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Water Energy Profile: Riding the Waves

Dams are the most common way of generating energy from the flow of water. Now investors are trying to tap into the massive energy resources of ocean waves and tides.

Picture Gallery (click the image to start)

Ocean waves have an energy potential of up to 2,000 Gigawatts. See how hydropower can be used (Photo: Reuters)

Over 80 percent of all electricity produced by renewable sources is produced by large hydroelectric dams. With low carbon dioxide emissions and operating costs, hydropower is an important part of a climate-friendly energy mix. Mega projects with devastating impacts on the environment, like the Three Gorges Dam in China, have tainted the image of hydropower. More sustainable sources, such as wave and tidal power, could save the reputation of water-based energy production.

Worldwide Importance and Future Trends

Hydropower accounts for around 20 percent of the world's electricity generation, and a little over 2 percent of the world's total energy supply Although dams often have big environmental and social impacts, the World Wide Fund for Nature (WWF) estimates that another 370 Gigawatts (GW) of large, medium, or small hydroelectric capacity could be developed "without unacceptable impacts" by 2050.

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The 1-2 percent annual global growth rates for large hydropower is significantly slower than growth in other renewable sectors, such as wind (over 20 percent) and solar (over 30 percent). China aims to increase its hydropower capacity by 160 percent to 300 GW by 2020.

Along with hydropower, scientists are developing other ways of generating energy from the world's water resources, though none are yet significant producers of energy. There are still only a few large wave and tidal power projects - a total global capacity of 0.3 GW in 2005 - bu researchers see a much bigger potential if investment grows. Ocean thermal energy conversion, also still an experiment, would generate energy by utilizing the differences between surface and deep-sea ocean temperatures, particularly in tropical climates.

Global Resources and Producers

WWF estimates that the global "economically feasible" large hydropower capacity is around 2,270 GW, of which only around 740 GW are being utilized. With 115 GW of installed capacity, China is the world's largest producer of hydroelectricity, with the United States, Canada, Brazil, and Russia rounding out the top five. Brazil produces over 80 percent of its electricity from hydroelectric dams.

The World Energy Council calculates the global wave power resource at around 2,000 GW, or about an eighth of total global energy consumption. Although researchers admit that technology still has a long way to go, there are some ambitious projects in the works. One is a wave farm off the coast of Portugal that will use large tubes equipped with hydraulic systems to harness wave power. The project financiers hope to soon see several hundred of these "sea snakes" bobbing in the Atlantic, which could produce 500 MW of electricity.

Scientists are also experimenting with tidal power, which would harness the strong currents that push and pull the ocean tides. So far, the biggest tidal plant in the world is the 240 MW project in La Rance, France, though this will be exceeded by the 254 MW project in Sihwa, South Korea in 2009 and again by a planned 812 MW project in Incheon.

Hoover Dam (click on the image to enlarge)

Taken in 1941 by Ansel Adams, this picture shows the Hoover Dam, the world's biggest hydropower project between 1939 to 1949. World hydropower capacity could be increased significantly if old power plants would be modernized (Photo: United States National Archives)

Energy Output

Since most dams use gravity, a hydroelectric dam's energy output depends largely on the height difference between the reservoir water source and the outflow. Water flow along the rivers is another important factor, as is the age and efficiency of a dam. Many of the world's older dams will need to be upgraded or "repowered" in the coming decades to improve efficiency, which will be expensive but could ultimately add another 30 GW to the global energy mix.

Hydro projects range in size and output from the "micro" hydro projects of less than 100 kilowatts (kW) to China's Three Gorges Dam, the largest in the world, which will have a capacity of over 18 GW once all o its generators go into operation.

Environmental Impact and Drawbacks

Large hydroelectric dams have a number of negative impacts on the local environment and human society. Dams disrupt river ecosystems and migrations, killing aquatic life that gets caught in turbine blades. Dams also create artificial reservoirs, which floods farmland and forests, and displaces wildlife and people. Hydroelectric projects are also susceptible to fluctuations in river flows and rainfall. Ghana, which depends on energy from the Volta River Dam, has suffered severe energy shortages in recent years because of lack of rainfall.

Large dams and reservoirs in tropical regions are important sources of greenhouse gases. According to Brazil's National Institute for Space Research (INPE), each year the world's dams give off over 100 million metric tons of methane. INPE scientists are developing ways to produce energy by burning this methane.

Smaller, low-impact hydroelectric systems - often called "small hydro" - have been proposed as an alternative to large-scale projects. According to WWF, a realistic scenario for the next 50 years would be a 100 GW increase in so-called "small hydro" capacity. Wave and tidal technology deployed has shown little environmental impact so far, but the industry is still in its infancy.

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