**ELECTRIC TRANSMISSION OF WATER POWER**

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**CHAPTER I. WATER-POWER IN ELECTRICAL SUPPLY**

Electrical supply from transmitted water-power is now distributed in more than fifty cities of North America. These include Mexico City, with a population of 402,000; Buffalo and San Francisco, with 352,387 and 342,782 respectively; Montreal, with 266,826, and Los Angeles, St. Paul, and Minneapolis, with populations that range between 100,000 and 200,000 each. North and south these cities extend from Quebec to Anderson, and from Seattle to Mexico City. East and west the chain of cities includes Portland, Springfield, Albany, Buffalo, Hamilton, Toronto, St. Paul, Butte, Salt Lake City, and San Francisco. To reach these cities the water-power is electrically transmitted, in many cases dozens, in a number of cases scores, and in one case more than two hundred miles. In the East, Canada is the site of the longest transmission, that from Shawinigan Falls to Montreal, a distance of eighty-five miles.

From Spier Falls to Albany the electric line is forty miles in length. Hamilton is thirty-seven miles from that point on the Niagara escarpment, where its electric power is developed. Between St. Paul and its electric water-power station, on Apple River, the transmission line is twenty-five miles long. The falls of the Missouri River at Cañon Ferry are the source of the electrical energy distributed in Butte, sixty-five miles away. Los Angeles draws electrical energy from a plant eighty-three miles distant on the Santa Ana River. From Colgate power-house, on the Yuba, to San Francisco, by way of Mission San José, the transmission line has a length of 220 miles. Between Electra generating station in the Sierra Nevada Mountains and San Francisco is 154 miles by the electric line.

These transmissions involve large powers as well as long distances. The new plant on the Androscoggin is designed to deliver 10,000 horse-power for electrical supply in Lewiston, Me. At Spier Falls, on the Hudson, whence energy goes to Albany and other cities, the electric generators will have a capacity of 32,000 horse-power. From the two water-power stations at Niagara Falls, with their twenty-one electric generators of 5,000 horse-power each, a total of 105,000, more than 30,000 horse-power is regularly transmitted to Buffalo alone; the greater part of the capacity being devoted to local industries. Electrical supply in St. Paul is drawn from a water-power plant of 4,000 and in Minneapolis from a like plant of 7,400 horse-power capacity. The Cañon Ferry station, on the Missouri, that supplies electrical energy in both Helena and Butte, has a capacity of 10,000 horse-power. Both Seattle and Tacoma draw electrical supply from the 8,000 horse-power plant at Snoqualmie Falls. The Colgate power-house, which develops energy for San Francisco and a number of smaller places, has electric generators of 15,000 horse-power aggregate capacity. At the Electra generating station, where energy is also transmitted to San Francisco and other cities on the way, the capacity is 13,330 horse-power. Electrical supply in Los Angeles is drawn from the generating station of 4,000 horse-power, on the Santa Ana River, and from two stations, on Mill Creek, with an aggregate of 4,600, making a total capacity of not less than 8,600 horse-power. Five waterpower stations, scattered within a radius of ten miles and with 4,200 horse-power total capacity, are the source of electrical supply in Mexico City.

The foregoing are simply a part of the more striking illustrations of that development by which falling water is generating hundreds of thousands of horse-power for electrical supply to millions of population. This application of great water powers to the industrial wants of distant cities is hardly more than a decade old. Ten years ago Shawinigan Falls was an almost unheard-of point in the wilds of Canada. Spier Falls was merely a place of scenic interest; the Missouri at Cañon Ferry was not lighting a lamp or displacing a pound of coal; that falling water in the Sierra Nevada Mountains should light the streets and operate electric cars in San Francisco seemed impossible, and that diversion of Niagara, which seems destined to develop more than a million horse-power and leave dry the precipices over which the waters now plunge, had not yet begun. In some few instances where water-power was located in towns or cities, it has been applied to electrical supply since the early days of the industry. In the main, however, the supply of electrical energy from water-power has been made possible only by long-distance transmission. The extending radius of electrical transmission for water-powers has formed the greatest incentive to their development. This development in turn has reacted on the conditions that limit electrical supply and has materially extended the field of its application. Transmitted water-power has reduced the rates for electric service. It may not be easy to prove this reduction by quoting figures for net rates, because these are not generally published, but there are other means of reaching the conclusion.

In the field of illumination electricity competes directly with gas, and in the field of motive power with coal. During the past decade it is well known that the price of gas has materially declined and the price of coal, barring the recent strike period, has certainly not increased. In spite of these reductions electrical supply from water-power has displaced both gas and coal in many instances.

Moreover, the expansion of electric water-power systems has been decidedly greater, as a rule, than that of electrical supply from steam-driven stations. An example of the fact last stated may be seen in Portland, Me. In the spring of 1899, a company was formed to transmit and distribute electrical energy in that city from a water-power about thirteen miles distant. For some years, prior to and since the date just named, an extensive electric system with steam-power equipment has existed in Portland. In spite of this, the system using water-power, on January 1st, 1903, had a connected load of 352 enclosed arcs and 20,000 incandescent lamps, besides 835 horse-power in motors.

Comparing the expansion of electric water-power systems with those operated by steam, when located in different cities, Hartford and Springfield may be taken on the one hand and Fall River and New Bedford on the other. The use of waterpower in electrical supply at Hartford began in November, 1891, and has since continued to an increasing extent. Throughout the same period electrical supply in Fall River has been derived exclusively from steam. In 1890 the population of Hartford was 53,230, and in 1900 it stood at 79,850, an increase of 50 per cent. At the beginning of the decade Fall River had a population of 74,398, and at its close the figures were 104,863, a rise of 40.9 per cent. In 1892 the connected load of the electric supply system at Fall River included 451 arc and 7,800 incandescent lamps, and motors aggregating 140 horse-power. By 1901 this load had increased to 1,111 arcs, 24,254 incandescent lamps, and 600 horse-power in motors. The electric supply system at Hartford in 1892 was serving 800 arcs, 2,000 incandescent lamps, and no motors. After the use of transmitted waterpower during nine years the connected load of the Hartford system had come to include 1,679 arcs, 68,725 incandescent lamps, and 3,476 horse-power of motor capacity in 1901. At the beginning of the decade Hartford was far behind Fall River in both incandescent lamps and motors, but at the end Hartford had nearly three times as many incandescent lamps and nearly six times as great a capacity in connected motors. As Fall River had a population in 1900 that was greater by thirty-one per cent. than the population of Hartford, and the percentage of increase during the decade was only 9.1 lower in the former city, water-power seems to have been the most potent factor in the rise of electric loads in the latter. Electric gains at Hartford could not have been due to the absence of competition by gas, for the price of gas there in 1901 was $1 per 1,000 cubic feet, while the price in Fall River was $1.10 for an equal amount.

Water-power began to be used in electrical supply at Springfield during the latter half of 1897. In that year the connected load of the Springfield electric system included 1,006 arcs, 24,778 incandescent lamps, and motors with a capacity of 647 horse-power. Five years later, in 1902, this connected load had risen to 1,399 arc lamps, 45,735 incandescent lamps, and a capacity of 1,025 horse-power in electric motors. At New Bedford, in 1897, the electric system was supplying 406 arc and 22,122 incandescent lamps besides motors rated at 298 horse-power. This load, in 1902, had changed to 488 arcs, 18,055 incandescent lamps, and 432 horse-power in capacity of electric motors. From the foregoing figures it appears that while 82 arc lamps were added in New Bedford, 393 such lamps were added in Springfield. While the electric load at New Bedford was increased by 134 horse-power of motors, the like increase at Springfield was 378 horse-power, and while the former city lost 4,067 from its load of incandescent lamps, the latter gained 20,957 of these lamps. During all these changes electrical supply in Springfield has come mostly from waterpower, and that in New Bedford has been the product of steam. Population at Springfield numbered 44,179 in 1890 and 62,059 in 1900, an increase of 40.5 per cent. In the earlier of these years New Bedford had a population of 40,733, and in the later 62,442, an increase of 53.3 per cent. In 1902 the average price obtained for gas at Springfield was $1.04 and at New Bedford $1.18 per 1,000 cubic feet.

Springfield contains a prosperous gas system, and the gross income there from the sale of gas was thirty-one per cent greater in 1902 than in 1897. During this same period of five years the gross income from sales of electrical energy, developed in large part by water-power, increased forty-seven per cent. For the five years of general depression, ending in 1897 gross annual income of gas sales in Springfield rose only five per cent, and the like electric income nine per cent. In the five years last named the electrical supply system was operated with coal.

The application of transmitted water-power in electrical supply has displaced steam as a motive power in many large industrial plants that never would have been operated from steam-driven electric stations. An example of this sort exists at Portland, where one of the motors operated by the electric water-power system, in an industrial plant, has a capacity of 300 horse-power. Every pound of coal burned in Concord, N. H., is hauled by the single steam railway system entering that city, which railway operates large car and repair shops there. Some years ago the railway installed a complete plant of engines, dynamos, and motors for electric-driving throughout these shops. These engines and dynamos now stand idle and the motor equipment, with an aggregate capacity of 590 horsepower, is operated with energy purchased from the local electrical supply system and drawn from water-power.

Another striking example of the ability of electric water-power systems to make power rates that are attractive to large manufacturers may be seen at Manchester, N. H. One of the largest manufacturing plants in that city purchases energy for the operation of the equivalent of more than 7,000 incandescent lamps, and of motors rated at 976 horse-power, from the electrical supply system there, whose generating stations are driven mainly by water-power. The Manchester electrical supply system also furnishes energy, through a sub-station of 800-horse-power capacity, to operate an electric railway connecting Manchester and Concord. This electric line is owned and operated in common with the only steam railway system of New Hampshire, so that the only inducement to purchase energy from the water-power system seems to be one of price.

In Buffalo the electric transmission system from Niagara Falls supplies large motors of about 20,000 horse-power capacity in manufacturing and industrial works, and 7,000 horse-power to the street railway system, besides another 4,000 horse-power for general service in lighting and small motors. Few large cities in the United States have cheaper coal than Buffalo, and in Portland, Concord, and Manchester coal prices are moderate. In the Rocky Mountain region, where coal is more expensive, the greater part of the loads of some electric water-power systems is made up of large industrial works. In Salt Lake City the electrical supply system, which draws its energy almost exclusively from water-powers, had a connected load of motors aggregating 2,600 horsepower as far back as 1901, and also furnished energy to operate the local electric railway, and several smelters six miles south of the city, besides all the local lighting service. As good lump coal sells in Salt Lake for $4.50 per ton, slack at less than one-half this figure, and the population there by the late census was only 53,531, the figures for the load of motors are especially notable. At Helena energy from the 10,000 horse-power station at Cañon Ferry operates the local lighting and power systems, two smelting and a mining plant.