Hydroelectricity

Lorna Parkinson

Large-Scale Hydropower on Columbia River, Washington State.
(Photo: Grant County PUD, Washington)

Hydropower has been used for centuries.

- First waterwheels 85 BCE
- Used for grinding grain
- Norias of Hama, Syria on the Orontes River (400 CE)
- Colonial America used waterwheels for sawing timber, fulling cloth, grinding grain, and making iron products
- Only source of mechanical power until the second half of the 19th century

Early forms of hydropower

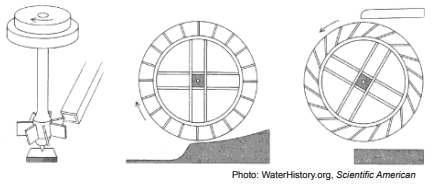


Photo: WaterHistory.org, *Scientific American*

Norse Wheel (vertical axis wheel)

Undershoot Wheel

Overshoot Wheel

Converting Hydropower into Electricity

- Electric generators developed in the 19th century
- Hydropower was a natural source of power for electric generators
- Conversion of potential energy of water in higher elevation into kinetic energy
- Rivers alone were unsuitable for generators
- Dams provided a solution where flow of water could be adjusted to meet electricity demands

Hydroelectric Power Facilities

- 1882: Appleton Edison Light Company
  - Fox River, Appleton, Wisconsin
  - DC for local industries
- 1887 San Bernadino, California
- 1907: 15% of all electricity
- 1920: 25%of all electricity

Hoover Dam

- 1931: Construction began
- Part of the New Deal during the Great Depression
- Employed more than 20,000 workers
- 1937: completed and generates electricity from the Colorado River
- 2,080 MW Capacity

Tennessee Valley Authority

- Created by Congress in 1933 as part of the New Deal
- Goals: power production, navigation, flood control, malaria prevention, reforestation and erosion control
- Built dams to harness the energy from the Tennessee Valley Rivers
- Energy from dams used for war industry
- Currently controls over 47 dams

Grand Coulee Dam

- Largest dam in the U.S.
- Fourth largest in the world
- Construction: 1933-1941 and 1967-1974
- 12 million cubic yards of concrete
- 6,809 MW
- Supplies 11 western states with electricity (WA, OR, ID, MT, WY, CO, CA, NV, NM, UT, AZ)

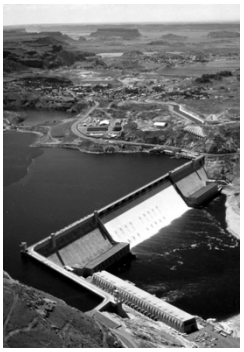
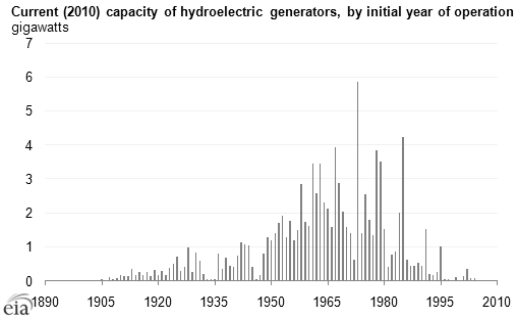
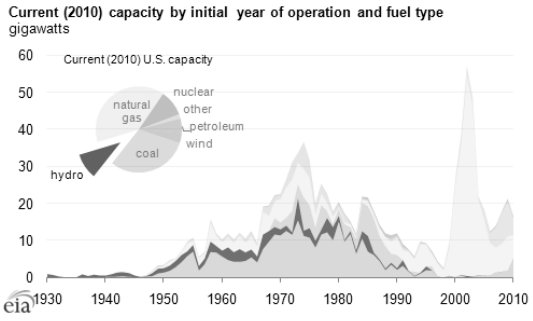


Photo: USBR http://www.usbr.gov/pn/grandcoulee/photogallery/aerials/pic2.html



U.S. Energy Information Administration, Form EIA-860 Annual Electric Generator Report, and Form EIA-860M



U.S. Energy Information Administration, Form EIA-860 Annual Electric Generator Report, and Form EIA-860M

Today

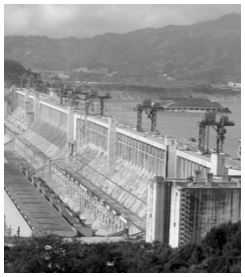
- 21% of the World's electricity comes from hydropower
- 7% of United States electricity from hydro
  - 8000 dams generating electricity
  - Total amount of electricity produced from hydropower has increased, but total percentage has decreased from 35% to 7%
  - Harnessed 50% of hydropower available
- 71% in Latin America
- 16% in Africa

Hydropower Output (2008)

	Electricity Generated (Billion kWh)	Installed Capacity (Thousand MW)
China	583	171
United States	272	78
Brazil	380	77
Canada	380	73
Russia	163	46
India	131	35
Norway	139	27
Japan	94	22
Sweden	80	17

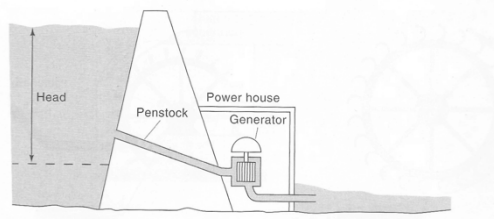
Three Gorges Dam

- Largest dam in the world
- Yangtze River
- Constructed over a time span of 17 years (1993-2009)
- Largest Concrete Structure in the world'
  - 1.4 miles wide
  - 607 feet high
  - Reservoir: 373 miles long
- Projected 22,000 MW



(Photo: Le Grande Portage http://commons.wikimedia.org/wiki/File:Three_Gorges_Dam,_Yangtze_River,_China.jpg)

How does hydroelectricity work?

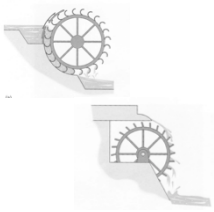


How does hydroelectricity work?

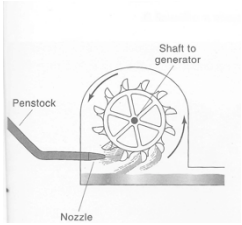
- Water flows through penstock to a reaction of impulse turbine
- Output is a function of the head and rate of water flow
- Head = vertical distance from highest level of dammed water to the power producing turbine
  - High head dam = 300 m or higher
  - Low head dam = 30 m or lower
- Power produced by high head dam or low head dam with a large volume of water flow

Impulse Turbines

Breast and Overshoot Waterwheels

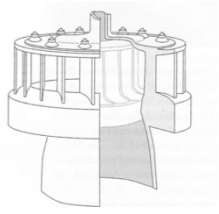


Pelton Turbine

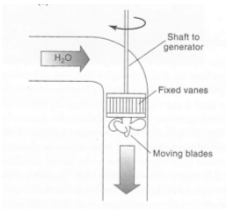


Reaction Turbines

Francis Turbine



Kaplan turbine



How does hydroelectricity work?

- High Head Hydroelectricity Power Plant
- Medium Head Hydroelectricity Plants
- Low Head Hydroelectricity Power Plants

Types of Dams

Arch Dams

Photo: Roosevelt Dam, J. Madigal Jr.

Gravity Dams

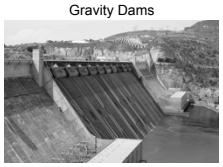


Photo: David Brodbeck, Grand Coulee Dam Spillway

Types of Dams

Buttress Dams

Photo: Stwaln Dam in Wales
http://www.britishdams.org/about_dams/buttress.htm

Embankment Dams

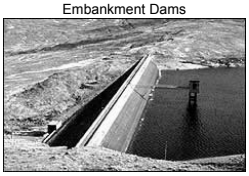
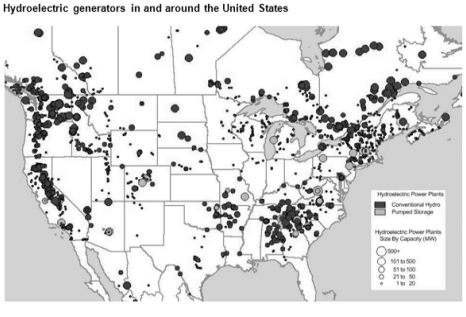


Photo: Quoich rockfil embankment dam in Scotland
http://www.britishdams.org/about_dams/embankment.htm

Hydroelectricity… Sounds Great!

- Renewable: water cycle
- Green: no solid waste or air pollution
- Cheap: low power bills
- Reliable: as long as water flows, there will be electricity
- Flexible: does not take a long time to change output levels
- Safe: no fuel involved
- Great Potential: Africa

But, we can't put it just anywhere



Hydroelectric power facilities have major environmental impacts.

- A dam will result in the flooding of large areas of land.
- Raw pollutants flowing downstream can be trapped in reservoirs.
- There can be a reduction of sediment and nutrients flowing downstream.
- All of these issues can result in health problems, and a decrease in plant and animal life.

Back to the Three Gorges Dam…

- Displaced 1.2 million people
  - Erosion caused by dam is expected to displace 100,000 more people
- Triggered land slides
- Destroyed ecosystems
- Water shortages and drought
- Reservoir-induced seismicity

Is there any hope?