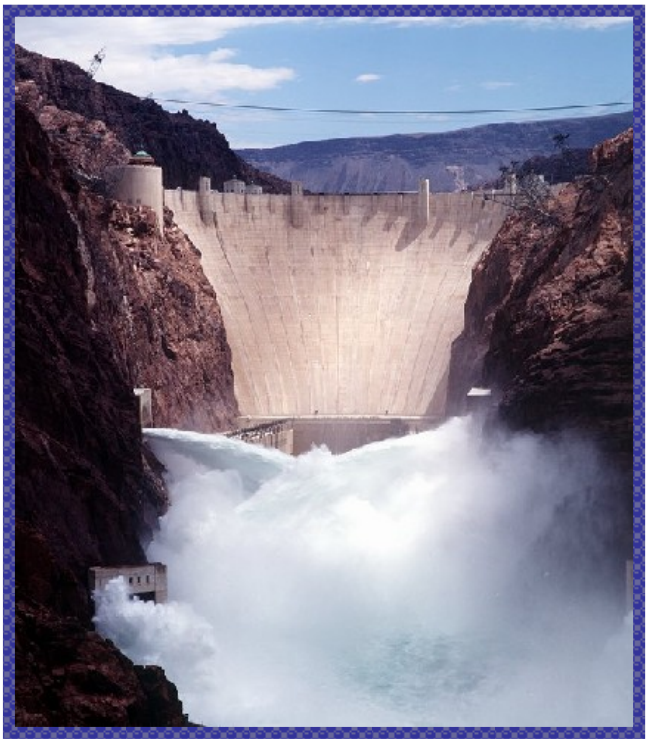
River-Generated Hydroelectric Power

As A Consumable Energy Resource



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Hydropower is a renewable resource. In fact, it is America's most utilized renewable resource. However, America only uses Hydropower to meet 10-12% of its energy needs. Around the world, hydropower only accounts for approximately 20% of the electricity generated and used. [1] These are interesting figures considering the availability of this resource. The water is already there, constantly provided by nature though rain and glacier melt in the form of powerful flowing rivers. Looking at the Grand Canyon, the power and energy of moving water is an undeniable fact. All that is required is to channel or harness that energy, and use it to power a generator that produces electricity. Then, this same water continues down the river's path. Water does not have to be mined or burned. It does not release CO_2 or any other forms of harmful emissions into the air. Why then is this resource not utilized more? To answer this question, it is necessary to look at the benefits, drawbacks, availability, ease of use, and the costs associated with hydropower.

So what exactly is hydroelectric power and how does it work? The force of moving water is used to produce electricity. Three things determine the amount of force exerted by the water; the available flow, speed of the flow, and also how high the water is before it falls. Ideally, it is preferable to build a dam and have a hydropower plant in a location where the water falls from a great height (for example, an existing water fall). This will produce the most electricity with the least effort.

At a hydroelectric plant, river water is released from a dam and travels down through a penstock to the turbines. The force of the water on the blades rotates the turbines. These turbines power generators which produce electricity. Voltage can be increased by sending the electricity through a transformer before it travels via power lines to homes, factories, or businesses, etc. (see Fig. 1).

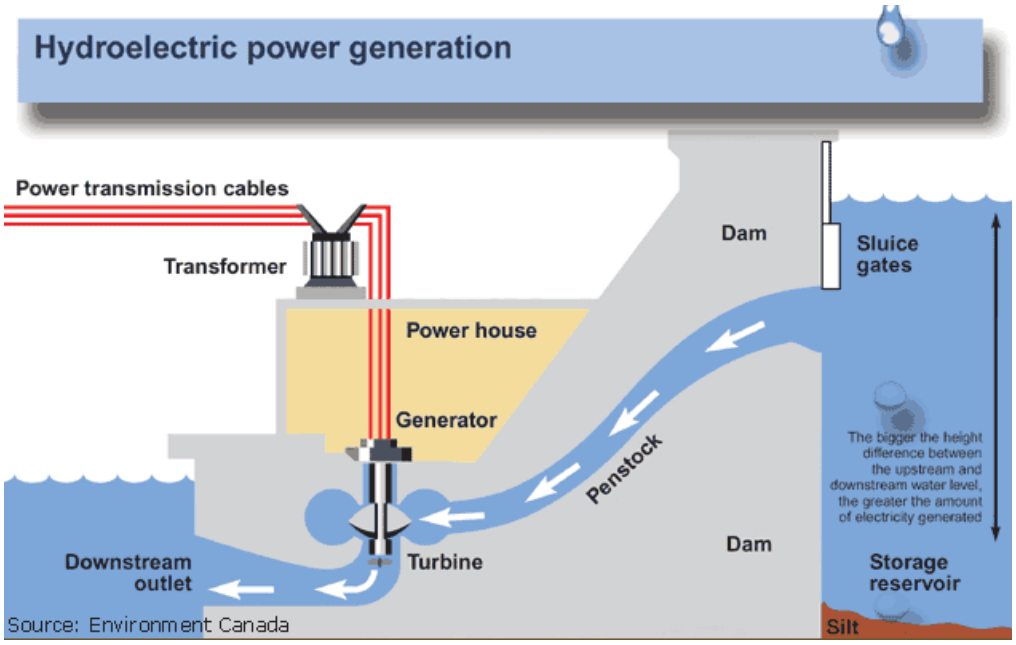


Fig. 1 *Source*: USGS: Water Science for Schools. http://ga.water.usgs.gov/edu/wuhy.html

There are different types of hydropower plants. Impoundments use dams to create reservoirs (as described in the previous paragraph). Water is released for the production of electricity or for the maintenance of water levels. A run-of-river, or diversion type plant doesn't necessarily make use of a dam. The natural flow and course of the river is used. Portions of the river flow may be diverted through a penstock to power a generator, and then flow back into the river below. A third type of facility is called a pumped storage facility. Sometimes, the demand for electricity is low. At a pumped storage facility water is pumped from a lower

reservoir to a higher reservoir during a period of low demand. Later, if the demand is high, the demand can be met quickly by releasing this stored water. A micro hydropower plant works on a small scale and is best suited for personal residences/businesses, farms, and small towns or villages (especially those that are remote). They do not require the use of dams and with turbines as small in diameter as four inches, result in the least amount of environmental impacts. [2]

Hydropower is used in many parts of the world from places as varied as New Zealand, England, Pakistan, and Nepal. Canada is the top producer in the world with 70+% of their electricity coming from hydroelectric power. The United States is second, with 10-12% of its energy needs satisfied through hydropower. (*This amount may seem deceiving, but it really is not when considering the fact that the total demand for energy is greater than most smaller/less populated countries)*. China ranks third.[3] Brazil, and Russia are the next top hydroelectric power producers followed by Norway, Japan, India, Sweden, and France. Norway and Austria produce over half of their needed electricity through hydropower plants.[4]

Several factors affect whether or not a society may or may not use hydropower. Geographically, there must be a river; and to efficiently generate power, a drop in elevation along that river is also needed. This is the scenario around the world. You will not find many hydroelectric plants in areas with flatter, constant elevations. This holds true within the United States as well. While the

Northwest produces much of the nation's hydropower, hydroelectric plants are few and far between in areas like Kansas, Florida, Indiana, and even New Jersey.

Another factor is money. Ever hear the phrase "it takes money to make money"? Well think of it as "it takes money to save money". On a large scale, hydroelectric power is a wonderfully cost efficient source of electricity – once it's been put in place. The building of a large dam and hydroelectric plant takes a lot of time, and a great deal of money. Some smaller, poorer countries cannot afford to build them, and attempt to seek out private funding; if they can find an interested party.

One other obstacle in the United States is the licensing process. This also requires a great deal of money and time. It can take up to 10 years to acquire a new license for hydropower plants but as little as 18 months for a natural gas plant.[5]

In the Northwest, hydropower is the premier power source providing electricity (and heating/cooling) to homes and businesses. This is the case in many other places as well. Globally, hydropower plants have also been built to power nearby factories that require large amounts of power; for example to manufacture aluminum.

There are many positive aspects to the use of hydroelectric power. One of the wonderful things about hydroelectric power is that it is a renewable resource. That is, unless we stop receiving rain or the glaciers stop melting, it doesn't look as if the supply will run out. Once set up, the process of producing power via

hydroelectricity is cost effective. It can almost *instantly* meet the changes in demand. While dams have their drawbacks, they do provide storage for rainwater, flood control, new habitats for some species, and opportunity for recreational activities. Then there is the biggest "pro" to this kind of power generation- *there is no pollution associated with the generating of hydropower.*

There are however, drawbacks to using hydroelectric power that are more associated with impoundment types of facilities where the use of large dams are needed.

In the United States, only 3% of the dams in existence also have hydroelectric capabilities. It seems unfair then, to blame the production of hydroelectric power for all the negative environmental effects. Many of the major drawbacks are associated with the building of dams, (which might only be used to control water levels and for irrigation), but is compounded by the addition of a hydroelectric power plant. [6]

When a dam is built on a river, the ecosystem is changed. Large areas of land are flooded, resulting in a large lake, or reservoir. This large body of water takes the place of what was once dry land and a fast flowing river. The rate at which the water flows is reduced. This slow moving water absorbs heat from the sun, becoming warmer. The colder water sinks because it is denser. This is called stratification. The colder water also has less oxygen. When this water is released through the dam from the bottom of the reservoir, it only makes sense that the

water flowing downstream of the dam will have a reduced oxygen content. This can result in habitat changes.

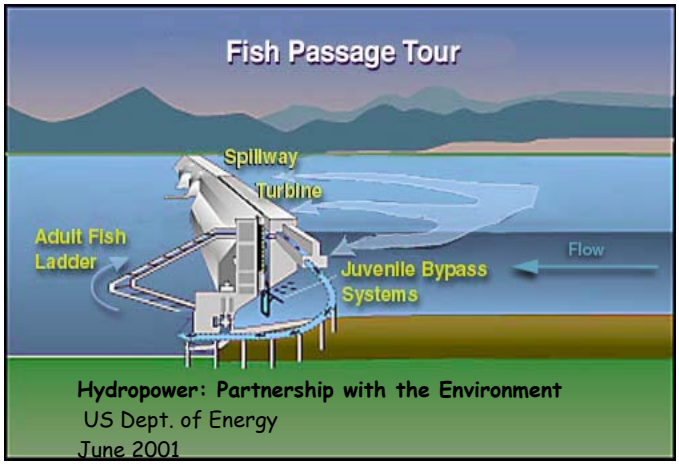
When water spills over a dam, air can become trapped along with the water as it falls to the surface. The air, mostly nitrogen, mixes with the water, increasing the nitrogen levels. This is called supersaturation. Supersaturated water is not good for the fish and can even cause death. The nitrogen absorbs into the tissues and when the fish swim to an area that is not supersaturated they can experience something similar to what scuba divers would call "the bends".[7]

When a dam is built, the shoreline, or riparian area, is covered by water. The habitat changes from the level of the water to the types of vegetation found along the shoreline. Some species are forced to search out new places to live while additional species will be attracted to the changed environment. For example, ducks, geese, and heron thrive on reservoirs.

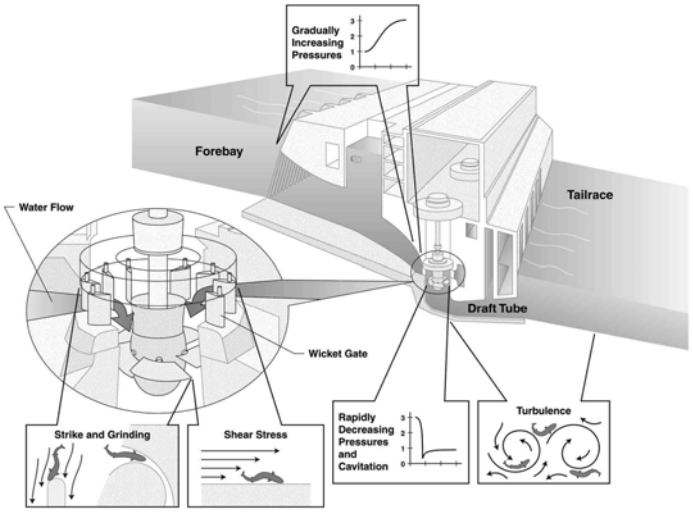
Sedimentation can also be a problem. The dam is a barrier and sediment will build up behind it. The habitat downstream can be negatively affected by a lack of nutrients it would normally receive from "traveling" sediment. Also, in places where sediment builds up, oxygen depletion is possible because at first, more fish, etc, will be attracted to this nutrient rich area. More organisms per area deplete the oxygen supply more quickly.

Erosion can occur with changing water levels and lack of shoreline vegetation. The water begins to carve into the shoreline, again changing the habitat and also adding to sedimentation.

One of the biggest drawbacks, especially in the Northwest, is how damming affects fish like salmon, who are born in smaller tributaries and must travel to the ocean as juveniles and then travel back again as adults in order to spawn. Dams make their journey much more difficult and hazardous – in both directions. The result has been a decline in salmon population. In addition to dangers that have already been mentioned concerning fish, the hydropower plant itself poses additional dangers. Salmon can become disoriented, injured, or die while passing through the plant and coming into contact with the turbines. When injured or disoriented, they are more susceptible to predators. Although dams utilize fish ladders, fish elevators, screens, hatcheries, and other tactics to lessen the effects on fish populations, the reported results are open to interpretation.



Hydropower: Partnership with the Environment
US Dept. of Energy
June 2001



Prime examples of negatively effected habitats and declines in salmon runs are the result of Washington State's Elwha and Gilnes Canyon Dams. This ecosystem has deteriorated so greatly that the removal of both dams is scheduled to begin in 2008. [8]

However, positive changes are being made. The Tennessee Valley Authority uses (porous hose) line diffusers (at the bottom of the dam), and aerating weirs (where spillover occurs), to add oxygen to the water. Also, new technology is being researched and tested to create turbines that are more efficient and pose less harm to fish that pass through them, increasing the chance of fish survival. These newer turbines are expected to reduce fish mortality caused by the pressure changes, stress, turbulence, strike, and the grinding fish typically experience when they pass thorough a turbine system. The goal is to replace aging turbines with these more efficient "fish-friendly" turbines.

What are other ideas for the future? Run-of-river and micro hydropower do not affect the surrounding ecosystem as negatively. Some areas are looking into more of these smaller, "dam-less" ways to produce hydroelectric power. Each would supply a smaller area, but still be cost effective while expecting a reduced impact on the environment. How much of our energy needs could be satisfied this way? What would be the impact on the environment if a great number of run of river and

micro hydropower producing plants began to be used? These are questions that still need to be answered.

It is apparent that the hydroelectric plants with the ability to produce the most power with the least cost (after initial set up), pose the greatest threat to our precious ecosystems. Each ecosystem is unique and the effects in each ecosystem need to be looked at individually. For smaller communities, micro hydropower may be one option, but what about larger cities. Are the improvements being tested going to show, over time, the results hoped for? All these factors need to be weighed along side other forms of energy that also do not have polluting by-products as we search for the best solution to our future energy demands.

Notes

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2. US Dept. of Energy. Hydropower: Partnership with the Environment. June 2001. http://hydropower.inel.gov/hydrofacts/pdfs/01-ga50627-01-brochure.pdf

3. British Hydropower Association MMII. 10 things you should know. n.d. http://www.british-hydro.org/infopage.asp?infoid=183

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8. Elwha River Restoration. Questions and Answers. 2000. http://www.nps.gov/olym/elwha/feedback.htm\

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