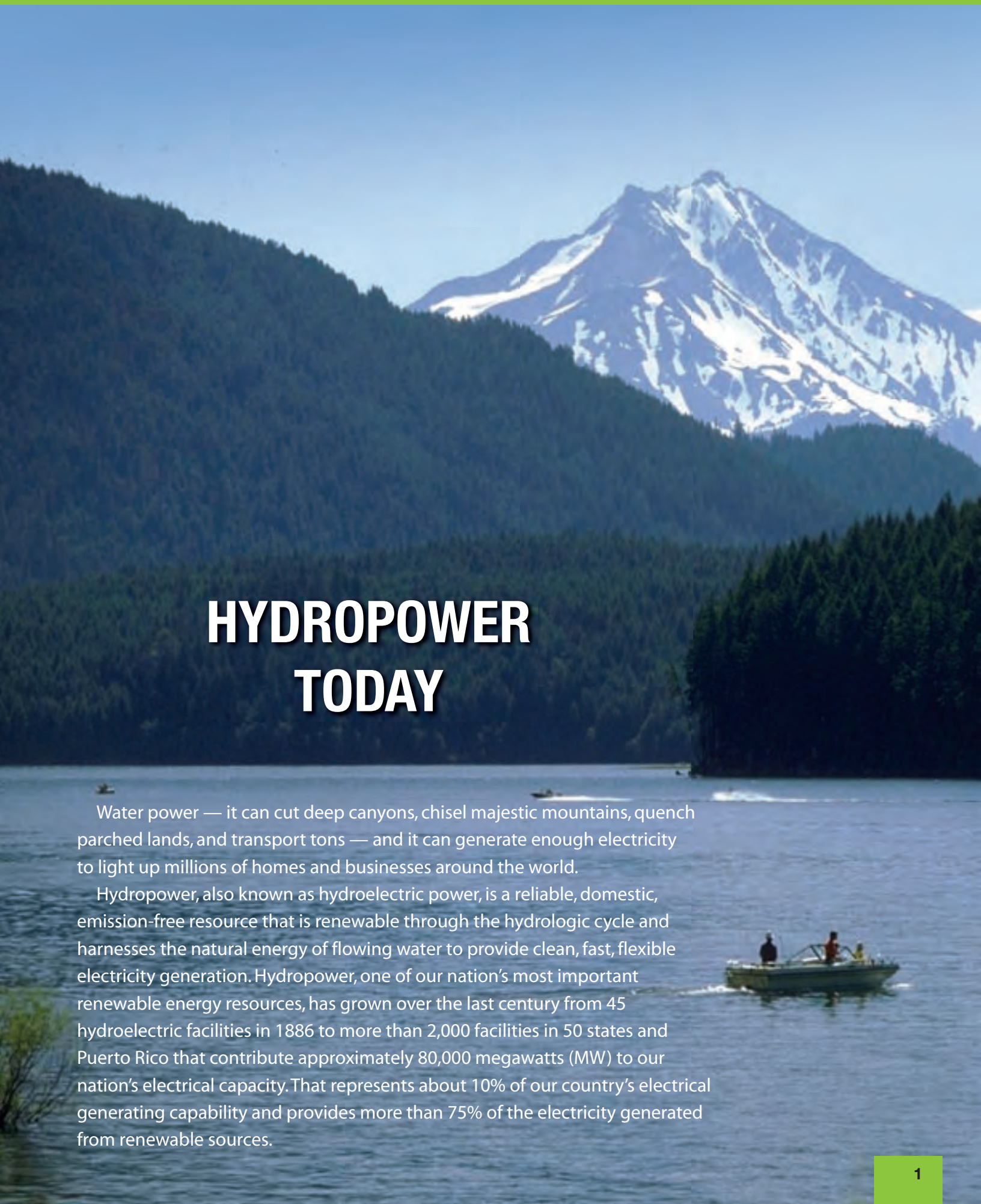
Modern Advances in Hydropower Technology

An Online Continuing Education Course for Engineers

Course Number: R-1003

Credit: 1 Hour / 1 PDH / 1 CPD



HYDROPOWER TODAY

Water power — it can cut deep canyons, chisel majestic mountains, quench parched lands, and transport tons — and it can generate enough electricity to light up millions of homes and businesses around the world.

Hydropower, also known as hydroelectric power, is a reliable, domestic, emission-free resource that is renewable through the hydrologic cycle and harnesses the natural energy of flowing water to provide clean, fast, flexible electricity generation. Hydropower, one of our nation's most important renewable energy resources, has grown over the last century from 45 hydroelectric facilities in 1886 to more than 2,000 facilities in 50 states and Puerto Rico that contribute approximately 80,000 megawatts (MW) to our nation's electrical capacity. That represents about 10% of our country's electrical generating capability and provides more than 75% of the electricity generated from renewable sources.

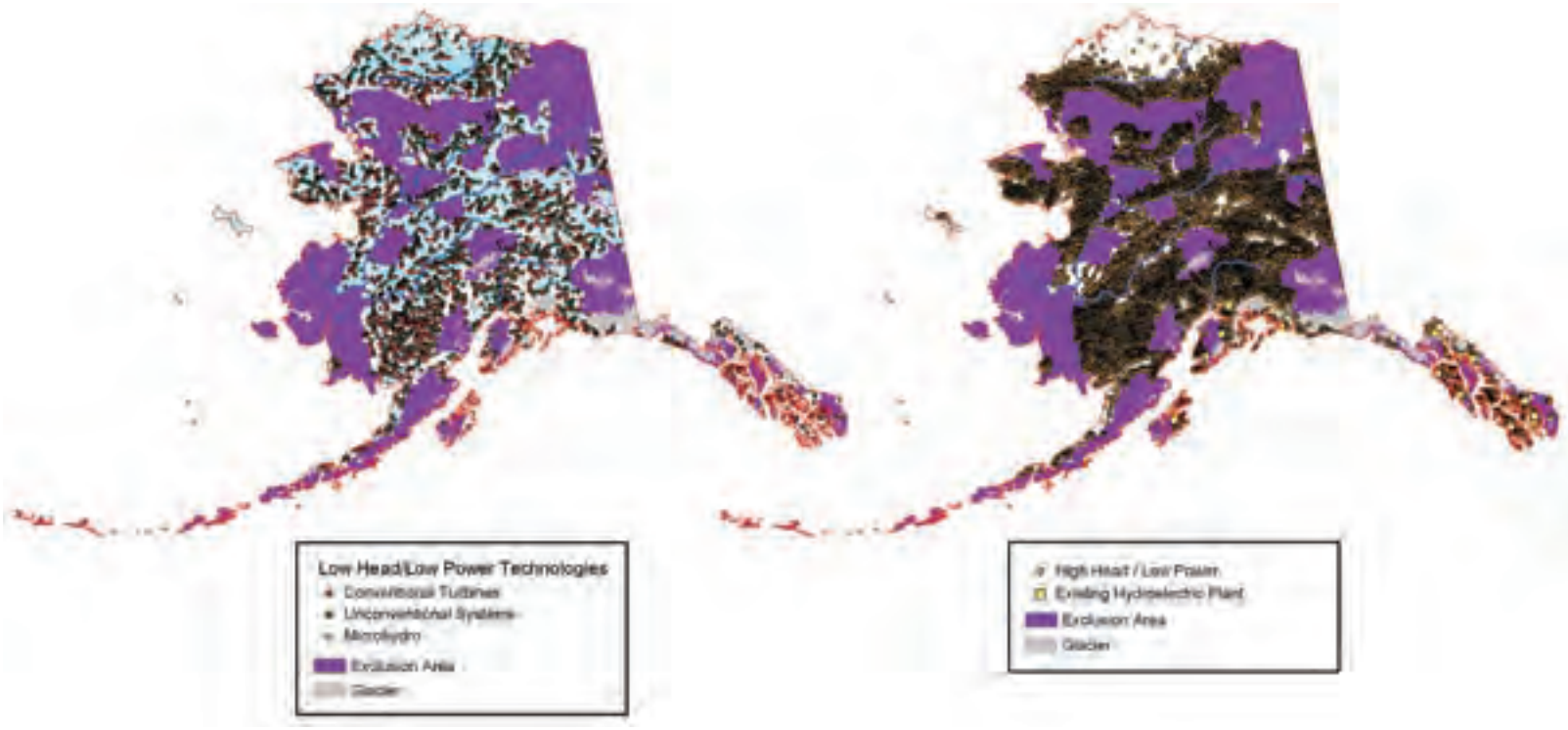
Because hydropower generation begins the minute water starts to fall through the turbines, it is capable of rapid response to peak demands and emergency needs, contributing to the stability of our nation's electricity grid and energy security. Hydropower is also one of the most economic energy resources and is not subject to market fluctuations or embargos, which helps support our nation's energy independence — and it can provide that support for years to come. The average lifespan of a hydropower facility is 100 years. By upgrading and increasing the efficiencies and capacities of existing facilities, hydropower can continue to support our nation's growing energy needs.

Hydropower also has more non-power benefits than any other generation sources, including water supply, flood control, navigation, irrigation, and recreation. In terms of recreation, hydropower projects in the United States provide the public with more than 47,000 miles of shoreline; 2,000 water access sites; 28,000 tent, trailer, and recreational vehicle sites for camping; 1,100 miles of trails; and 1,200 picnic areas.

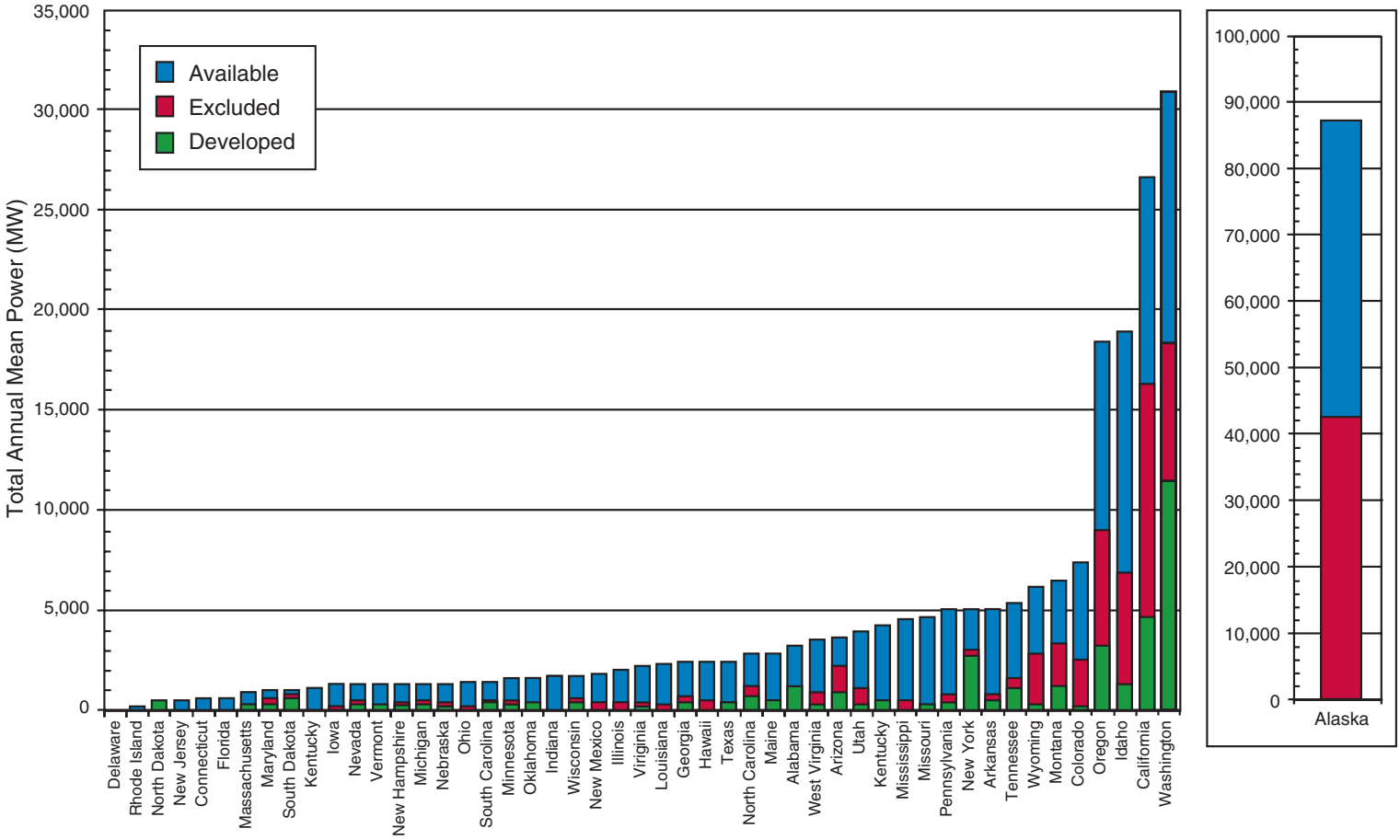
While there are many advantages to hydroelectric production, the industry also faces unique environmental challenges. Potential environmental impacts include changes in aquatic and stream side habitats; alteration of landscapes through the formation of reservoirs; effects on water quality and quantity; interruption of migratory patterns for fish such as salmon, steelhead, American shad, and sturgeon; and injury or death to fish passing through the turbines. The challenge facing hydropower researchers today is how to take advantage of one of our nation's most plentiful renewable resources to produce the electricity we need without endangering the aquatic species and habitats upon which the health of the environment and industries such as fishing and river tourism depend. Unless they find a way to meet this challenge, researchers and industry members feel it is unlikely that much additional hydropower will be added to our generation mix through undeveloped resources.

According to a water energy resources assessment conducted by the U.S. Department of Energy (DOE), the estimated average available power of undeveloped U.S. resources is 170,000 MW. Available resources are resources that have not been developed and are not excluded from development by federal statutes and policies. The Alaska Region contains the largest available potential with slightly less than 45,000 MW. The Pacific Northwest Region has the second highest amount of available potential with almost 40,000 MW. Together these two regions contain about half of the estimated available U.S. hydropower potential.

Low power resources (resources with less than 1 MW of power) make up about 50,000 MW of the total available potential. These resources could be captured using technologies not requiring the use of dams, thus avoiding many of the environmental impacts. Development of about 30 % of these resources would require unconventional systems or microhydro technologies. Partial use of the remaining available potential of approximately 120,000 MW composed of high power (greater than or equal to 1 MW) resources represents an additional source of low power potential that



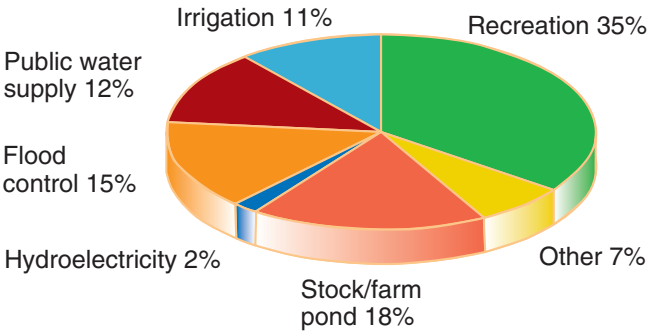
Water energy resource maps for Alaska are typical for the low power resource distribution maps for each state that were produced during resource assessment.



Total power potential of water energy resources in the 50 states. The blue bar segments show the amount of available potential for each state. Green bar segments show the amount of developed potential and red segments show the amount of potential excluded from development.

could be captured using conventional turbine technology in configurations offering the same low impact environmental benefits.

Beyond the recently quantified undeveloped resources, the National Hydropower Association estimates that more than 4,300 MW of additional or "incremental" hydropower capacity could be brought on line by upgrading or augmenting existing facilities. That is enough hydropower capacity to meet the electricity needs of the states of New Hampshire and Vermont. ♦



Source: U.S. Army Corps of Engineers, National Inventory of Dams

Primary purposes or benefits of U.S. dams.

Types of Hydropower Plants

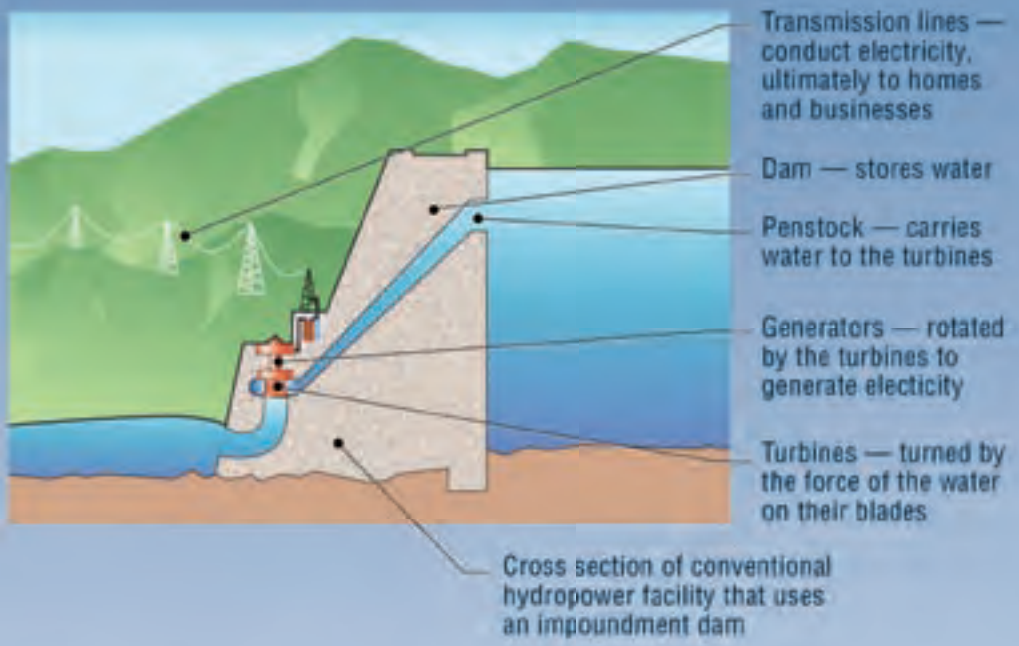
Many dams were built for other purposes and hydropower was added later. In the United States, there are about 80,000 dams of which only 2,400 produce power. The other dams are for recreation, stock/farm ponds, flood control, water supply, and irrigation.

Hydropower plants range in size from small systems for a home or village to large projects producing electricity for utilities.

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

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 either to meet changing electricity needs or to maintain a constant reservoir level.



An impoundment hydropower plant uses a dam to store water in a reservoir.

The Tazimina project in Alaska is an example of a diversion hydropower plant. No dam was required.

Diversion

A diversion facility channels a portion of a river through a canal or penstock. It may not require the use of a dam.

Run-of-River

A run-of-river project uses water within the natural flow range of the river, requiring little or no impoundment.

Pumped Storage

When the demand for electricity is low, a pumped storage facility stores energy by pumping water from a lower reservoir to an upper reservoir. During periods of high electrical demand, the water is released back to the lower reservoir to generate electricity.

Sizes of Hydroelectric Power Plants

Facilities range in size from large power plants that supply many consumers with electricity to small and micro plants that individuals operate for their own energy needs or to sell power to utilities.

Large Hydropower

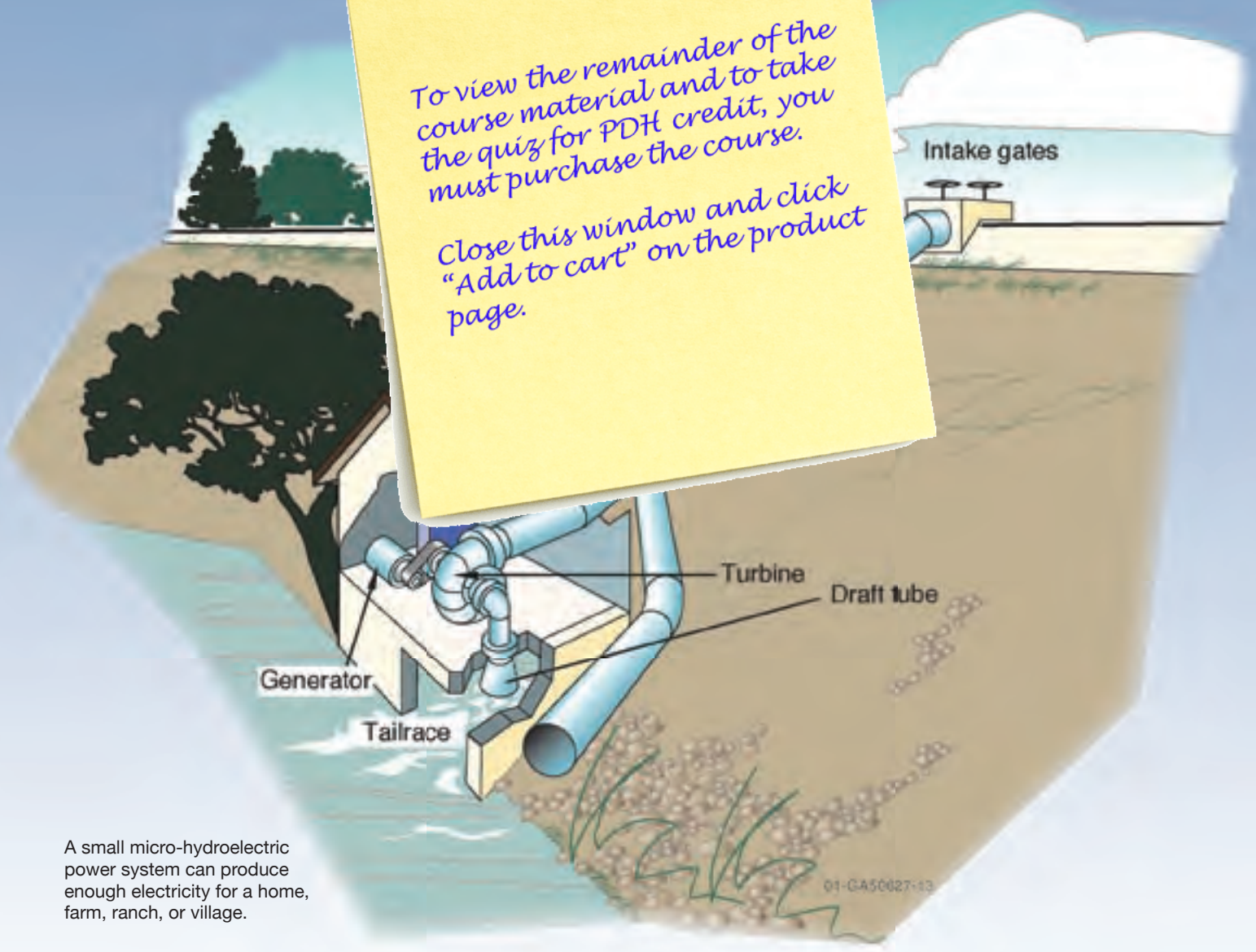
Although definitions vary, DOE defines large hydropower as facilities that have a capacity of more than 30 MW.

Small Hydropower

Although definitions vary, DOE defines small hydropower as facilities that have a capacity of 100 kilowatts to 30 MW.

Micro Hydropower

A micro hydropower plant has a capacity of up to 100 kW. A micro hydropower system can produce enough electricity for a home, farm, ranch



A small micro-hydroelectric power system can produce enough electricity for a home, farm, ranch, or village.