

HYDROELECTRIC POWER GENERATION: LEVERAGING GRAVITY AND WATER FOR RENEWABLE ENERGY

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Dams transform the landscapes around us, repurposing rivers and supplying energy to countless households worldwide. These massive structures of civil engineering have existed since the dawn of civilization and are now essential in generating electricity on a global scale, accounting for 16% of the world's electricity output [1]. At first look, dams might seem like just large barriers preventing floods, but they, and especially hydroelectric power plants within them, leverage one of the most plentiful resources on Earth: gravity.

Hydroelectric facilities utilize the potential energy of water stored by dams, capturing the energy of water as it descends. This process involves turbine generators that convert the water's kinetic energy into mechanical one, which is then transformed into electrical energy with remarkable efficiency. Contemporary hydroelectric installations can convert the dam-stored water's energy into electricity with up to 95% efficiency, a significant contrast to the roughly 50% efficiency of top fossil fuel power plants [2]. Dams, together with their hydroelectric facilities, vary greatly in size and power output, ranging from small structures powering a handful of homes to giants like China's Three Gorges Dam that powers whole cities. Let's delve into how these power plants operate. Modern hydroelectric installations comprise two primary components:

1. A dam: Dams create a large reservoir of potential energy by collecting water at high altitudes. Besides generating energy, dams help manage water flow and store energy for future use;

2. A turbine: Acting much like a water-powered windmill, the turbine converts the dam-released water flow into mechanical energy. The moving water forces the turbine to spin, harnessing the kinetic energy of the water [1].

Understanding these elements highlights the ingenious use of nature's forces in producing clean, renewable energy through the strategic management of water resources facilitated by dams. Generators within hydroelectric plants capture the mechanical spinning motion from the turbines and transform it into electricity. The mechanism of action in these generators mirrors the functioning of generators in various contexts, not exclusive to hydropower scenarios. Subsequently, power transmission lines are tasked with delivering the generated electricity from the dam and its accompanying power plant directly to residential areas and other locations in need of energy. By proceeding with the discussion of a dam's energy-producing capabilities, several factors dictate the amount of electricity a dam can generate. These include the height of the water drop, the volume of water flowing, and the efficiency at which the turbines and generators operate. Key aspects to consider are that the greater the height from which the water falls, the more potential power it generates due to gravity's influence, accelerating at 9.81 meters per second squared. Consequently, a dam standing 100 feet tall would possess double the energy-generating potential of a 50-foot dam [2].

Moreover, the volume of water plummeting significantly affects a dam's ability to produce energy. While the height determines the potential power, the actual energy output hinges on the volume of water descending at that height. Unfortunately, the volume of incoming water, dictated by natural flow into the reservoir, is largely beyond human control. However, by regulating the flow towards turbines, dam and hydroelectric plant managers can somewhat influence electricity production rates, akin to charging and depleting a battery. Ultimately, the efficiency of the turbines and generators plays a crucial role.

References

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