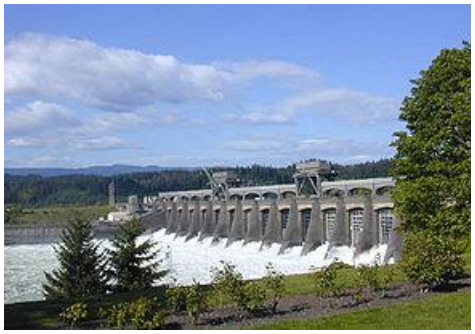
Hydroelectric Energy

Definition of Hydroelectric Energy

Hydroelectric energy is energy derived from the movement of water.

Water has mass. It falls and flows downward due to gravity. When it moves, it has kinetic energy which can be harnessed. Kinetic energy is the energy of motion.



How is hydroelectric energy harnessed?

In order to harness hydroelectric energy, a power plant needs to be installed in an area with flowing water. This may include a dam that blocks or diverts water. It may also include one or more reservoirs.

What is hydroelectric energy used for?

Hydroelectric energy is used for electricity generation accounting for 6% of all U.S. generation as of 2008. It is the most widely used *sustainable* source of energy.

Brief History of Hydroelectric Energy

People have been using the flow and the power of water to drive machines for many centuries.

Aqueducts

Many centuries ago, the ancient Romans used a vast network of aqueducts to bring water to the city from outlying regions.

Water Wheels

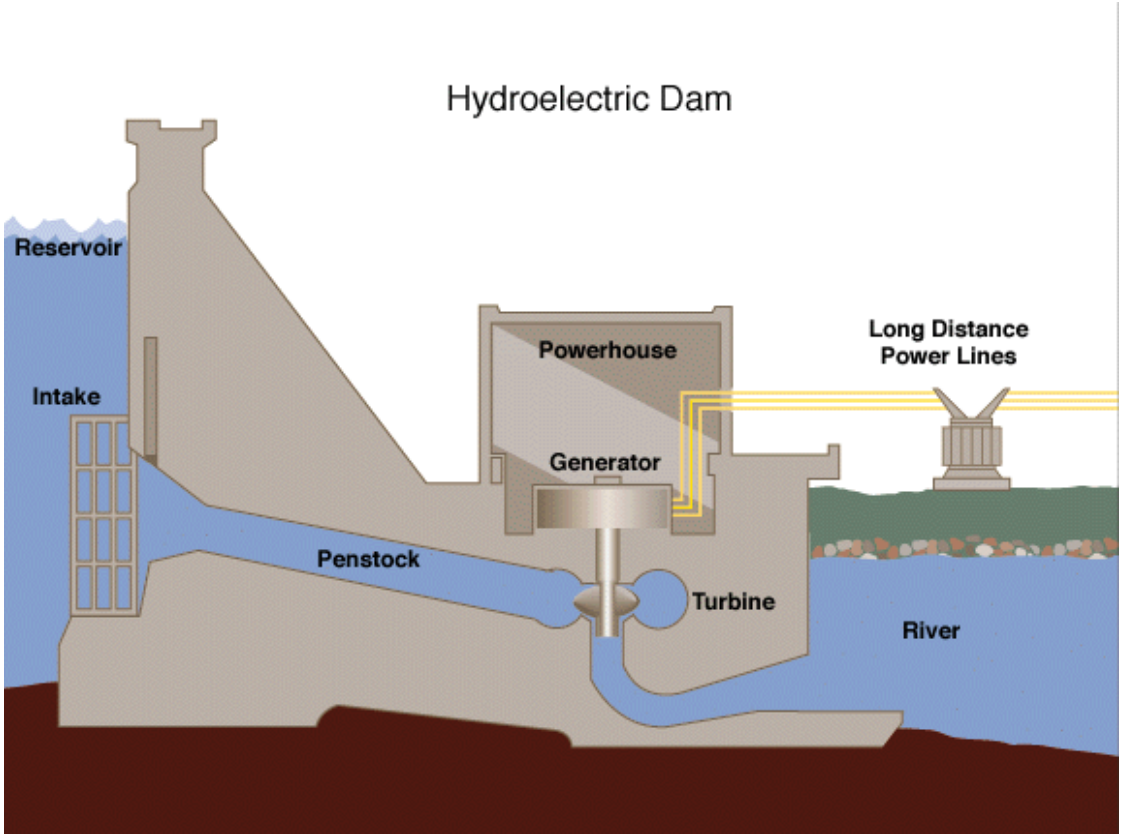
Early Europeans and Asians used water wheels placed in flowing streams to turn big stone wheels that ground up grains for making bread. They were called grist mills.

Dams

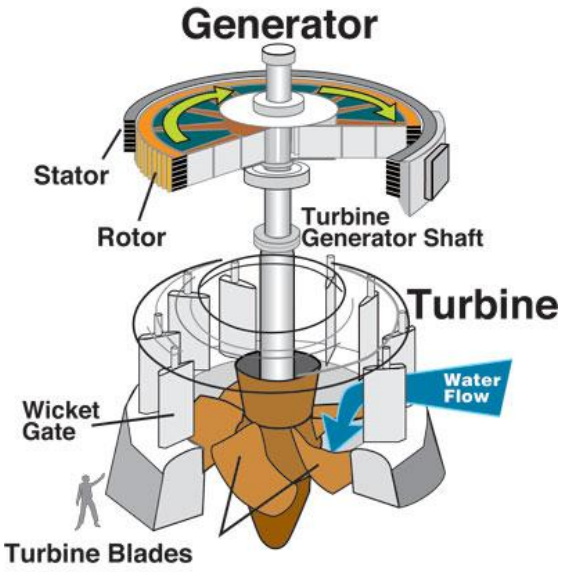
More recently, dams were implemented to impede the flow of running water and release it when needed. The force of the water then turns generators to make electricity for modern society.

Harnessing Hydroelectric Energy: Dams

One method for harnessing hydroelectric energy is a ***dam,*** or impoundment facility.



While water wheels extract some of a stream's power, it was discovered that much more power could be extracted if pressure could be built up. One cannot accumulate pressure in a running stream, but when a dam is built, the water piles up behind the dam so—at the base of the dam—the pressure is increased dramatically. When released, the pressurized water shoots down the penstock and through a system of propellers called a turbine.



The water that is piled up behind the dam has gravitational potential energy, since it can do work as it falls downward. This work is used by spinning the turbine, which gains kinetic energy. As the generator makes electricity, this kinetic energy is converted to electrical potential energy, which is then transported to homes and businesses for use in light bulbs, refrigerators, and the like.

Amount of Electricity Generated

The amount of electricity that can be generated depends on the river flow as well as the dam height.

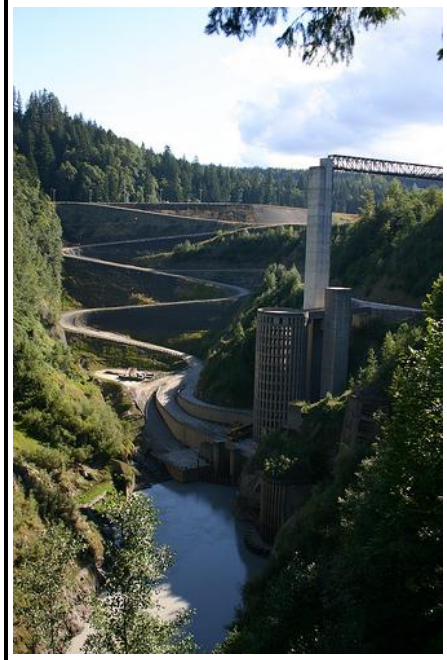
The pressure is proportional to the height of the dam (depth of the water), as **P=ρgh** where ρ is the density of the water, **g** is the acceleration of gravity at the surface of the Earth, and **h** is the depth of the water. Because of this, the taller the dam, the greater the force that can be generated to turn a turbine faster and generate electricity. This also explains why the turbines are located at the base of the dam.

The width of the dam does not matter, but is often controlled by the topography of the area that makes wider dams necessary to catch all the water flow.

If more water is allowed to flow through the turbine than the river supplies from upstream, the water level will decrease and the reservoir can eventually run dry.

DID YOU KNOW?

There are a tremendous number of large dams in the world. Only a small percentage of them were built for power generation. Most dams are built for irrigation, flood control, navigation, and many other reasons. This dam on the White River near Enumclaw, Washington was built to prevent massive floods that occurred on an annual basis.



Dam Designs

The impoundment dam is only one way to harness hydroelectric energy from flowing water.
Here are two other ways to design hydroelectric facilities.

Run-of-the-river System

Run-of-the-river systems do not require a dam to back up water in a reservoir. Instead, they extract energy from the natural flow of water. A facility may chose to build a dam to help divert water onto an artificial course in order to supply enough moving water to exert adequate force on the turbines. Diverted water joins the natural flow downriver, thus, these systems have reduced environmental impact. If the water flow is more than can be used, gates open to allow passage of excess water.

Pumped Storage System

In a pumped storage system, a special reservoir is created for water storage so that more electricity can be generated during times of peak demand. Excess generated electricity at times of lower demand is used to pump water back up into the special reservoir. When needed, water from the extra reservoir "recharges" the system. This helps provide power when people need it most. Pictured above, the Kinzua Dam in Pennsylvania is supplemented by the Seneca Pumped Storage Facility on the left-side of the picture.

Supplying and Transporting Hydropower to your Home

A river flows all the time but electricity customers need more energy as certain times of the day.

During peak demand, like hot summer afternoons and cold winter evenings, more water is allowed to flow through dams and their turbines. When there is less need for electricity, the water is allowed to build up again. In this way, a dammed reservoir behaves like a constantly charging battery.

Because hydroelectric energy needs to travel great distances, hydropower did not become widely used until the technology was invented to transmit electricity over distance.

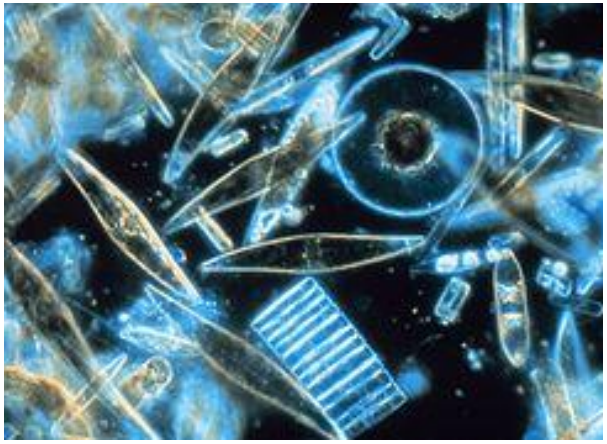
As is the case for other energy sources, hydroelectric energy needs to be transported from remote locations to city centers where it is needed. The transportation of electricity from dams requires an efficient distribution grid.

Environmental Problems of Hydroelectric Facilities

Large dams and the reservoirs they create are very useful, but they also create environmental problems.

Ultimately, dams *do not stop* the water, but they *do stop* virtually all the sediment from moving downstream. This causes the reservoir to fill up with sediment reducing the volume of the reservoir. This also starves the downstream sections of the river and coastline of the sediment they depend on for maintenance of channels, islands, deltas, and other landscape features.

Dams prevent fish from swimming upstream to their spawning grounds. If fish cannot migrate and spawn, then their population decreases. People have attempted to remedy this problem with different approaches, but most commonly implemented is a fish ladder which creates a stepped system. The fish jump onto each step to safely surpass the dam.

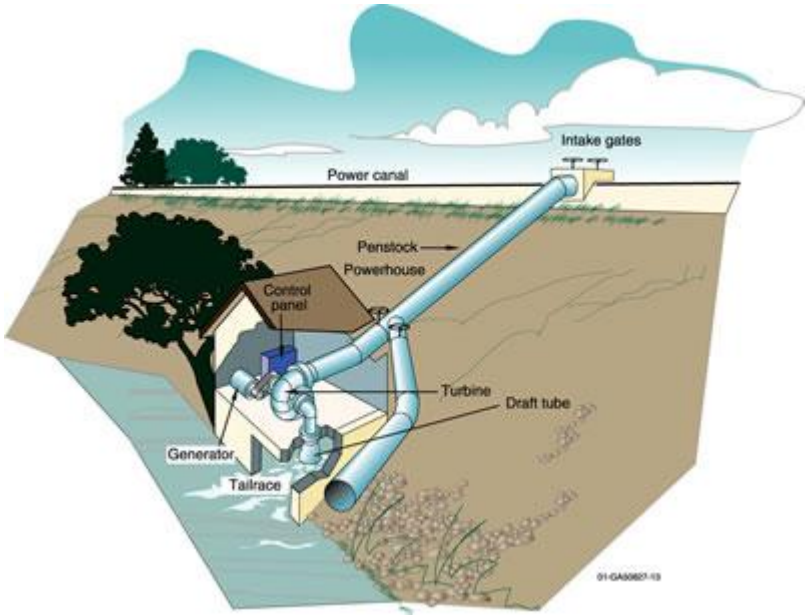


Dams create quiet lakes where delicate silica-loving diatoms (micro-organisms which are pictured above) can grow. This takes silica out of the river. When water reaches the ocean, there is little silica left for diatoms in the ocean. Without silica, the diatoms do not bloom and harmful algal blooms take their place.

Dam Sizes

Since large dams satisfy our need for hydroelectricity but can have a severe impact on the environment. Smaller dams—also called micro hydropower plants—are a modern compromise. While these very small facilities do not impact the environment as much, they also do not generate as much electricity as major dams, and need to be deployed locally in backyards, small municipal locations, and other places where the electricity is needed.

This is Three Gorges Dam in China. It is the world's largest power station for hydroelectric energy. Large dams yield at least 30 MW. The installed capacity of Three Gorges is 22,500 MW. It supplies electricity to the grid, approximately 3% of China's total electricity.



This is a design for a micro hydropower plant. It would have a capacity of about 100 kW. That would be enough electricity for a single home or maybe a small village. This type of hydroelectric facility is very effective in developing nations.

Benefits and Challenges of Hydroelectric Energy

BENEFITS

Hydroelectric energy offers significant benefits, which include:

- Hydroelectric energy is clean; it does not pollute the water or air.
- Hydroelectric energy is a renewable energy source because it relies on water which is continually available since the water cycle is driven by the sun.
- Depending on the design of the hydroelectric facility, electricity can be generated continuously or on demand.
- Reservoirs created by dams can create lots of human recreational activities including boating, fishing, and swimming.
- Hydroelectric plants are a good long term economic investment. Some of today's plants were built 50 to 100 years ago.

CHALLENGES

There are challenges to using hydroelectric energy, which include:

- Water sources from hydroelectric energy are often far from the grid.
- Dams can impact fish populations because they impede fish from migrating upstream.
- Dams can harm native plants and animals that live in the area by changing the water's temperature and the river's flow, as well as the chemistry of the water downstream (e.g. diatom blooms).
- Droughts can impede hydropower facilities from functioning well.
- When a new dam is constructed, people living in the sited reservoir area need to relocate.
- If a dam fails, the results can be catastrophic.

FINAL THOUGHT: While dams have a great many beneficial uses, there are some disadvantages that must be considered which are now preventing the construction of many new dams.