Energy from Hydropower

Hydropower generated approximately seven percent of the nation's electricity in 2005. The United States is the largest producers of hydropower in the world, second only to Canada. In the Pacific Northwest, up to 70 percent of electricity is generated from hydropower. Of the 75,187 existing significant dams in the United States however, less than 3 percent are used for hydroelectric generation.

Total U.S. hydroelectric capacity is 103.8 gigawatts (GW) including pumped storage projects. Non-federal, licensed conventional hydroelectric capacity (excluding pumped storage) equals 40.0 gigawatts at 2,162 sites in the United States. The federal government owns another 38.2 GW at 165 sites (excluding pumped storage).

Hydropower produces electricity by running water from a reservoir through a hydraulic turbine that spins and drives the generator shaft. A hydroelectric plant produces between 100 kW to 500 MW of electricity, depending on size. Though the emissions produced from hydropower plants are negligible, dam construction to create water reservoirs carries other environmental impacts.

Learn More
- coal
- hydro
- natural gas
- nuclear
- oil
- renewables

Hydro Energy Technologies

While hydropower turbine manufacturers have incrementally improved turbine technology to improve efficiencies, the basic design concepts have not changed for decades.

The type of hydropower turbine selected for a project is based on the height of standing water and the flow, or volume of water, at the site. Other deciding factors include how deep the turbine must be set, efficiency, and cost.

Impulse Turbine

The impulse turbine generally uses the velocity of the water to move the runner and discharges to atmospheric pressure. The water stream hits each bucket on the runner. There is no suction on the down side of the turbine, and the water flows out the bottom of the turbine housing after hitting the runner. An impulse turbine is generally suitable for high head, low flow applications.

Pelton Hydropower Turbine

A pelton wheel has one or more free jets discharging water into an aerated space and impinging on the buckets of a runner. Draft tubes are not required for impulse turbine since the runner must be located above the maximum tailwater to permit operation at atmospheric pressure.

Cross-Flow Turbine

A cross-flow turbine is drum-shaped and uses an elongated, rectangular-section nozzle directed against curved vanes on a cylindrically shaped runner. The cross-flow turbine allows the water to flow through the blades twice. The first pass is when the water flows from the outside of the blades to the inside; the second pass is from the inside back out. A guide vane at the entrance to the turbine directs the flow to a limited portion of the runner. The cross-flow was developed to accommodate larger

water flows and lower heads than the Pelton.

Reaction Turbine

A reaction turbine develops power from the combined action of pressure and moving water. The runner is placed directly in the water stream flowing over the blades rather than striking each individually. Reaction turbines are generally used for sites with lower head and higher flows than compared with the impulse turbines.

Propeller Turbine

A propeller turbine generally has a runner with three to six blades in which the water contacts all of the blades constantly. Through the pipe, the pressure is constant. The pitch of the blades may be fixed or adjustable. The major components besides the runner are a scroll case, wicket gates, and a draft tube. There are several different types of propeller turbines:

- **Bulb turbine:** The turbine and generator are a sealed unit placed directly in the water stream.
- **Straflo:** The generator is attached directly to the perimeter of the turbine.
- **Tube turbine:** The penstock bends just before or after the runner, allowing a straight line connection to the generator.
- **Kaplan:** Both the blades and the wicket gates are adjustable, allowing for a wider range of operation.
- **Francis:** A Francis turbine has a runner with fixed buckets (vanes), usually nine or more. Water is introduced just above the runner and all around it and then falls through, causing it to spin. Besides the runner, the other major components are the scroll case, wicket gates, and draft tube.

Kinetic Energy Turbines

Also called free-flow turbines, the kinetic energy turbines generate electricity from the kinetic energy present in flowing water rather than the potential energy from the head. The systems may operate in rivers, man-made channels, tidal waters, or ocean currents. Kinetic systems utilize the water stream's natural pathway. They do not require the diversion of water through manmade channels, riverbeds, or pipes, although they might have applications in such conduits. Kinetic systems do not require large civil works; however, they can use existing structures such as bridges, tailraces and channels.

During the 1980s, the environmental effects of hydropower became a significant issue impacting hydropower projects. Many hydro projects constructed decades ago blocked fish passage and affected wildlife habitats. R&D is currently underway to help fishery biologists and turbine designers better address these concerns while improving hydropower technology.

In the mid-1990s, the U.S. Department of Energy (DOE) began research into advanced hydropower technology. The goal was to develop systems that generate more electricity with less environmental impact. DOE funded the conceptual designs of four turbine types: a redesigned Kaplan and Francis turbine, a dissolved-oxygen-enhancing turbine, and a new turbine type that borrows technology from the food processing industry.

Many of the turbine manufacturers have begun designing environmentally friendly turbines. The hydropower industry and DOE have joined together in developing the Advanced Hydropower Turbine System (AHTS) program, which could improve the survival rates of fish while also improving the efficiency of generation.

Additional Resources

- National Hydropower Association
- Department of Energy's Wind and Hydropower Technologies Program
- Bureau of Reclamation Hydroelectric Power
- Sustainable Energy Coalition