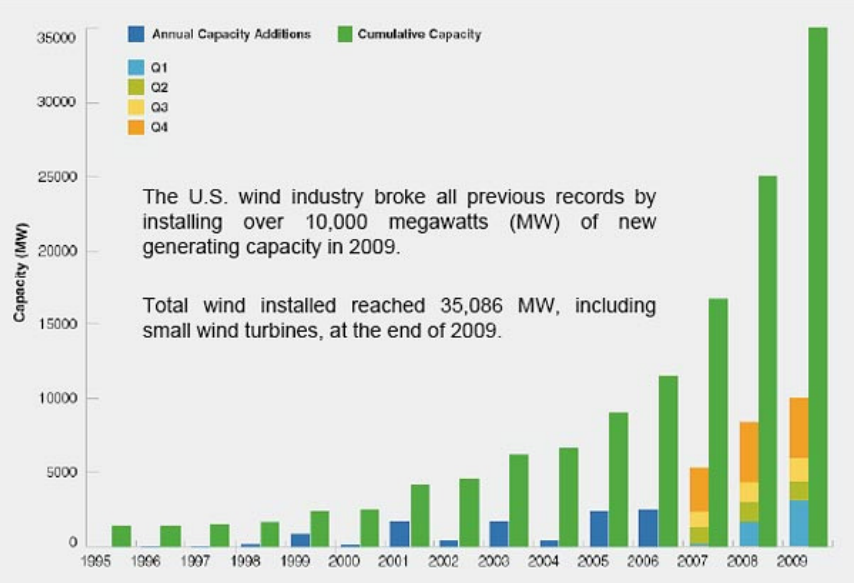

Wind power in the U.S. Image available at http://e360.yale.edu/content/images/0410-wind-energy-report.html

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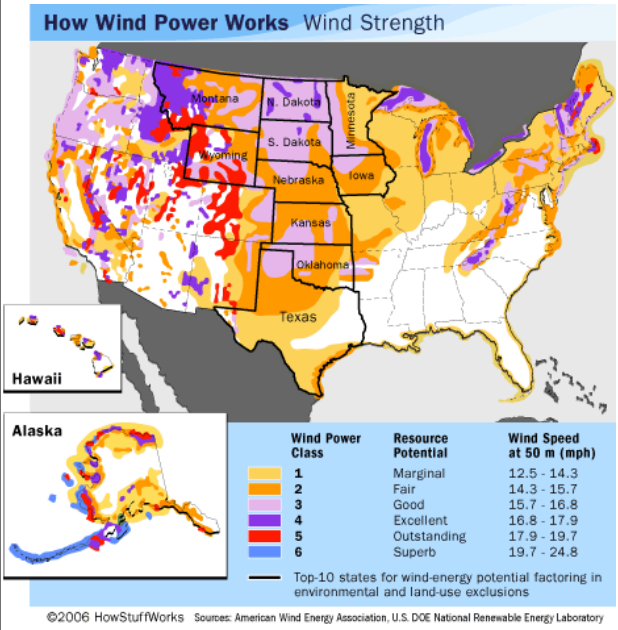
Potential Wind Power in the U.S.



Feasible wind energy:

Wind speeds ≥ 9 mph for small turbines;
≥ 13 mph for large turbines.
These wind speeds are common in the United States, although most of it is unharnessed.

Image available at http://science.howstuffworks.com/wind-power6.htm

Wind Power: How It Works

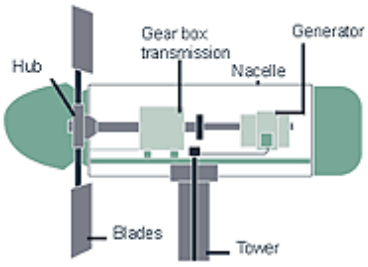


Diagram of a nacelle interior

A wind turbine is comprised of a tower, topped by an enclosure called a nacelle, and the rotor, which is the propeller-like structure connected to the nacelle. The nacelle houses an electrical generator, power control equipment and other mechanical equipment, which is connected to the rotor. The wind strikes these blades, and due to their shape, the wind causes the rotor to spin. When the wind is strong enough, the rotational energy in the rotor is converted to electrical energy within the generator.

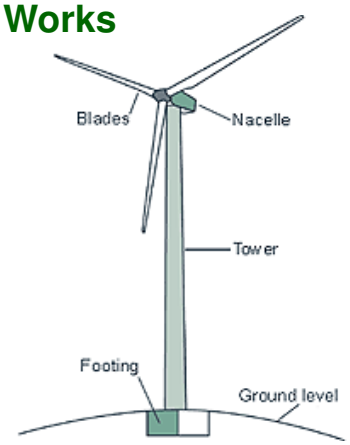


Diagram of a Wind Turbine

SEDA Renewable Energy & Cogeneration: **Wind** Energy

http://www.seda.nsw.gov.au/ren_wind_body.asp

TABLE 8-1 Pros and Cons of Wind Power

Arguments Against Wind Power	Arguments in Favor of Wind Power
Many sites—including offshore ones—are far from centers of demand, requiring long transmission lines to be built.	This is also true of many potential new hydroelectric projects.
Wind power needs some tax incentives to compete with traditional forms of electricity production.	Conventional and nuclear power plants receive much larger, though indirect, subsidies.
The construction of windmills at some remote sites requires roads, forest clearing, and other destructive infrastructure.	
Windmills kill wildlife, especially bats and birds of prey.	Studies show that very few birds are killed by wind turbines, especially compared to the number killed by cars, cats, etc.
Huge areas of land, and therefore of habitat, are required to construct enough windmills to have a substantial effect on electricity supply.	

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TABLE 8-1 Pros and Cons of Wind Power

Arguments Against Wind Power	Arguments in Favor of Wind Power
The continuous motion of the blades produces low-grade noise pollution nearby.	Noise level is comparable to traffic.
On-shore wind farms are a form of "visual pollution."	Sites remote from areas of dense population can be used.
Wind power is usually intermittent, with a low annual load factor, and requires backup facilities using traditional resources to remain constantly on-call.	Excess wind energy can be stored mechanically by pumping water to elevated storage facilities or in batteries and then used when needed to produce electricity.
	Very little greenhouse gas emissions are associated with wind energy compared to fossil-fuel combustion. There is no nuclear waste to store or potential radiation problems compared to nuclear power.

- ***Most economical*** among the renewable energy sources
  - **Current cost ~ 5 cents/kWh (about the same cost for new coal plants)**

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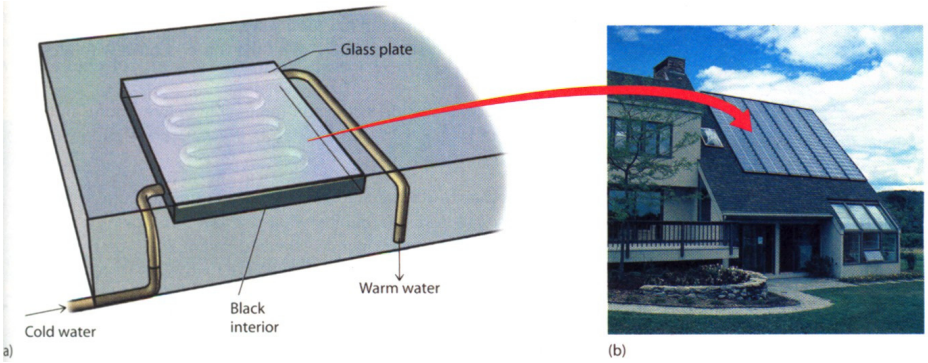
3. Solar Power

- Energy from sunlight used directly or captured and then converted to electricity



The figure above shows a *solar energy collector* (Figure a), usually located on rooftops (b) for heating water [which, in this case, is used to heat an outdoor pool]

The collector is simply made of a black (to absorb more heat) metal box covered with glass pane (to provide a greenhouse effect)

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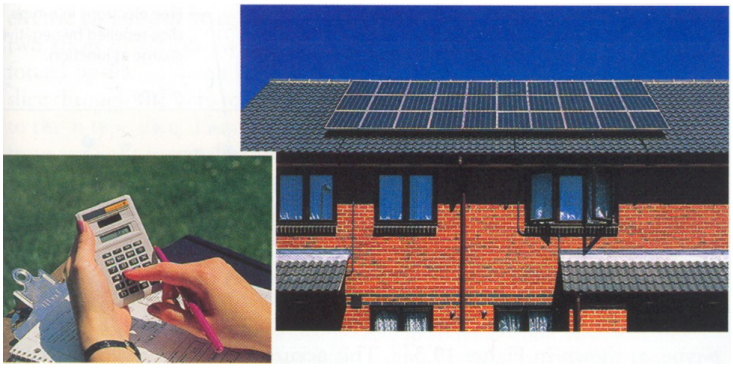
Solar Power – Cont.



Photovoltaic solar cells, which directly convert sunlight into electricity, are made of semiconducting materials. The simplest cells power watches and calculators; more complex systems can light houses and provide power to the electric grid.

Photo:Suchocki, 2001

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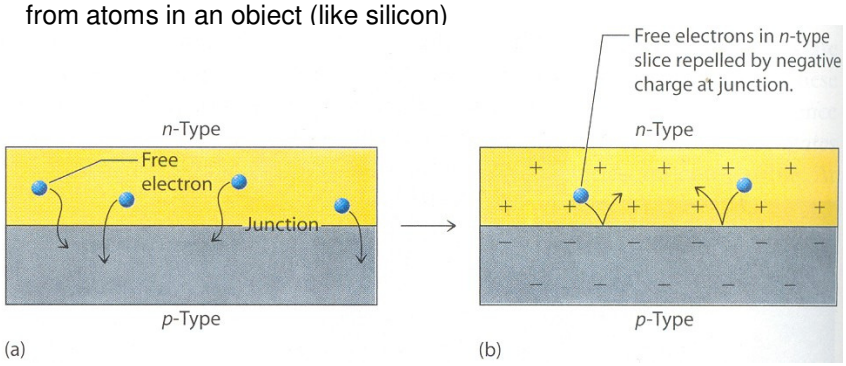
Solar Power: How It Works

How do ***photovoltaic solar cells*** work?

(Powered radios, small electronic devices in space shuttles)

- Rely on **photoelectric effect** = ability of light to knock electrons away from atoms in an obiect (like silicon)



- **Sunlight strikes silicon surface; electrons migrate from n-type to p-type (a); charge builds up (b) after a while**

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