Sustainability White Paper #37
Energy - Hydopower
John May, 2008

Some Basics of Hydroelectric Power

Hydroelectric power comes from fast-flowing or falling water. The water turns turbines that turn generators that create electricity. The only waterfall in the U.S. with sufficient flow and height to support a traditional large generating station is Niagara Falls.[i] Otherwise, hydroelectric stations are built at dams, where the reservoir impounded by the dam creates the desired head. Often, such reservoirs are multipurpose, also serving as recreational facilities and sources for water.

The more water flowing through the turbines, the more power generated. The more speed with which it flows, the more power generated. The farther and more steeply water falls, the higher its speed. You can see where this is going: tall dams on large rivers generate the most power.[ii] Hoover Dam generates enough electricity to supply 1.3 million people because it has a head (the distance the water falls) of 530 ft.[iii] The Grand Coulee Dam, with a smaller, but still considerable head of 330 ft., generates roughly three times as much power because the flow of the Columbia River is so much larger than the Colorado.[iv]

In 2006, world consumption of hydroelectric power was 688.1 MTOE,[v] which was roughly 6% of world energy use. U.S. consumption was 65.8 MTOE, which was roughly 3% of U.S. energy use.[vi] Statistics for the most recent years in Missouri are not yet available, but in 2004, we consumed about 350,000 MTOE of hydroelectric energy, less than 1% of our total energy use.[vii] The fraction of electricity generated by hydroelectric used to be larger, but there has been a proliferation of coal and nuclear power plants since WW-II. (One reason why climate change has become such an issue.)

Some generating stations are built to channel the stream through the power plant without creating a large reservoir. This design is called *run of the river*. The flow of most rivers fluctuates according to how much snow and rain fall. Large reservoirs can be used to even-out those flows, but run of the river plants cannot. The amount of power generated by such a plant fluctuates with the flow of the river.[viii] Some large run of the river plants are members of multiple dam systems, and the flow of the river is controlled by upstream reservoirs. The Chief Joseph Dam, downstream from the Grand Coulee Dam in Washington, is an example.[ix]

In the U.S., most of the obvious sites for traditional large hydroelectric projects have already been developed. Today, new hydroelectric plants tend to be smaller run of the river plants, located on smaller streams with lower heads.[x]

Hydroelectric generating plants have focused on rivers where large heads could be attained because more power could be generated, making the cost of building the plant more economical. But schemes involving low-head dams (like the dams on the Mississippi) are also possible. In addition, it may prove possible to harness the power of rivers or tidal flows without dams, or to harness the power in ocean waves. The energy contained in ocean tidal flows and ocean waves is very large, and if they could be harnessed economically, the amount of power generated would be significant. These possibilities will be discussed in a separate white paper.

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[i] *World's largest waterfalls*. World Waterfall Database. Retrieved 12/10/2007 at http://www.world-waterfalls.com/database.php?s=N&t=W&orderby=avevolume&sortLimit=5000. There is also a generating station on the Willamette River in Oregon. But because the flow and head of this water fall are about 1/3 and 1/8 of Niagara Falls, it produces roughly 1% of the electricity.

[ii] See *Hydropower,* Wikipedia, http://en.wikipedia.org/wiki/Hydropower, for equations describing the physics of the relationship.

[iii] *Frequently asked questions: Power*. Hoover Dam website, Bureau of Reclamation. Retrieved 12/10/2007 at http://www.usbr.gov/lc/hooverdam/faqs/powerfaq.html.

[iv] *Grand Coulee powerplant*. Bureau of Reclamation. Retrieved 12/10/2007 at http://www.usbr.gov/power/data/sites/grandcou/grandcou.html.

[v] MTOE means million metric tons of oil equivalent. It is the amount of energy released by burning one million metric tons of oil. A metric ton is about 2,204 lbs.

[vi] *BP Statistical Review of Energy, 2007*. British Petroleum. Available online at http://www.bp.com/statisticalreview.

[vii] *Table S1. Energy consumption estimates by source and end-use sector, 2004*. Energy Information Administration. Retrieved 11/6/2007 at http://www.eia.doe.gov/emeu/states/_seds.html.

[viii] For an article on run of the river generating stations, see *Run of the river hydroelectricity*. Wikipedia. Retrieved online 12/10/2007 at http:// http://en.wikipedia.org/wiki/Run-of-the-river_hydroelectricity.

[ix] *Hydropower*. Chief Joseph Dam, U.S. Army Corps of Engineers. Retrieved online 12/10/2007 at http://www.nws.usace.army.mil/PublicMenu/Menu.cfm?sitename=cjdam&pagename=hydropower.

[x] For some examples of small run of the river generating plants, see http://www.canhydro.com/powerplants_hydro.htm.