Frank Mace, Associate Project Manager
New York State Energy Research and Development Authority
Albany, NY

HYDROPOWER and HYDROELECTRIC POWER

Description:
Hydropower, also called water power or hydraulic power, is derived from the energy embedded in moving water.

History is full of examples of water wheels or water mills with associated mill ponds. These systems functioned for thousands of years and provided power for the production of flour, lumber, and textiles. Hydropower also provided power for irrigation and cranes for loading and unloading cargo ships.

Most of us, however, associate hydropower with the production of electricity or hydroelectricity—for use in homes, public buildings, and commercial establishments.

Hydroelectric generation stations, such as the one located at Niagara Falls, which was completed in 1886, take advantage of the natural falls. However, most hydroelectric projects require a dam and an associated reservoir to provide what is called the "head." The head is simply the pressure exerted by the weight of the water, based upon elevation (or distance) between the top of the water and the generating equipment. When the water is released and allowed to flow, it provides the power necessary to drive the turbines.

The 1930's saw large scale projects, such as the construction of Hoover Dam (creating Lake Mead), which was completed in 1936 on the Arizona/Nevada border, and also saw the creation of the Tennessee Valley Authority (TVA) in 1933. The TVA constructed dams and reservoirs for flood control and hydroelectric power in seven states. In addition, these projects provided much-needed employment during the Great Depression. The TVA also advanced efforts in reforestation and malaria control and trained farmers in techniques for improving crop yield and soil conservation.

The U. S. Army Corps of Engineers provides a historical perspective on hydropower:

"Unlike the West, where irrigation became the focus of attention, the East was more concerned over hydropower development. Beginning in the early 1880's, when a plant in Appleton, Wisconsin, first used falling water to produce electricity, the construction of hydroelectric dams on the nation's waterways proliferated. These private dams threatened navigation and forced Congress, acting through the Corps of Engineers, to regulate dam construction. The Rivers and Harbors Acts of 1890 and 1899 required that dam sites and plans be approved by the Secretary of War and the Corps of Engineers before construction. The General Dam Act of 1906 empowered the
federal government to compel dam owners to construct, operate, and maintain navigation facilities without compensation whenever necessary at hydroelectric power sites." See: U. S. Corps of Engineers: 

The U. S. Army Corps of Engineers also offer this explanation of the process of hydroelectric power:

"A hydraulic turbine converts the energy of flowing water into mechanical energy. A hydroelectric generator converts this mechanical energy into electricity. The operation of a generator is based on the principles discovered by Faraday. He found that when a magnet is moved past a conductor, it causes electricity to flow. In a large generator, electromagnets are made by circulating direct current through loops of wire wound around stacks of magnetic steel laminations. These are called field poles and are mounted on the perimeter of the rotor. The rotor is attached to the turbine shaft and rotates at a fixed speed. When the rotor turns, it causes the field poles (the electromagnets) to move past the conductors mounted in the stator. This, in turn, causes electricity to flow and a voltage to develop at the generator output terminals." See: The U.S Department of the Interior, Bureau of Reclamation: http://ga.water.usgs.gov/edu/hyhowworks.html.

Dams and reservoirs are expensive, create challenges to navigation and aquatic life, and take up valuable real estate. More recently, we have seen the development of tidal power, or dam-less power. One example of tidal power is located in the East River in New York City. A New York State Energy Research and Development Authority (NYSERDA) publication explains this process:

"Capturing the natural ebb and flow of the tides has always been a challenge filled with potential benefit. For the past century, hydropower was created by building dams to channel water through powerhouses, where giant turbines captured the power of the falling water. Recently, increased attention to hydrogeneration has centered around a kinetic method of hydropower. By using dozens of small generators in a section of the East River off of Roosevelt Island, near midtown Manhattan, a project is demonstrating kinetic generation. The Roosevelt Island project features tri-bladed turbines capable of turning on their horizontal axes to capture both the ebb and flow of the East River. Submerged prototypes have shown positive results, and regulatory approval is underway for a section of river covering a little over one acre. The potential is to generate 5 to 10 MW of electricity by 2010." See: NYSERDA: General Reports, "Renewal—Tidal Power," p. 13: http://www.nyserda.ny.gov/en/Publications/NYSERDA-General-Reports/~/media/Files/Publications/NYSERDA/05-06%20Section%201.ashx.
Hydroelectric stations are appropriate for any geographic location that has moving water. This form of power is the most common renewable energy source worldwide and accounts for almost half of all renewables in the United States. According to The Need Project (2008), hydropower produces 20 per cent of the world’s electricity; and in the United States, New York ranks third in the use of hydropower for the generation of electricity: http://www.need.org/needpdf/infobook_activities/IntInfo/HydroI.pdf. Hydropower is the cheapest way to generate electricity in the United States—cheaper than coal or nuclear plants—and produces no air pollution because it does not burn fuel.

**Benefits:**

**For consumers**

- Hydroelectric power produces no air pollution, promoting a healthier living environment for community residents.

- The lower cost of hydroelectric power makes homeownership and rental costs more affordable for older people, individuals with disabilities, and families, supporting their ability to remain living in their communities.

**For the community**

- The lower cost of hydroelectric power supports the activities of the business community and lowers the operating costs of other community sectors, such as health care facilities and schools.

- Hydroelectric power is a renewable energy source, reducing reliance on traditional non-renewable fuels.

- Hydroelectric power avoids fuel costs in the production of electricity, and, therefore, stabilizes the cost of energy over the life of the plant.

- The avoidance of fossil fuels makes hydroelectric power more environmentally friendly and reduces greenhouse gas emissions.

- Lakes created by hydroelectric dams can also contribute to flood control, irrigation, recreation, and wildlife.

**Impediments or barriers to development or implementation:**

- Hydroelectric power is dependent upon rainfall for the supply of flowing water.

- Hydroelectric stations must be sited in areas with moving water.

- Hydroelectric generation is a long-term investment.

- Hydroelectric generation may require the construction of a dam and reservoir.

- Hydroelectric projects may have an impact on aquatic life.
Resource—examples:

- Higley Hydroelectric Station, Lower Raquette River, St. Lawrence County, NY—as part of NYRSERDA’s Renewable Portfolio standard, this station was re-powered to increase output from 4.5Mw to 6.2 Mw: [http://www.nyserda.ny.gov/Page-Sections/Energy-and-Environmental-Markets/Renewable-Portfolio-Standard/Project-Gallery.aspx](http://www.nyserda.ny.gov/Page-Sections/Energy-and-Environmental-Markets/Renewable-Portfolio-Standard/Project-Gallery.aspx).


Resource—written and web:


Resource—technical assistance contact names:

- Frank W Mace, LEED AP, DGCP Distributed Generation Certified Professional NYSERDA 17 Columbia Circle Albany, New York 12203-6399 (518) 862-1090, ext. 3433 e-mail: fwm@nyserda.org