

Supplementary Notes: (PJ Shlachtman, Miller book) Energy Efficiency and Renewable Energy Resources

What is Energy Efficiency?

- 84% of all commercial energy in used in the US is wasted
- Energy efficiency - the percentage of total energy input that does useful work
- Life cycle cost - the initial cost plus lifetime operating costs
- The net efficiency of the entire energy delivery process is determined by the efficiency of each step in the energy conversion process.
- The 3 least energy efficient using devices are incandescent light bulbs, vehicles w/ internal combustion engines, and nuclear power plants producing electricity for space heating.

Why it is important to reduce energy waste

1. make nonrenewable fossil fuels last longer
2. gives us more time to phase in renewable energy resources
3. decreases dependence on oil imports
4. lessens need for military intervention in the oil-rich and politically unstable Middle East
5. Reduces local and global environmental damage
6. Is the cheapest and quickest way to slow projected global warming
7. Saves more money, provides more jobs, improves productivity and promotes more economic growth per unit of energy than other alternatives.
8. Improves competitiveness in the international marketplace.

The reason there is not more emphasis on improving energy efficiency is the glut of low-cost underpriced fossil fuels.

A second cause is huge government subsidies

Ways to Improve Energy Efficiency

How can we use waste heat?

- Energy cannot be recycled
- For a house: insulate it, eliminate air leaks and equip it with an air-to-air heat exchanger

How can we save energy in industry?

Cogeneration

- production of two useful forms of energy from the same fuel source.
- Efficiency can be increased to approx. 90%

Replacing energy-wasting electric motors; use adjustable-speed drives

How can we save energy in producing electricity? The Negawatt Revolution

The negawatt revolution is known as demand-side management - reducing demand for electricity

How can we save energy in Transportation?

1. Increase the fuel efficiency of motor vehicles
 - There is little interest in fuel-efficient vehicles when gasoline is so cheap
2. Electric cars
 - pollution to recharge batteries is produced elsewhere
 - Electric cars are not very efficient
3. Shift to more energy efficient way to move people and freight

How can we save energy in buildings?

- Superinsulated houses; air-to-air heat exchangers
- Use the most energy-efficient ways to heat houses: passive solar heating and high-efficiency natural gas furnaces. [electric resistance heating is the most wasteful]
- Heat pumps work in warm climates
- For existing homes add insulation, plug leaks and install energy saving windows
- Use the most energy-efficient ways to heat water (using electricity is the least efficient)
- Use the most energy-efficient appliances and lights
- Rebates or tax credits for building energy-efficient buildings, etc.

Direct use of solar energy for heat and electricity

The Renewable Energy Age

Using Solar Energy to Heat Houses and Water

- **Passive Solar Heating**
 - captures sunlight directly within a structure and converts it into low-temperature heat for space heating
 - Thermal mass stores collected energy as heat and releases it day and night
- **Active Solar Heating** - special collectors absorb solar energy; a fan or pump is used to circulate the hot water
- Net energy yield is moderate; CO₂ not emitted; land disturbance is minimal
- Owners need solar legal rights

How Can Solar Energy Be Used to Generate High-Temperature Heat and Electricity?

1. Central Receiver System (Power Tower)
2. Heliostats - computer controlled mirrors
3. Solar Thermal Plant (distributed receiver system)
4. Parabolic dish collectors
5. Nonimaging optical solar concentrator
6. Solar cookers

Producing Electricity from Solar Cells - The PV Revolution

Photovoltaic Cells (Solar Cells) - Sunlight falling on a wafer thin silicon sheet releases a flow of electrons creating an electric current.

High net energy yield; works in cloudy weather.

Cost of PVs is high;

Storage of electricity produced is a problem

- Batteries are expensive
- Flywheels are promising

Producing Electricity from Moving Water and from Heat in Stored Water

Hydroelectric Power

- Large-scale hydroelectric project (large dam)
- Small-scale hydroelectric project - a low dam with no reservoir
- Pumped storage hydropower systems - water reservoirs at two different levels
- Moderate to high net energy yield
- Flood vast areas, destroy wildlife habitat, uproots people, ...

Producing electricity from Tides and Waves

- Few suitable sites and construction costs are high

Producing electricity from heat stored in water

- OTEC (Ocean thermal energy conversion)
- Saline solar ponds
- Freshwater solar ponds

Producing electricity from Wind

- Unlimited source at favorable sites
- Land underneath turbines can be used for grazing cattle or farming
- Need steady winds

Producing Energy from Biomass

- Organic matter can be burned directly as a solid fuel, or converted into gaseous or liquid biofuels.
- Potentially renewable if managed properly.
- Biogas (60% methane, 40% CO₂); liquid methanol; liquid ethanol
- Biomass Plantations of Btu Bushes: burned directly or converted to alternative fuels
- Requires large areas of land
- Burning Wood
 - contains pollutants known to cause cancer, bronchitis, emphysema
 - Need efficient wood-burning stoves
- Burning agricultural or urban wastes
 - Bagasse - residue left after harvesting and processing sugar cane.

Solar Hydrogen Revolution

Water can be split by electricity into H₂ and O₂.

Geothermal Energy

Sustainable Energy Strategy

- improved energy efficiency
- chose projects carefully
- we cannot continue to depend on a single nonrenewable energy source.

What the government can do

- increase fuel efficiency standards for motor vehicles
- establish energy-efficiency standards for buildings and appliances
- increase government sponsored R&D to improve energy efficiency
- give tax credits and exemptions for purchases of energy efficient vehicles, houses, buildings and appliances
- phase in full-cost pricing to include the environmental impact