Chapter 19
Hydropower

Introduction

Hydropower is the most common source of renewable electricity in the United States. In 2005, even with the recent expansion of the renewable energy sector from sources such as wind, solar and biomass, hydropower still comprised 73 percent of the nation's renewably generated electricity.

Large-scale hydroelectric power generation is, however, concentrated in certain geographic regions in the U.S., most notably the Pacific Northwest.[1] Texas hydroelectric power has played an important role in the past, particularly in bringing electricity and jobs to rural areas of the state in the mid-1900s. Currently, however, it is a tiny portion of the state's electricity supply with little economic impact and limited prospects for expansion.

History

Human beings have harnessed the power of moving water for millennia, originally for purposes such as grinding grain and sawing wood. They have been employing its power to generate electricity since the 19th century, near the very beginning of the electric age. For example, Niagara Falls, New York began powering its street lights with hydroelectricity in 1881. In the following year, the world's first hydroelectric power plant opened in Appleton, Wisconsin.[2]

Until the development of effective transmission technology in 1893, however, hydroelectricity was limited to uses near its water source.[3]

Uses

Most American hydroelectric power is generated through the force of falling water, by damming a stream or river to raise its water level and then allowing the water to fall against a turbine connected to a generator. Thus, the potential energy of the elevated water is transformed into kinetic energy of the falling water, which becomes mechanical energy in the turbine, and transformed again into electric energy in the generator (**Exhibit 19-1**).

Another type of what is called "conventional" hydroelectric power comes from "run-of-river" facilities that rely on the strength of the river's flow to drive turbines, without raising the water level with a dam. To provide significant amounts of electricity in this way requires a fast-flowing river, usually found in steep terrain or where a large stream is confined in a narrow bed.

Still another form of hydroelectric power is created through what is called "pumped storage," in which water is moved from a lower-elevation storage facility (either a reservoir or a purpose-built container) to a higher elevation for release during peak demand. Although pumping the water uphill consumes more electricity than is generated by the water flowing back down, the financial return for the peak power is higher than the cost of pumping water during off-peak times.[4] Furthermore, this procedure can be used to store the energy from intermittent or variable sources such as wind and solar power, a technical challenge receiving a lot of attention; this use for pumped storage is currently being tested in Europe.[5] Consequently, hydroelectric power in this pumped-hydro configuration becomes an enabler for bringing online greater capacity from non-hydroelectric renewable sources.

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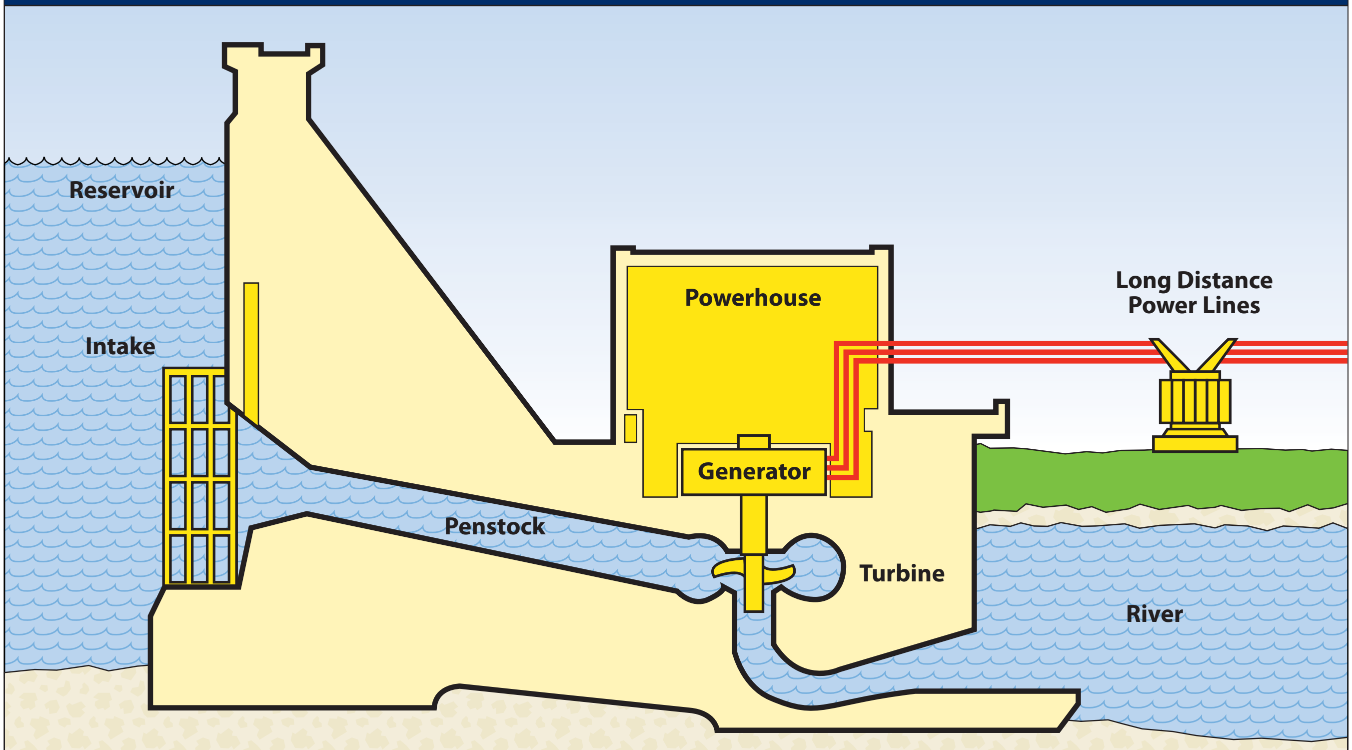
For most common types of hydroelectric power, the amount of electricity generated is in direct proportion to the volume of water in motion and the distance it falls; in other words, doubling the amount of water or the height of the water's fall will double the amount of electricity that can be produced.[6] Because of the site requirements for power production, most dams in the U.S. do not generate any electricity, but instead were built for flood control and irrigation (**Exhibit 19-2**).

Hydropower requires no transportation or fuel combustion. As with other methods of generating electricity, transmission capacity is needed to deliver hydropower to the electric grid. Most hydroelectric plants have been around for so long, however, that their transmission infrastructure

EXHIBIT 19-1

Schematic of a Hydroelectric Dam



Source: Tennessee Valley Authority.

is well established. If an existing plant were to require new transmission capability, issues of access, rights of way and property ownership might arise. In the case of new dams and reservoirs, however, developing transmission lines is a minor obstacle compared to site selection, land acquisition and potential displacement of people, property and wildlife.

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Hydropower in Texas

Hydroelectricity made its largest impact on Texas in the mid-1930s, as part of the rural electrification efforts of the New Deal.[7] With the fresh example of the federally funded Tennessee River Authority's hydroelectric dams, and aided by the considerable political clout held by Texans in Washington, the Lower Colorado River Authority (LCRA) was able to build four of an eventual six dams on the Colorado River between 1935 and 1941.[8]

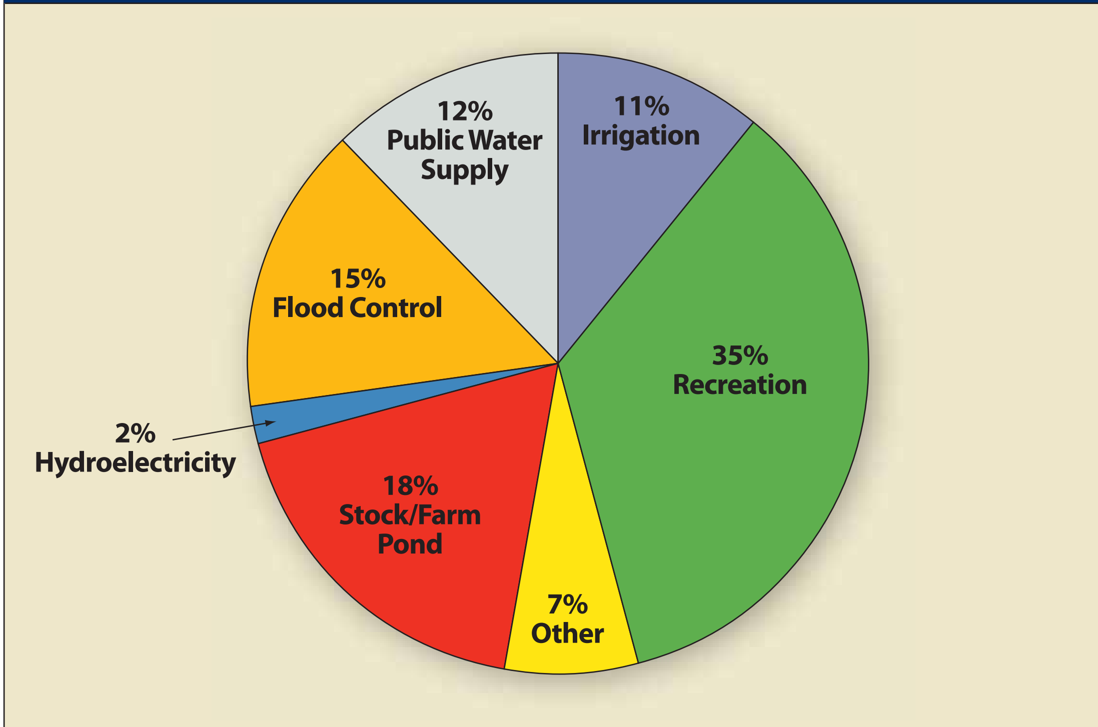
Economic Impact

Hydroelectricity brought jobs as well as electricity to the Hill Country and other areas of the state. Nevertheless, other sources of power soon dwarfed the contribution of dams. At the end of 1946, 15 percent of Texas' electricity came from hydropower; its share fell to less than half of that within about seven years.[9]

Because reservoirs in Texas are used primarily for water storage, dam operators can choose to release water through the power plant at the times when the resulting electricity is more valuable. Consequently, hydropower often is used to supplement the electrical grid during times of peak demand; the power plants can start generating within seconds. Hydropower's availability for use during peak demand enhances its economic value, but in largely semi-arid Texas, water usually is not released from reservoirs solely to generate electricity, so its economic potential is not always realized.

EXHIBIT 19-2

Primary Purpose or Benefit of U.S. Dams



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

In the long run, the role of Texas dams in controlling flooding and preventing property damage has proven more economically important to the state than hydroelectric power.

Production

In current usage, "hydropower" refers solely to electricity generated by water, most often through a dam. As of 2006, Texas has only 23 dams with hydroelectric power plants out of hundreds of medium to large dams around the state. These 23 dams have a total generating capacity of 673 megawatts (MW), although the amount of electricity they actually produce annually is well below the maximum potential of generating 100 percent of the time. In 2004, Texas hydropower plants operated at an average 22 percent capacity factor, and in 2006 the capacity factor averaged only 11 percent. Hydropower production is limited by droughts or other factors that affect surface water flows.[10]

Availability

Most of Texas' terrain does not lend itself to large-scale hydroelectric projects. In 2004, hydro accounted for 0.62 percent of the state's electrical capacity and only 0.34 percent of electricity actually produced.[11] In the absence of additional hydroelectric plants, these percentages will continue to shrink as the state's overall generating capacity grows.

While Texas has some identified potential for additional hydroelectric capacity, the likelihood of its development is not high. Reservoirs can face opposition from the public and policy-makers, and all the new reservoirs being proposed by water planners are intended for storing water supplies. (It should be noted, however, that some of the state's water supply — about 1.5 percent of all Texas water consumed in 2004 — is consumed by traditional power plants in the process of generating electricity.) Even if all of the state's potential hydroelectric sites were dammed and supplied with generators, the total capacity would still be less than 1.5 percent of the current state total. Texas simply does not have many big-river/big-drop settings that would justify overcoming the hurdles of land acquisition, construction cost and ecosystem destruction inherent in dam building and reservoir creation.

More than 12 percent of Texas' hydropower capacity belongs to the Sabine River Authority, which lies in the Southeastern Electric Reliability Council region rather than that of the state's main power grid, the Electric Reliability Council of Texas (ERCOT). Another 10.4 percent of the state's generation capacity flows into the part of the Southwest Power Pool grid, which covers most of the Panhandle and parts of Northeast Texas. LCRA owns six of the 22 hydroelectric plants that feed energy into the ERCOT grid; these comprise more than 65 percent of ERCOT's hydro-generating capacity. Plants owned by the U.S. Corps of Engineers and various river authorities provide the remainder.[12]

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Costs and Benefits

The cost of generating hydroelectric power lies almost entirely in the construction of the dam and power plant.[13] Once in place, its costs are largely limited to equipment maintenance, with no further costs for fuel and its transportation, so operating expenses for hydroelectric plants are significantly lower than those for other conventional power plants.

As long as there is sufficient water to run the turbines, electricity can be produced very cheaply. Compared even to mature nuclear plants, hydropower costs less than half as much to produce, at under 0.9 cents per kilowatt-hour (kWh).[14] It then joins the stream of power transmitted and sold in the wholesale and retail markets at the same prices as electricity generated by other means, complete with premiums for peak demand production.

But dams and reservoirs are expensive to build. The cost of the proposed Marvin Nichols reservoir in northeast Texas, for example, has been estimated at $2.2 billion, with no power plant included.[15] And water dammed for use in city water systems is unlikely to be released for other purposes, even to generate low-cost electricity.

Environmental Impact

The environmental impact of hydropower is mixed. Although a hydroelectric plant uses the motion of water as a renewable fuel, *gathering* that water can have a large impact on the environment. The most obvious impact is the destruction of a river ecosystem and its replacement with a reservoir. This displaces flora and fauna as well as human inhabitants, and disrupts any activity dependent on aspects of the prior ecosystem, such as bottomland timber. In addition, below the dam the instream flow (the amount of water left flowing in the river) is affected, as are downstream water users and bays and estuaries at the coast. And, because reservoirs created behind dams vastly expand the surface area of the water body, evaporative water loss increases significantly.

Reservoirs also collect sediment, concentrating nutrients as well as pollutants; eventually (as can be seen in older Texas reservoirs) these sediments build up, making the reservoirs shallower.[16] And recent research has found that reservoirs and hydroelectric dams, previously thought of as zero-emissions power sources, actually do emit greenhouse gasses, particularly methane from the decomposition of organic materials (**Exhibit 19-3**).[17] Although scientists are debating how much gas is released and under what conditions, there is little disagreement about the fact that it occurs. This phenomenon is particularly relevant in tropical locations with large reservoirs that contain significant amounts of buried biomass.[18]

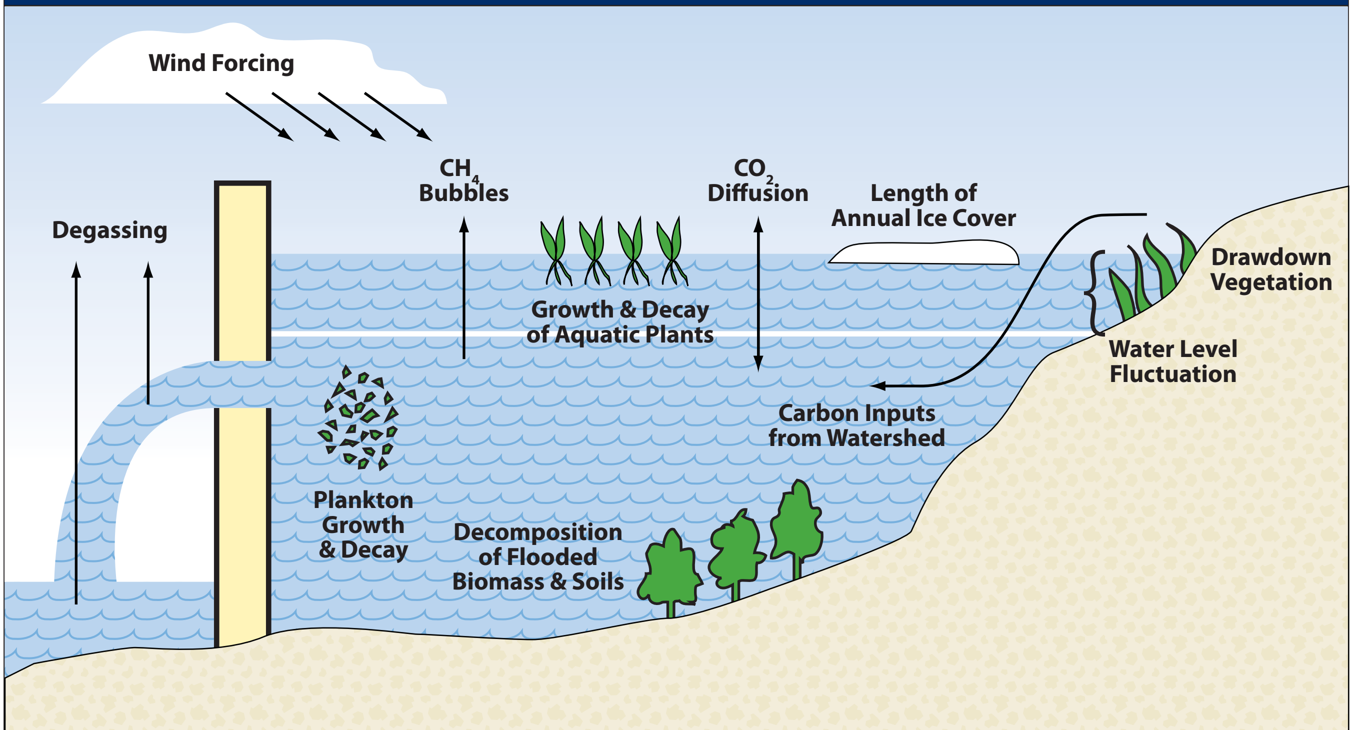
More study is required to accurately compare the environmental impacts of hydroelectricity with other power sources.[19] Some have even proposed ways to tap the methane in reservoirs for use in power production.[20] Overall, hydroelectric dams remain a low-emission method of generating electricity compared to fossil fuel power plants and, as noted at the beginning of this chapter, the largest source of renewable electricity in the United States.

Other Risks

If a dam breaks due to extreme rainfall or inadequate maintenance, it can cause great damage downstream. The safety of aging dams has been the subject of a considerable amount of discussion both domestically and worldwide. The fact that a fairly large portion (25 percent or more) of dams included in the National Inventory of Dams are

Exhibit 19-3

Some Key Factors Influencing Reservoir Emissions



Source: International Rivers Network.

at least 50 years old is a concern, particularly in light of subsequent improvements in design and construction standards.[21]

State and Federal Oversight

If any new hydroelectric plants were built, most of the laws affecting them would concern the dam and reservoir rather than the generating plant. In Texas, the water in rivers belongs to the state, and state regulation covers dams and reservoirs unless they are built on federal land. Federal environmental regulations concerning wetlands and wildlife protection also could come into play, depending on the site.

Subsidies and Taxes

Hydropower is such a mature technology that it often is not even included in discussions and incentive programs for renewable energy. Nevertheless, renewable energy tax credits are available for hydroelectric power production, and federal ownership of a number of dams allows the U.S. government to set subsidized prices for the electricity they produce. More information on this topic can be found in Chapter 28.

Other States and Countries

Texas has no plans for new hydroelectric facilities, and, according to the Energy Information Administration, through 2010 only four states will add new hydroelectric capacity, for a total additional 16 MW of capacity.[22]

Hydroelectric capacity is still expanding in other parts of the world, with the largest growth occurring in Asia, particularly China and India, and in Central and South America and Canada.

China has several large projects under way, including Three Gorges, which will provide 18,200 MW of hydroelectricity capacity by 2009, and India is adding over 13,000 MW in the next few years. In countries that already rely heavily on hydropower, such as Brazil, greater emphasis and investment is expected on the diversification of electricity sources.[23] Even so, the current administration in Brazil is pushing for large new hydroelectric projects in the Amazon region, stirring much controversy.[24]

Outlook for Texas

Hydroelectricity supplies a very small percentage of Texas' power supply, and that percentage is shrinking as total generating capacity grows. Although the state has some limited potential for additional hydropower, there are no current plans to develop it. The new reservoirs being planned for the state do not include electric generation plants; those plans are about water, not power.

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While existing facilities may be able to increase their generating capacity due to efficiency improvements from new turbines or other factors, these gains are likely to be modest. The amount of hydroelectricity Texas generates this year and into the future is more likely to depend on the weather — floods or droughts — than on state demand for electricity. In all likelihood, hydropower has reached its peak in Texas.

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