Water power

Contributed by: Theodore Baumeister

Publication year: 2020

Power developed from movement of masses of water. Such movement is of two kinds: (1) the falling of streams through the force of gravity (**Fig. 1**), and (2) the rising and falling of tides through lunar (and solar) gravitation. *See also:* EARTH'S GRAVITY FIELD; GRAVITY; TIDE.

While that part of solar energy expended to lift water vapor against gravity is a minute fraction of the total, the absolute amount of energy that is theoretically recoverable from resulting streams is an enormous but unknown quantity. Of this, but a tiny portion is actually suitable for harnessing.

Hydroelectric power

As the output from hydroelectric plants has grown, their contribution to the total electric power has dropped because steam-electric plants have grown at a much more rapid rate. Hydro plants, with their initial high cost and generally long distances from major load centers, must compete with the large fuel-fired stations and nuclear plants. Large dam sites usually must be justified not only on the value of the power developed, but also on the benefits from flood control, irrigation, and recreation. Problems of migrating fish, conservation, and preservation of esthetic values are also factors. On the other hand, water-power developments add greatly to power-system flexibility in meeting peak and emergency loads. Excavation and tunneling techniques have lowered construction costs. The economies of low-head [less than 20 m (66 ft)] sites are improved by axial-flow turbines of the tubular type. In addition, combining water power with floating solar power or land-based wind power may provide additional benefits of balancing out each other and reducing transmission costs by using a common substation and transmission system (**Fig. 2**). *See also:* DAM; ELECTRIC POWER GENERATION; ELECTRIC POWER SUBSTATION; ELECTRIC POWER TRANSMISSION; ENERGY SOURCES; HYDROELECTRIC GENERATOR; SOLAR ENERGY; WIND POWER.

Silting

The capacity of hydro plants cannot be counted on forever because of gradual filling of reservoirs with sediment. This effect is serious for irrigation, flood control, and navigation. Even when a lake behind a power dam becomes filled completely with silt, electric power can be generated on the run-of-the-river flow, although output would vary with stream flow. *See also:* RESERVOIR.

The rate of silting varies widely with drainage basins. Because the Columbia River carries comparatively little silt, the reservoirs at Grand Coulee and Bonneville dams should have lives of many hundreds of years. The Colorado

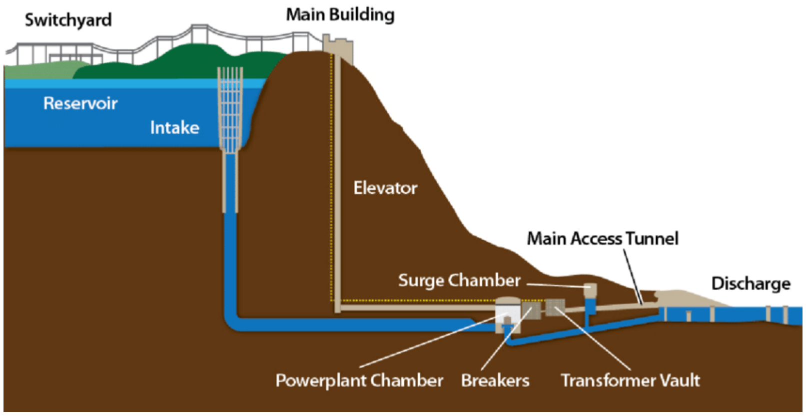

Fig. 1 **Pumped-storage hydroelectric plant. (U.S. National Renewable Energy Laboratory)**

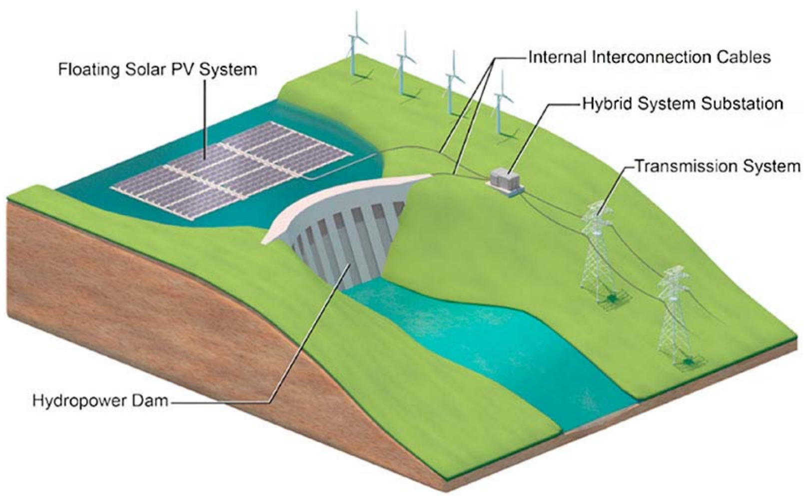

Fig. 2 **Hybrid systems of floating solar panels (or land-based wind turbines) and hydroelectric plants may potentially be able to produce a significant portion of the electricity generated worldwide. (U.S. National Renewable Energy Laboratory)**

River, on the other hand, is muddy. In the first 13.7 years after Hoover Dam went into operation in 1935, 175,600 hectare-meters (1424×10^6 acre-feet) of silt was dumped into Lake Mead. That is equivalent to a layer 1 m deep over 1756 km^2 (1 ft deep over 2225 mi^2). This inflow of silt has been diminished about 22% by the construction of other dams upstream, for example, the Glen Canyon Dam. It is expected that Lake Mead will have a useful life of more than 500 years.

Pumped storage

In pumped-storage hydroelectric systems, water is pumped from a stream or lake to a reservoir at a higher elevation (**Fig. 1**). Pumping up to a storage reservoir is most commonly done by reversing the hydraulic turbine and generator. The generator becomes a motor driving the turbine as a pump. Power is drawn from the power system at night or on weekends when demand is low. It is not practical to shut down large, high-temperature steam stations or nuclear units for a few hours at night or even over a weekend. Because they must run anyway, the cost of pumping power is low, whereas the power generated from pumped storage at peak periods is valuable. Also, the pumped-storage system provides a means of supplying power quickly in an emergency situation, for example, during the failure of a large steam or nuclear unit. A pumped-storage system can be changed over from pumping to generation in 2 to 5 min. *See also:* PUMPED STORAGE.

Tidal power

A portion of the kinetic energy of the rotation of the Earth appears as ocean tides. The mean tide of all the oceans has been calculated as 0.6 m (2 ft), and the mean power as 40 TW (5.4×10^{10} hp) or, on a yearly basis, the equivalent of 4×10^{19} joules (3.6×10^{3} kWh). However, only a minute amount of this is likely to be harnessed for use. For tidal sites to be of sufficient engineering interest, the fall would have to be at least 4.5 m (15 ft). There are few such falls, and some of these are in remote areas. The only tide-power sites that have received serious attention are on the Severn River in England, the Rance River, and Mont St. Michel in northern France, the San José and Deseado rivers of Argentina, the Petitocodiac and Memramcook estuaries in the Bay of Fundy, Canada, the Passamaquoddy River where Maine joins New Brunswick, Canada, and the Cambridge Gulf of Western Australia.

The Passamaquoddy site, which has a potential of 1800 MW (peak), is the only important tidal-power prospect in the United States. However, engineers do not consider its electrical output to be economically competitive with power that is produced by other means.

A second major handicap to tidal power is that, with a simple, single-basin installation, power is available only when there is a several-meter difference between levels in the sea and the basin. Thus, firm power is not available. Also, periods of generation occur in consonance with the tide—not necessarily when power is needed.

The only major tidal power plant in operation is the one near the mouth of the Rance River in Normandy, France. This plant operates on 12-m (40-ft) tides. It began operation in 1967. It consists of twenty-four 10-MW bulb-type turbine-generator units of novel design. The system embodies a reservoir into which seawater is pumped during off-peak hours. Turbines are then run as pumps, power being drawn from the French electrical grid. The plant produces 1.8×10^{15} J (5×10^{8} kWh) annually, including a significant amount of firm power.

Tidal power is an appealing and dramatic technique, and some other large plants may be constructed. However, the total contribution of the tides to the world's energy supply will be miniscule. *See also:* HYDROLOGY; TIDAL POWER.

Theodore Baumeister

Keywords

water power; hydropower; hydroelectricity; pumped storage; tidal power; renewable energy

Bibliography

J. Jurasz et al., Integrating a wind- and solar-powered hybrid to the power system by coupling it with a hydroelectric power station with pumping installation, *Energy*, 144:549–563, 2019
DOI: http://doi.org/10.1016/j.energy.2017.12.011

N. Lee et al., Hybrid floating solar photovoltaics-hydropower systems: Benefits and global assessment of technical potential, *Renew. Energy*, 162:1415–1427, 2020 **DOI: http://doi.org/10.1016/j.renene.2020.08.080**

A. Roberts et al., Current tidal power technologies and their suitability for applications in coastal and marine areas, *J. Ocean Eng. Mar. Energy*, 2:227–245, 2016 **DOI: http://doi.org/10.1007/s40722-016-0044-8**

Additional Readings

S. K. Sur, *A Practical Guide to Construction of Hydropower Facilities*, CRC Press, 2019

International Water Power and Dam Construction (magazine)

U.S. Geological Survey: Hydroelectric power water use