Renewable fuels

Renewable

- Wind
- Biomass
- Hydro
- Solar
- Geothermal

Wind

- Wind is caused by the uneven heating of the earth by the sun.
- Solar heating varies with time and with the reflectance of the surface
- Kinetic energy of the wind is converted to electrical energy
Wind Energy

- History
- The U.S. wind industry currently generates about 4.5 billion kilowatt-hours of electricity (1999)
- 2,251 MW of installed capacity in the US

Kinetic Energy

\[ \text{Energy} = \frac{1}{2}mv^2 = \frac{1}{2}Apv^2 \]

4. Renewable Fuels
Energy obtained

- Difference in Kinetic Energy of the incoming wind and outgoing wind

Area

Length

If the wind is traveling at \( \mathbf{v} \) meters/s,
Then in one second it will travel 10 meters

Volume of air that is passing
the blades of the mill = area of the mill \( A \) \( \times \) velocity \( \mathbf{v} \)
\( \text{m}^3/\text{s} = \text{m}^2 \times \text{m/s} \)

Power From a Wind Mill

Mass flow rate of air passing the mill
\( \mathbf{V} \) (m/s) \( \times \) density \( \rho \) (kg/m³)
\( = \text{Area} \times \text{velocity} \times \text{density} \)

Kinetic energy/time = \( \frac{1}{2} \) mass flow rate \( \times \) velocity²

Power = \( \frac{1}{2} \) Area \( A \) \( \times \) Velocity \( \mathbf{v} \) \( \times \) density \( \rho \) \( \times \) velocity²

\[ \text{Power} = \frac{1}{2} A \rho \mathbf{v}^3 \text{ Watts} \]
Most of the US wind generation sites are currently operating in California.

**Hydroelectric Energy**

- Stored water in a dam has potential energy.
- When released the kinetic energy is captured by a generator and electricity is produced.

**Hydroelectric Power**
Current Status

- About one fifth of electricity in the world is generated from hydropower.
- The United States is one of the largest producers of hydropower in the world, second only to Canada.
- 10 percent of U.S. electrical generation.
- Total U.S. hydroelectric capacity is 103.8 GW including pumped storage projects.

Capacity of US Hydroelectric Sites in the US

<table>
<thead>
<tr>
<th>Site</th>
<th>Year</th>
<th>Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grand Coulee</td>
<td>1942</td>
<td>6500 MW</td>
</tr>
<tr>
<td>John Day</td>
<td>1969</td>
<td>2200 MW</td>
</tr>
<tr>
<td>Niagara (NY)</td>
<td>1961</td>
<td>2000 MW</td>
</tr>
<tr>
<td>The Dalles</td>
<td>1957</td>
<td>1800 MW</td>
</tr>
<tr>
<td>Chief Joseph</td>
<td>1956</td>
<td>1500 MW</td>
</tr>
<tr>
<td>McNary</td>
<td>1954</td>
<td>1400 MW</td>
</tr>
<tr>
<td>Hoover</td>
<td>1936</td>
<td>1345 MW</td>
</tr>
<tr>
<td>Glen Canyon</td>
<td>1964</td>
<td>950 MW</td>
</tr>
</tbody>
</table>

Schematic of a Hydro Power Plant

- Transmission lines conduct electricity, ultimately to homes and businesses.
- Cistern - holds water.
- Penstocks - carries water to the turbines.
- Generators - rotate with the turbines to generate electricity.
- Turbines - turned by the force of the water on their blades.

Cross section of conventional hydropower facility that uses an impounded dam.
Advantages of Hydroelectricity

- Clean, renewable and reliable energy source
- Cheap electricity
- Capable of converting 90 percent of available energy into electricity
- Operational flexibility – can be easily controlled to match demand

Environmental

- Non polluting
- Enhance wetlands and support healthy fisheries. Wildlife preserves can be created around reservoirs, which in some cases, provide stable habitats for endangered or threatened species.

Disadvantages

- Hydroelectric facilities disrupt natural river flows.
- Hydropower may alter river and riverside habitat.
- Impede the natural flow of sediments
- Catastrophic failure
- Significant obstacle to fish migration
Future of Hydroelectric Power

- When screening for environmental, legal and institutional factors at potential sites, there are 29,780 MW of hydro generation—most of which can be developed without the construction of a single, new dam.
- In the US the "good spots" are already in use or located at environmentally sensitive sites.