

## Parts of a Hydroelectric Plant

Most conventional hydroelectric plants include four major components (see graph below):

**1. Dam.** Raises the water level of the river to create falling water. Also controls the flow of water. The reservoir that is formed is, in effect, stored energy.

**2. Turbine.** The force of falling water pushing against the turbine's blades causes the turbine to spin. A water turbine is much like a windmill, except the energy is provided by falling water instead of wind. The turbine converts the kinetic energy of falling water into mechanical energy.

**3. Generator.** Connected to the turbine by shafts and possibly gears so when the turbine spins it causes the generator to spin also. Converts the mechanical energy from the turbine into electric energy. Generators in hydropower plants work just like the generators in other types of power plants.

**4. Transmission lines.** Conduct electricity from the hydropower plant to homes and business.

## How Much Electricity Can a Hydroelectric Plant Make?

The amount of electricity a hydropower plant produces depends on two factors:

**1. How Far the Water Falls.** The farther the water falls, the more power it has. Generally, the distance that the water falls depends on the size of the dam. The higher the dam, the farther the water falls and the more power it has. Scientists would say that the power of falling water is "directly proportional" to the distance it falls. In other words, water falling twice as far has twice as much energy.

**2. Amount of Water Falling.** More water falling through the turbine will produce more power. The amount of water available depends on the amount of water flowing down the river. Bigger rivers have more flowing water and can produce more energy.

Power is also "directly proportional" to river flow. A river with twice the amount of flowing water as another river can produce twice as much energy.

Let's say that there is a small dam in your area that is not used to produce electricity. Maybe the dam is used to provide water to irrigate farmlands or maybe it was built to make a lake for recreation. As we explained above, you need to know two things:

**3. How far the water falls.** From talking to the person who operates the dam, we learn that the dam is 10 feet high, so the water falls 10 feet.

**4. Amount of water flowing in the river.** We contact the United States Geological Survey, the agency in the U.S. that measures river flow, and learn that the average amount of water flowing in our river is 500 cubic feet per second.

Now all we need to do is a little mathematics.

Engineers have found that we can calculate the power of a dam using the following formula:

$$\text{Power} = (\text{Height of Dam}) \times (\text{River Flow}) \times (\text{Efficiency}) / 11.8$$

**Power** The electric power in kilowatts (one kilowatt equals 1,000 watts).

**Height of Dam** The distance the water falls measured in feet.

**River Flow** The amount of water flowing in the river measured in cubic feet per second.

**Efficiency** How well the turbine and generator convert the power of falling water into electric power. For older, poorly maintained hydro plants this might be 60% (0.60) while for newer, well-operated plants this might be as high as 90% (0.90).

**11.8** Converts units of feet and seconds into kilowatts.

For the dam in our area, let's say we buy a turbine and generator with an efficiency of

80%. Then the power for our dam will be:

$$\text{Power} = (10 \text{ feet}) \times (500 \text{ cubic feet per second}) \times (0.80) / 11.8 = 339 \text{ kilowatts}$$

To get an idea what 339 kilowatts means, let's see how much electric energy we can make in a year.

Since electric energy is normally measured in kilowatt-hours, we multiply the power from our dam by the number of hours in a year.

$$\text{Electric Energy} = (339 \text{ kilowatts}) \times (24 \text{ hours per day}) \times (365 \text{ days per year}) = 2,969,000 \text{ kilowatt hours}$$

The average annual residential energy use in the U.S. is about 3,000 kilowatt-hours for each person. So we can figure out how many people our dam could serve by dividing the annual energy production by 3,000.

$$\text{People Served} = (2,969,000 \text{ kilowatt-hours} / 3,000 \text{ kilowatt-hours per person}) = 990 \text{ people.}$$

So our local irrigation or recreation dam could provide enough renewable energy to meet the residential needs of 990 people if we added a turbine and generator.

## Types of hydropower plants

There are three types of hydropower facilities: impoundment, diversion, and pumped storage. Some hydropower plants use dams and some do not.

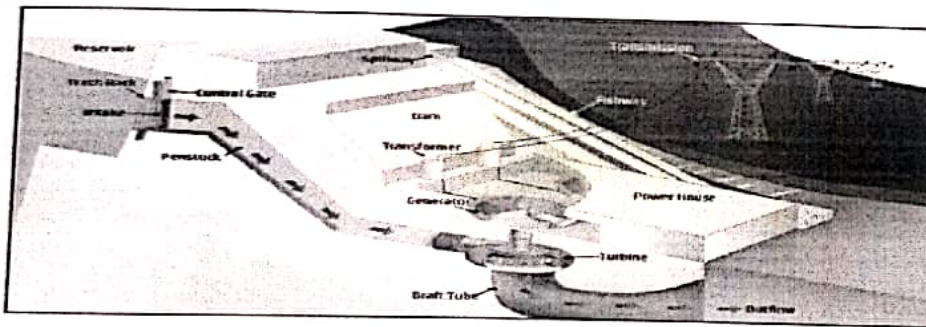
Although not all dams were built for hydropower, they have proven useful for pumping tons of renewable energy to the grid. In the United States, there are more than 90,000 dams, of which less than 2,300 produce power as of 2020. The other

dams are used for recreation, stock/farm ponds, flood control, water supply, and irrigation.

Hydropower plants range in size from small systems suitable for a single home or village to large projects producing electricity for utilities. Learn more about the sizes of hydropower plants.

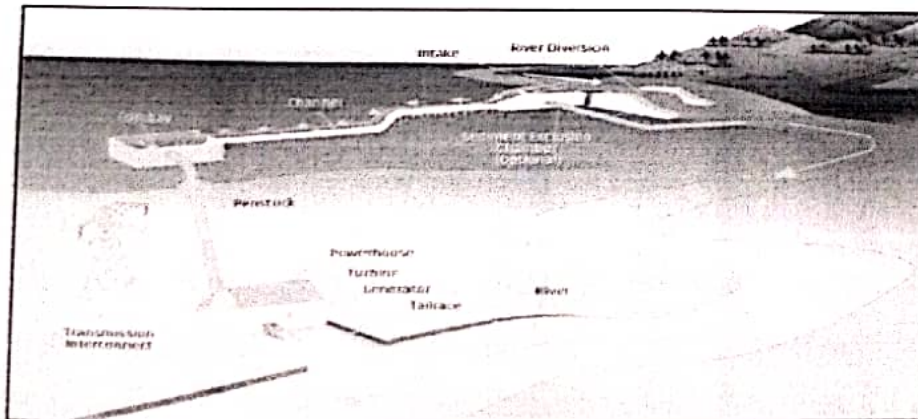
## IMPOUNDMENT

The most common type of hydroelectric power plant is an impoundment facility. An impoundment facility, typically a large hydropower system, uses a dam to store river water in a reservoir. Water released from the reservoir flows through a turbine, spinning it, which in turn activates a generator to produce electricity. The water may be released to meet changing electricity needs or other needs, such as flood control, recreation, fish passage, and other environmental and water quality needs.



## DIVERSION

A diversion, sometimes called a “run-of-river” facility, channels a portion of a river through a canal and/or a penstock to utilize the natural decline of the river bed elevation to produce energy. A penstock is a closed conduit that channels the flow of water to turbines with water flow regulated by gates, valves, and turbines.



## **PUMPED STORAGE**

Another type of hydropower, called pumped storage hydropower, or PSH, works like a giant battery. A PSH facility is able to store the electricity generated by other power sources, like solar, wind, and nuclear, for later use. These facilities store energy by pumping water from a reservoir at a lower elevation to a reservoir at a higher elevation.

When the demand for electricity is low, a PSH facility stores energy by pumping water from the lower reservoir to an upper reservoir. During periods of high electrical demand, the water is released back to the lower reservoir and turns a turbine, generating electricity.

## **SIZES OF HYDROELECTRIC POWER PLANTS**

Hydropower facilities range in size from large power plants, which supply many consumers with electricity, to small and even 'micro' plants, which are operated by individuals for their own energy needs or to sell power to utilities.

### **Large Hydropower**

Although definitions vary, DOE defines large hydropower plants as facilities that have a capacity of more than 30 megawatts (MW).

### **Small Hydropower**

Although definitions vary, DOE defines small hydropower plants as projects that generate between 100 kilowatts and 10 MW.