

## Renewable Energy

We define *renewable energy* resources as those which are constantly being replenished and will never run out. Most (but not all) renewable energy comes either directly or indirectly from the sun.

Types of renewable energy

- » Solar
- » Wind
- » Biomass
- » Geothermal
- » Hydropower

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## Renewable Energy - Solar

Solar energy can be used in several different ways. We can use the sun to [1] directly heat homes and buildings, [2] superheat oil which in turn heats water to produce steam for electricity generation and [3] generate electricity direct via use of photovoltaic cells.

Passive solar heating



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Solar thermal e-generation



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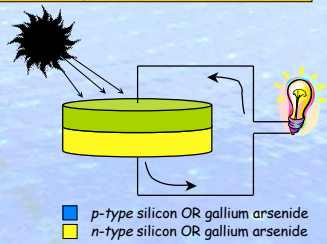
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Photovoltaic cells



■ p-type silicon OR gallium arsenide  
■ n-type silicon OR gallium arsenide

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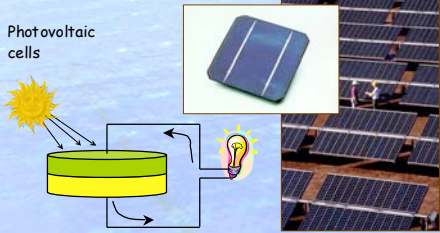
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Photovoltaic cells




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## Renewable Energy - Wind

Wind energy is a form of solar energy. The sun warms the Earth's atmosphere, which creates wind. We've been harnessing the wind for hundreds of years via the use of windmills. The modern equivalent of the windmill is the *wind turbine*.

**Altamont Pass, CA**  
 (30 mi east of San Francisco)

5,041 Wind turbines generate 544 MW of electricity




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## Renewable Energy - Bioenergy

Bioenergy (*i.e.* energy from biomass) has been around for thousands of years ever since humans began burning wood to cook food or to stay warm. Even today, wood is still our biggest source of bioenergy.

The direct burning of biomass generates about as much carbon dioxide as burning fossil fuels; however, if one tree is planted for every tree burned, the net carbon dioxide emission is ZERO.

**Other uses of biomass**

Heat biomass in absence of oxygen to convert it to a liquid fuel called **PYROLYSIS OIL** then use like petroleum

Ferment biomass (*e.g.* CORN) to produce ethanol which can then be used in gasoline blends or used directly

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## Renewable Energy - Geothermal

Geothermal energy comes from the heat generated by the interior of the Earth.

The heat from the Earth produces underground steam, which can be used directly as a heat source or can be used to power a steam turbine to produce electricity.




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## Renewable Energy - Hydropower

The most common type of hydropower plant uses a dam on a river to store water in a reservoir. Water released from the reservoir flows through a turbine, spinning it, which in turn activates a generator to produce electricity.

In addition to producing electricity, dams ensure a year-round supply of water in those areas that have seasonal precipitation or snowmelt. Dams confine water in reservoirs (human-made lakes) from which flow can be regulated

» Dams do provide Benefits

- » Generation of electricity - Hoover Dam, AZ (1434 MW)  
Three Gorges Dam, China (18,200 MW!)
- » Flood control - reservoirs hold huge volumes of water
- » Recreation - fishing, boating, water-skiing, etc

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## Renewable Energy - Hydropower

Unfortunately dams also have large drawbacks (e.g. The Three Gorges Dam on the Yangtze River in China). It is scheduled for completion in 2009 and will produce 18,200 MW (about 23 large nuclear or coal-fired power plants!)

- » Loss of farmland, living space - 13 cities, 140 towns and 1352 villages must be resettled ≈ 2 million people
- » Loss of wildlife habitat - 610 ft high, 1.3 miles wide, 410 mile long reservoir
- » Huge construction costs - \$17 - 75 Billion!
- » Extremely Controversial
- » Concentrations of pollutants increase upstream
- » Concentrations of nutrients decrease downstream

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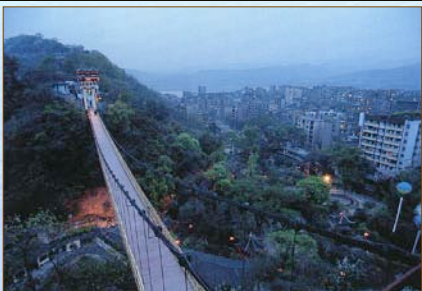
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## Renewable Energy - Hydropower

City of Fengdu, China before Three Gorges



Source: National Geographic Magazine, September 1997

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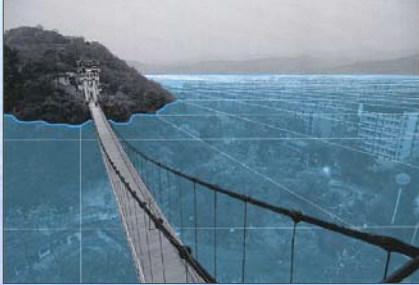
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