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Hydro power: Those Damn Dams

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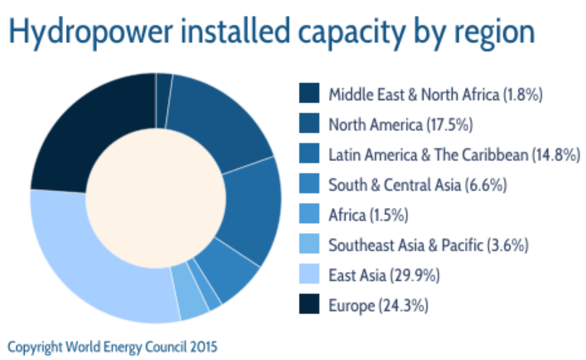
HYDRO POWER: THOSE DAMN DAMS

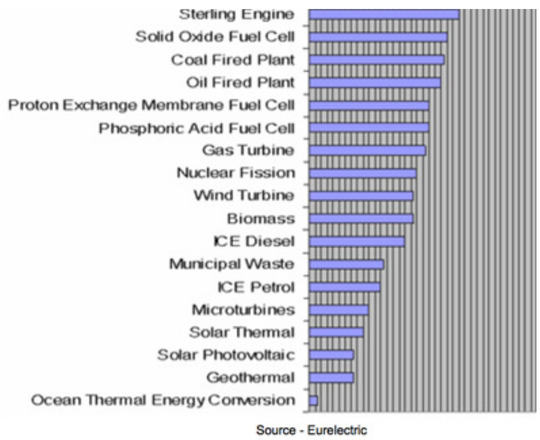
Niagara Falls, site of the world's first hydropower plant.

Ogintz, Eileen. "In Niagara Falls, Family Travel Writers Agree: Passport is a Must to Teach Kids the World." Huffington Post Blog. 26 Sep 2013.

Step aside, fossil fuels. Hydropower has indisputably been the prominent driver behind humanity's technological and societal development, Hydropower has continuously proved to be a tried and tested renewable energy source, generating the vast majority of electricity from water-based technologies. The power of moving water lights up entire cities, and its global significance will only increase as we move closer to what is regarded as the world's total hydro resource of 40,000 terawatt hours per year (TWh y-1)[1], or a third of the global energy production (in 2004, EIA 2006[2]). Hydropower utilizes this dynamic force of nature to be the most consistent of all the renewable energy sources, producing 19% of the world's electricity. As of 2007, only 21% of the fully capacity (some 7200 TWh y-1) is in operation in more than 150 countries.[3] As the leading source of renewable energy, hydropower provides 77% of all electricity generated by renewable sources worldwide,[4] accounting for 70% of produced electricity in the northwestern United States and a staggering 99% in Norway.[5]



Ultimately, hydropower is a second-hand result of solar energy— it is a product of the natural hydrologic cycle of evaporated water from lakes and oceans redeposited as rain or snow at high elevation. By channeling the gravity driven water through turbines, hydropower plants efficiently extract energy, without any wasteful heat transfer. They convert as much as 95% of available energy into electricity, a rate that compares impressively to the dismal 45% efficiency of the best fossil fuel plants[6,7] or Solar Photovoltaic's 15%.



TYPES OF FACILITIES

Currently, there are 3 ways to extract energy from our Earth's watery resources. The most common type of hydroelectric power plant is the impoundment facility, in which power is obtained by converting the stored potential energy contained by a dam. The dam releases water from the reservoir, through the turbines, according to electricity needs.[8] While impoundment facilities require the use of a dam, a diversion or run-of-river hydropower plant extracts a portion of the total kinetic energy contained by the flowing water itself by channeling a portion of a river through a canal or penstock.[9] Of the ten largest hydropower projects in the world, all are impoundment dams except the Niagara Falls hydropower plant, which boasts a diversion facility.[10]

The third type of hydropower, referred to as pumped storage, works similar to a battery. Water from a lower reservoir is pumped uphill to a reservoir at a higher elevation as a way to store the electricity generated by other power sources such as solar, wind, and nuclear for later use.[11] During periods of high electrical demand, the water drives a turbine as it is released back to the lower reservoir. As a result, a complete shift to renewable energy is viable if hydropower is used in tandem to supplement the more variable renewable energy sources such as solar and wind. Unfortunately, this technology, which guarantees between a 70% to 80% efficiency, requires the proximity of a preexisting mountain and a large source

1. Ramage, Janet. "Hydroelectricity." Renewable Energy: Power for a Sustainable Future. Ed. Godfrey Boyle. 3rd ed. Oxford: Oxford UP, 2012. 185-235. Print. pg 190

2. Odendahl, Sandra. "Our Clean Energy Present." Listed. 18 Sept. 2012.

3. Tester, Jefferson W., Elisabeth M. Drake, Michael J. Driscoll, Michael W. Golay, and William A. Peters. "Hydropower." Sustainable Energy: Choosing Among Options. 2nd ed. Cambridge: MIT, 2012. 619-41. Print. pg 620

4. 2012 International Energy Statistics, Energy Information Administration. Web. http://www.eia.gov/cfapps/ipdbproject/IEDIndex3.?tid=2&pid=2&aid=12

5. Odendahl, Sandra. "Our Clean Energy Present." Listed. 18 Sept. 2012.

6. "Hydroelectric Power." Alternative Energy Solutions for the 21st Century. Web.

7. Ramage, pg 197

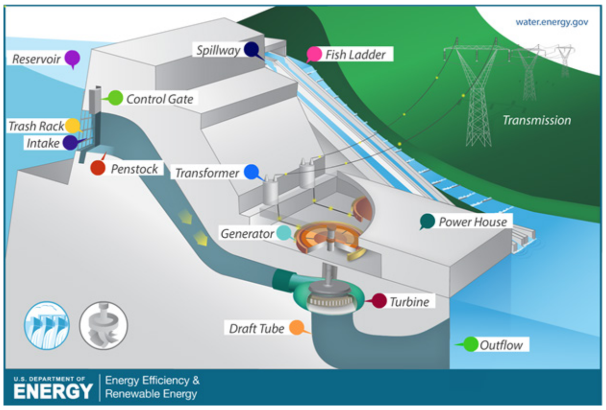
8. "Types of Hydropower Plants." Energy.gov. U.S. Department of Energy: Office of Energy Efficiency and Renewable Energy.

9. Tester, pg 620

10. Tester, pg 621

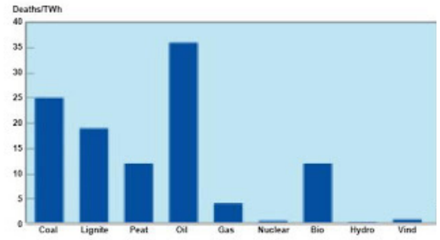
11. Tester, pg 620

of water, which occurs rarely in the deserts where solar farms are located.

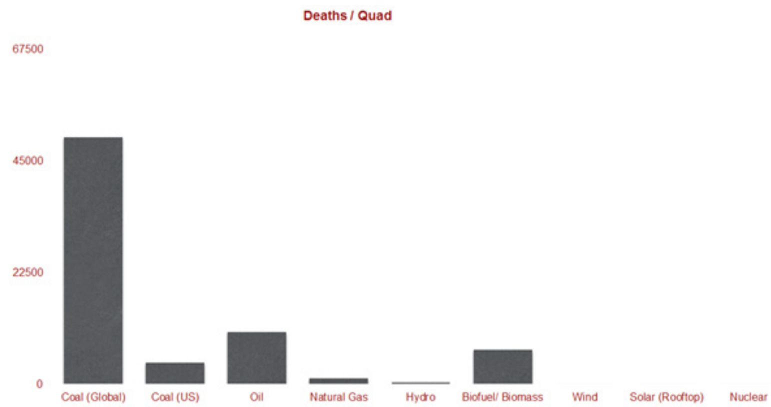


Despite the common association between hydroelectric plants and a smaller environmental footprint, the ecological issues surrounding hydroelectricity are significant. From an economic standpoint, although upfront capital costs of hydropower infrastructure are high, facilities have an average lifetime of 50 to 100 years. These long-term investments benefit multiple generations, can be easily upgraded to incorporate novel technologies, and have very low operating and maintenance costs ($500 to $3500 per kW).[12] However, as a result of the anaerobic decay of vegetable matter brought under water, reservoirs release more methane than natural water bodies. Despite this, greenhouse gas forcing of hydropower is approximately 40 times less, in CO_2 equivalents, than coal-fired power plants.[15]

Collapses do happen, such as the 1975 Banqiao incident in which ~171,000 people died and 11 million people lost their homes, but hydroelectricity has historically compared very well with other types of power plants in terms of serious damage due to plant failures.[16] Hydropower provides 15% of the world's electricity, yet causes less than 0.8% of total deaths that result from burning coal, which accounts for roughly 50% of the world's electricity.[17] Over-dependence on hydropower can also cause problems when rainfall patterns change for an extended period (e.g. El Niño). In 2010, Venezuela suffered rolling blackouts as several years of low rainfall depleted the Guri reservoir which powered their major hydropower plant.[18] Aquatic hypoxia, interference with fresh water fish migration patterns, and the accumulation of silt that deprives the soil downstream of vital nutrients are consequences related to interventions in nature due to the damming of water, changed water flow, and the construction of roads and power lines, which affect the complex interaction between numerous physical and biological factors.[19]



Currently, further development of hydropower resources is limited in many countries by available capital for construction of dams and turbine-generator stations and by environmental concerns. Since we have already developed all of the most attractive hydropower reserves, each subsequent plant would be less cost effective and more environmentally disruptive. For example, the MeKong river is tempting from a power perspective, but implementing a hydropower plant there would likely wipe out a species of dolphin among other massive social impacts.[20] Further damming of other rivers, such as the Schuylkill and Delaware, is possible, but the costs would far outweigh the marginal benefits. All in all, if operated in a socially responsible manner, hydropower still represents the best concept of sustainable development for the needs of now and the future generations.



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12. International Renewable Energy Agency. Renewable Energy Technologies: Cost Analysis Series. Volume 1: Power Sector. Issue 3 of 5. Hydropower. June 2012.

13. Ramage, pg 219

14. "10 Reasons for Promoting Hydroelectricity." ITAIPU BINACIONAL.

15. Tester, pg 635

16. Ramage, pg 221

17. Conca, James. "How Deadly Is Your Kilowatt? We Rank The Killer Energy Sources." Forbes/Energy. 10 Jun 2012.

18. United States. Department of Commerce. U.S. Commercial Service. IMI: Electric Power Crisis in Venezuela. Feb. 2010. Web.

19. Førsund, Finn R. Hydropower Economics: An Overview.

20. Tester, pg 622