Chapter 19

ALTERNATIVE ENERGY AND THE ENVIRONMENT

19.1 INTRODUCTION

Case Study: Spirit Lake Community School District in Iowa, Going With the Wind

The Spirit Lake School District made a decision in 1991 to reduce their dependency on fossil fuels. This is a real example of 'think globally, act locally'. This District is using wind turbines, installed at the schools, to augment their consumption of electrical power.

● Renewable alternatives derive from wind, water, solar or biomass. Note that wind, water and biomass energy sources are indirect sources of solar energy. Because wind, water and biomass energy are derived from solar energy, their rate of renewal depends on the sun and they may be temporarily depleted. Nonrenewable alternatives include nuclear, the subject of Chapter 19. The renewable energy sources are low quality energy in the sense that the energy is not concentrated and not easily portable. The total energy available from renewable sources is large (see Table 19.1), but because it is dilute it is not always economical given the current price of fossil fuel.

19.2 SOLAR ENERGY

●The amount of solar energy reaching the earth's surface exceeds our total consumption by orders magnitude, but it averages only 177 W/m^2, in other words it is very dilute. Solar energy may be used passively or actively. Buildings can be designed to take advantage of solar energy in a passive way (see Fig. 19.3). Active solar designs require mechanical power of some type to circulate air or water.

● Solar collectors provide space heating or hot water.

● Photovoltaics convert sunlight directly into electricity. Their 1^{st}-law efficiencies are as high as 10%. Photovoltaic systems can provide enough energy for lighting and simple appliances. An estimated ½ million homes use photovoltaics in the U.S., 10,000 in Germany. DOE estimates that the manufacturing cost of photovoltaic modules was $2.10 watt in 2003. The cost of conventional electricity is on the order of 8 cents/kwh. At these rates, it would take about 3 years of actual power generation by the photovoltaic system to break even. The economics are not attractive for most regions, but the manufacturing cost is declining.

● Power towers are centralized electric generation plants where a field of mirrors focus the solar energy on a collector. They have not proven to be economical.

● Luz solar electric-generating system utilizes a system of solar collectors (curved mirrors) to heat a synthetic oil that flows though a heat exchanger that drives steam turbines. It has characteristics like a power tower, but is a hybrid system that uses natural gas as a backup.

● Solar ponds

● Ocean thermal energy conversion (OTEC) would use the temperature gradient in tropical oceans to produce electricity. In theory, warm water at the surface could vaporize a gas such as ammonia, which would turn a turbine, and cold water from depth would condense the gas. A prototype was constructed in Hawaii. There are many problems associated with this technology and unknowns, including effects on ocean circulation and biofouling.

19.3 HYDROGEN

● Hydrogen gas may be an important fuel in the future. It is a clean fuel. The byproduct of hydrogen combustion is water. It is a concentrated form of energy that can be transported. It can be produced by passing an electric current through water to decompose the water molecule into oxygen and hydrogen, a process known as **electrolysis**. Hydrogen can also be produced from hydrocarbons, including natural gas. The nation of Iceland is attempting to become the first hydrogen based energy economy using its abundant geothermal energy resources.

19.4 WATER POWER

● Hydroelectric power uses the water stored behind dams. In the U.S., hydroelectric plants account for about 10% of total production.
● Hydroelectric power has a number of environmental costs. For example, fish migrations are disrupted. Another cost is the loss of scenic rivers.

A CLOSER LOOK 19.1: FUEL CELLS

● Fuel cells are highly efficient power plants that produce electricity by combining fuel and oxygen in a electrochemical reaction. Hydrogen is the most common fuel type. The reaction is essentially the opposite that of electrolysis. Experimental fuel cells have been developed that can power automobiles.

19.5 TIDAL POWER

● Tidal power can be harnessed in several ways. In areas of extreme tide range, such as the Bay of Fundy, which has a 15 m tide, a dam constructed across the estuary would let water enter on the incoming tide, then release the water through turbines at low tide. The energy potential is great, and so is the environmental cost. Though proposed, a tidal power plant has not been constructed at Fundy. There is a 240,000 kW tidal plant at La Rance, France.

19.6 WIND POWER

● Most wind mills generate about 1kW of electricity, which is only practical for decentralized power generation. California has about 17,000 windmills with a capacity of about 1,400 MW. This is about 80% of all windmills in the U.S. In West Europe windmill generators are quite common. Several states offer incentives for wind power. For grid-connected systems, Minnesota offers a 1.5 cent/kWh payment for net excess generation for small wind energy projects. Cost varies with capacity. A 3 kW machine can be found for about $13,000 and a 17.5 kW machine for $31,000 (Forsyth et al. 2000.

NREL report). At $0.08/kWh, the payback time of these machines would be about 3-6 years.

19.7 BIOFUELS

● Biofuel is from the energy recovered from biomass. This can take a number of forms ranging from direct combustion of biomass to fermentation of alcohol, which can be mixed with gasoline. Some people are concerned about the prospect of fields of corn being used to produce alcohol at the expense of hungry populations.

19.8 GEOTHERMAL ENERGY

● … is natural heat from the interior of the earth that can be harnessed to produce electricity or heat buildings. Total installed capacity worldwide is approaching 9,000 MW. 40 million people depend on geothermal energy for their electricity. Geothermal energy is not uniformly distributed and is only available where hot rocks are in reach of drilling equipment or where steam rises to the surface.

19.9 POLICY

● A rational energy policy should encourage research by private industry and should provide funding for basic research, ensure fair access to alternative energy sources, encourages the internalization of external cost of fossil fuel energy, and promotes the dissemination of information about the costs and benefits of alternative energy sources.

CRITICAL THINKING: HOW CAN WE EVALUATE THE ALTERNATIVES?

Evaluate the alternative energy sources. What are the pros and cons? What are the environmental costs of each?

Web Resources

http://www.users.qwest.net/~rberger1/category.htm This is a portal to alternative energy resource sites.

http://www1.eere.energy.gov/solar/photovoltaics.html A good site devoted to photovoltaics.