Hydroelectric Power

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Sunday, 26 August 2007
Last Updated Sunday, 26 August 2007

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Hydroelectric dam in cross section

The upper reservoir and dam of the Ffestiniog Pumped-Storage Scheme in north Wales.The power station at the lower reservoir has four water turbines which can generate 360 megawatts of electricity within 60 seconds of the need arising. The water of the upper reservoir (Llyn Stylan) can just be glimpsed on the right.

Hydroelectricity is electricity obtained from hydropower. Most hydroelectric power comes from the potential energy of dammed water driving a water turbine and generator. Less common variations make use of water's kinetic energy or undammed sources such as tidal power. Hydroelectricity is a renewable energy source.

The energy extracted from water depends not only on the volume but on the difference in height between the source and the water's outflow. This height difference is called the head. The amount of potential energy in water is directly proportional to the head. For this reason, it is advantageous to build dams as high as possible to produce the maximum electrical energy.

While many hydroelectric schemes supply public electricity networks, some projects were created for private commercial purposes. For example, aluminium processing requires substantial amounts of electricity, and in Britain's Scottish Highlands there are examples at Kinlochleven and Lochaber, designed and constructed during the early years of the 20th century. Similarly, the 'van Blommestein' lake, dam and power station were constructed in Suriname to provide electricity for the Alcoa aluminium industry.

In most parts of Canada (the provinces of British Columbia, Manitoba, Ontario, Quebec and Newfoundland and Labrador) hydroelectricity is used so extensively that the word "hydro" is used to refer to any electricity delivered by a power utility. The government-run power utilities in these provinces are called BC Hydro, Manitoba Hydro, Hydro One (formerly "Ontario Hydro"), Hydro-Québec and Newfoundland and Labrador Hydro respectively. Hydro-Québec is the world's largest hydroelectric generating company, with a total installed capacity (2005) of 31,512 MW Contents

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Importance

Hydroelectric power, using the kinetic, or movement energy of rivers, now supplies 20% of world electricity. Norway produces virtually all of its electricity from hydro, while Iceland produces 83% of its requirements (2004), Austria produces 67 % of all electricity generated in the country from hydro (over 70 % of its requirements). Canada is the world's largest producer of hydro power and produces over 70% of its electricity from hydroelectric sources.

Apart from a few countries with an abundance of it, hydro capacity is normally applied to peak-load demand, because it can be readily stored during off-peak hours (in fact, pumped-storage hydroelectric reservoirs are sometimes used to store electricity produced by thermal plants for use during peak hours). It is not a major option for the future in the developed countries because most major sites in these countries having potential for harnessing gravity in this way are either being exploited already or are unavailable for other reasons such as environmental considerations. [edit]

Advantages and disadvantages

The chief advantage of hydro systems is elimination of the cost of fuel. Hydroelectric plants are immune to price increases for fossil fuels such as oil, natural gas or coal, and do not require imported fuel. Hydroelectric plants tend to have longer lives than fuel-fired generation, with some plants now in service having been built 50 to 100 years ago. Labor cost also tends to be low since plants are generally heavily automated and have few personnel on site during normal operation.

Hydroelectric plants generally have small to negligible emissions of carbon dioxide and methane due to reservoir emissions, and emit no sulfur dioxide, nitrogen oxides, dust, or other pollutants associated with combustion. Since the generating units can be started and stopped quickly, they can follow system loads efficiently, and may be able to reshape water flows to more closely match daily and seasonal system energy demands. Hydroelectric plants with reliable hydrological histories are dispatchable and can be considered firm capacity. Consequently, in normal water years hydroelectric plants designed for a firm load will have a useful amount of surplus energy that may be exportable if transmission is available.

Pumped storage plants currently provide the most significant means of storage of energy on a scale useful for a utility, allowing low-value generation in off-peak times (which occurs because fossil-fuel plants cannot be entirely shut down on a daily basis) to be used to store water that can be released during high load daily peaks. Operation of pumped-storage plants improves the daily load factor of the generation system.

Reservoirs created by hydroelectric schemes often provide excellent leisure facilities for water sports, and become tourist attractions in themselves. Multi-use dams installed for irrigation, flood control, or recreation, may have a hydroelectric plant added with relatively low construction cost, providing a useful revenue stream to offset the cost of dam operation.

In practice, the utilization of stored water is sometimes complicated by demand for irrigation which may occur out of phase with peak electricity demand. Times of drought can cause severe problems, since water replenishment rates may not keep up with desired usage rates. Minimum discharge requirements represent an efficiency loss for the station if it is uneconomic to install a small turbine unit for that flow.

Concerns have been raised by environmentalists that large hydroelectric projects might be disruptive to surrounding aquatic ecosystems. For instance, studies have shown that dams along the Atlantic and Pacific coasts of North America have reduced salmon populations by preventing access to spawning grounds upstream, even though most dams in salmon habitat have fish ladders installed. Salmon smolt are also harmed on their migration to sea when they must pass through turbines. This has led to some areas barging smolt downstream during parts of the year. Turbine and power-plant designs that are easier on aquatic life are an active area of research.

Generation of hydroelectric power can also have an impact on the downstream river environment. First, water exiting a turbine usually contains very little suspended sediment, which can lead to scouring of river beds and loss of riverbanks. Second, since turbines are often opened intermittently, rapid or even daily fluctuations in river flow are observed. In the Grand Canyon, the daily cyclic flow variation caused by Glen Canyon Dam was found to be contributing to erosion of sand bars. Dissolved oxygen content of the water may change from preceding conditions. Finally, water exiting from turbines is typically much colder than the pre-dam water, which can change aquatic faunal populations, including endangered species.

The reservoirs of hydroelectric power plants in tropical regions may produce substantial amounts of methane and carbon dioxide. This is due to plant material in newly flooded and re-flooded areas being inundated with water, decaying in an anaerobic environment, and forming methane, a very potent greenhouse gas. The methane is released into the atmosphere once the water is discharged from the dam and turns the turbines. According to the World Commission on Dams report, where the reservoir is large compared to the generating capacity (less than 100 watts per square metre of surface area) and no clearing of the forests in the area was undertaken prior to impoundment of the reservoir, greenhouse gas emissions from the reservoir may be higher than those of a conventional oil-fired thermal generation plant [1]. In boreal reservoirs of Canada and Northern Europe, however, greenhouse gas emissions are typically only 2 to 8 percent of any kind of conventional thermal generation.

Another disadvantage of hydroelectric dams is the need to relocate the people living where the reservoirs are planned. In many cases, no amount of compensation can replace ancestral and cultural attachments to places that have spiritual value to the displaced population. Additionally, historically and culturally important sites can be lost, such as the Three Gorges Dam project in China, the Clyde Dam in New Zealand and the Ilisu Dam in Southeastern Turkey.

Some hydroelectric projects also utilize canals, typically to divert a river at a shallower gradient to increase the head of the scheme. In some cases, the entire river may be diverted leaving a dry riverbed. Examples include the Tekapo and Pukaki Rivers. [edit]

Hydro-electric facts [edit]

Oldest

- Cragside, Rothbury, England completed 1870, Water commercial service at Minneapolis.
- Duck Reach, Launceston, Tasmania. Completed 1895. The first publicly-owned hydro-electric plant in the Southern Hemisphere. Supplied power to the city of Launceston for street lighting.
- Decew Falls 1, St. Catharines, Ontario, Canada completed 25 August 1898. Owned by Ontario Power Generation. Four units are still operational. Recognised as an IEEE Milestone in Electrical Engineering & Computing by the IEEE Executive Committee in 2002. [edit]

Largest hydro-electric power stations

Itaipu Dam

The La Grande Complex in Quebec, Canada, is the world's largest hydroelectric generating system. The eight generating stations of the complex have a total generating capacity of 16,021 MW. The Robert Bourassa station alone has a capacity of 5,616 MW. A nineth station (Eastmain-1) is currently under construction and will add 480 MW to the total. An additional project on the Rupert River, currently undergoing environmental assessments, would add two stations with a combined capacity of 888 MW. [edit]

Fully operational

Name	Country	Completed	Max Generation	Annual Production
Itaipú	Brazil/Paraguay	1983	12,600 MW	93.4 TW-hours
Guri	Venezuela	1986	10,200 MW	46 TW-hours
Grand Coulee	United States	1942/1980	6,809 MW	22.6 TW-hours
Sayano Shushenskaya	Russia	1983	6,400 MW	
Robert-Bourassa	Canada	1981	5,616 MW	
Churchill Falls	Canada	1971	5,429 MW	35 TW-hours
Iron Gates	Romania/Serbia	1970	2,280 MW	11.3 TW-hours

These are ranked by maximum power. [edit]

In progress

- Three Gorges Dam, China, First power July 2003,Scheduled completion, 2009, 18,200 MW [edit]

Countries with the most hydro-electric capacity

- Canada, 341,312 GWh (66,954 MW installed)
- USA, 319,484 GWh (79,511 MW installed)
- Brazil, 285,603 GWh (57,517 MW installed)
- China, 204,300 GWh (65,000 MW installed)
- Russia, 173,500 GWh (44,700 MW installed)
- Norway, 121,824 GWh (27,528 MW installed)
- Japan, 84,500 GWh (27,229 MW installed)
- India, 82,237 GWh (22,083 MW installed)
- France, 77,500 GWh (25,335 MW installed)

These are 1999 figures and include pumped-storage hydroelectricity schemes. [edit]

References

- New Scientist report on greenhouse gas production by hydroelectric dams.
- International Water Power and Dam Construction Venezuela country profile
- International Water Power and Dam Construction Canada country profile
- Tremblay, Varfalvy, Roehm and Garneau. 2005. Greenhouse Gas Emissions - Fluxes and Processes, Springer, 732 p. [edit]

See also

Wikimedia Commons has media related to: Category:Hydroelectric_power

- Hydropower
- List of energy topics
- Wave power
- Tidal power
- List of reservoirs and dams
- Tennessee Valley Authority

- Small hydro
- Pumped-storage hydroelectricity
- Environmental concerns with electricity generation
- William George Armstrong, 1st Baron Armstrong an early private hydro-electric station [edit]

External links
- Hydroelectric power
- World Commission on Dams report on environmental and social effects of large dams, including discussion of greenhouse gas emissions
- Hydroelectricity - Water potential powered systems, focusing on non-impactive small hydro. (FreeEnergyNews.com)
- River Energy - river turbine systems, not dam. (FreeEnergyNews.com)

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