Factors Affecting the Location of Steam-Electric Generating Plants of the American Electric Power System

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The literature on the subject published in the past, for example by Deacy and Griess (4) and Zimmermann (7), in dealing with the relative importance of coal and market in the location of steam-electric generating plants, concluded that coal was unimportant, but that, given a water supply, market was the dominant factor affecting plant location.

The purpose of this paper is to point out how technological improvements have brought about changes in the relative importance of factors affecting the location of steam-electric generating plants. Examples employed to inquire into the question are the more recently installed plants of the American Electric Power System, a system which operates in a region where market, fuel, and water, the three most important locational factors, are found in ample amounts.

New Technology of Thermoelectricity Production

A change of emphasis in location of thermoelectricity production has followed from four technological advances: 1, the development of long-distance high-voltage transmission; 2, the substantial increase in the size of turboalternator sets; 3, the "cyclone furnace" which burns pulverized fuel or even the "slurry" from the coal washing plants now installed at almost all modern collieries; and 4, advances in boiler design which allow for pressures in excess of 2,000 pounds of steam pressure per square inch as compared with 500 pounds per square inch prior to World War II (5).

Modern 100 megawatt turboalternators attain a thermal efficiency of almost 33 per cent, compared with 26 per cent realized by the 30-megawatt sets common before World War II. The British Central Electricity Board operates a 550-megawatt set, an operation that attains an efficiency of almost 37 per cent (5).

The high-presure boilers and enormous new turboalternator units have reduced the capital cost of producing a kilowatt of electric power to almost half of that of 30 years ago; not only have they greatly improved the competitive position of thermoelectricity as compared with hydroelectricity, but they have also had consequences for the location of thermal stations (5).

High-voltage and D. C. Transmission

The most important of the above four technological advances, with respect to the relative importance of fuel and market in determining the location of thermoelectric generating plants, is the improvement in high-voltage transmission.

Fryer (5) points out that: ". . . with the anticipated increase in the demand for power, substantial cost reductions per unit should be possible from the use of very high-voltage lines. Apart from economies of scale in transmission, very high-voltage lines make possible the interchange of large blocks of power in giant networks, for in very large quantities, transmission of power becomes feasible over distances greater than those normally regarded as the limit of economic transmission. . . . For many years the longest and highest-voltage line in the United States was the 285-kilovolt line between Hoover Dam and Los Angeles, but Sweden has a 380-kilovolt line connecting the Harspranget Hydroelectric station within the Arctic Circle with Halsberg in central Sweden, a distance of over 600 miles, and even higher voltages are employed in the U.S.S.R."

With the development of higher transmission voltages, electricity can now be transmitted hundreds of miles economically. United States electric utilities now operate more than 100,000 miles of transmission lines that carry power at 138,000 volts and more than 20,000 miles of lines that transmit power at 230,000 volts. In 1953, the American Electric Power System commissioned a 345,000 volt network that now interconnects electric systems in seven states and has more than 1,600 miles of 345,000 volt lines (2).

An incredible amount of condensing water is needed to accomplish the desired spread between the temperature of the steam entering and that leaving the turbine for efficient operation. According to Fryer a station uses about 50 gallons of water per hour per kilowatt of power generated (5). At this rate of water use, the Breed Plant located on the Wabash River south of Terre Haute would require 25-million gallons per hour. A body of water large enough to supply this prodigious amount of condensing water thus becomes a major factor in determining the location of modern giant steam power plants.

The American Electric Power System

The American Electric Power System is a group of six investor owned electric utilities operating companies, each interconnected with the others by high-voltage transmission lines, permitting their operations to be fully integrated and thus forming a single major power system.

All of the plants and the company's load centers are tied together by a network of some 14,000 circuit miles of transmission lines, extending from Lake Michigan to the border of North Carolina.

Steam Plants of the American Electric Power System

The following are some of the more recently installed plants of the American Electric Power System (2).

BREED PLANT. The Breed Plant is located on the Wabash River in Sullivan County, Indiana, aproximately thirty miles south of Terre Haute. Coal is supplied by the new Thunderbird Mine developed nearby by Ayrshire Collieries Corporation and transported via its new shorthaul railroad.

The Breed Plant houses a single 500,000 kilowatt, cross-compound turbine-generator unit. At the time it was placed in commercial operation in 1960 it was the largest and most efficient unit ever operated. This plant is so efficient that it generates a kilowatt hour of electricity with only seven-tenths of a pound of coal.

BIG SANDY PLANT. The Big Sandy Plant, placed in commercial operation in 1963, is located on the Big Sandy River at Louisa, Kentucky. This is the American Electric Power System's newest steam-electric power station. This plant houses a single 265,000 kilowatt generating unit.

The unique feature of Big Sandy is its giant cooling tower which will provide the cool water required by the plant's condenser. The hyperbolic shaped, natural-draft concrete tower, first of its kind in the Western Hemisphere, rises 320 feet above ground, wtih a base diameter of 245 feet and a top diameter of 140 feet.

CLINCH RIVER PLANT. The Clinch River Plant, the three units of which went into operation during the period 1958-61, is located on the Clinch River near Carbo in southwestern Virginia.

This plant has three 225,000 kilowatt generating units. Coal for the Clinch River Plant is supplied by a nearby Clinchfield Coal Company mine.

A special feature of the plant's operation is its use of six wooden cooling towers to furnish cool water for steam condensation. Among the worlds largest, they have a combined cooling capacity of 330,000 gallons a minute.

KAMMER PLANT. The Kammer Plant is located on the Ohio River at Captina, West Virginia, south of Wheeling. The Kammer Plant has three 225,000 kilowatt generating units. All of Kammer's coal needs are furnished by the adjacent Ireland Mine of Consolidation Coal Company and delivered via conveyor.

MUSKINGUM RIVER PLANT. The Muskingum River Plant is located at Beverly, in southeastern Ohio, on the Muskingum River. This plant has a total generating capacity of 889,000 kilowatts. Its two 215,000-kw units went into operation in 1953-54, and its two 225,000-kw units in 1957-58.

Through the years, Muskingum River has been rated as one of the lowest production cost steam plants in the world. Its entire coal supply, some 2½ million tons a year, is delivered via a unique 4½ mile belt conveyor system directly from Ohio Power Company's nearby Muskingum Mine.

PHILO PLANT. The Philo Plant is located on the Muskingum River near Zanesville, Ohio. This plant has a generating capacity of 497,000 kilowatts. The number six unit at Philo Plant which went into operation in 1957 operates at the steam pressure of 4,500 pounds per square inch. Unit six was also the first unit to use a steam temperature as high as 1,150°F. and to reheat the steam twice during its passage through the unit. This "break-through" of the "steam barrier" paved the way for later super-critical units at other American Electric Power System plants.

WINDSOR PLANT. The Windsor Plant is located on the Ohio River in West Virginia, about ten miles north of Wheeling. This power plant has a generating capability of 300,000 kilowatts. Although it is an old plant, it is an example of the importance of proximity of coal. The coal supply for Windsor comes from an adjacent mine, located in a hill near the plant, and is delivered by belt conveyor.

Location of the Steam-electric Generating Plants of the American Electric Power System

The major steam power plants of the American Electric Power System have broad general similarities, but each one has some distinct characteristics peculiar to that individual plant. With respect to factors affecting location of the plants certain specific factors are more prominent at some plants than at others.

It cannot be correctly generalized that fuel was unimportant in the location of steam-electric generating plants of the American Electric Power System as was concluded by Deasy and Griess (4) in the case of the Pennsylvania plants. The plants of this system are located in the heart of American's bituminous coal area with the Appalachian Field on the east and the Eastern Interior Field on the west.

In the selection of a site for a steam electric generating plant, the quality of coal available in a particular area is important. Generally, the coal found in the Appalachian Highlands is of a superior quality. Coal within the area of the American Electric Power System's steam generating plants, however, does vary in caloric value. This variance is important to the efficiency of an electric power generating plant.

Prices of coal vary according to the source and type. Power companies are interested in the cost of coal delivered to generating plants. Consequently, freight rates, as well as prices at the mine, will enter into the calculations of site selection. It can safely be stated that the transporting of coal to the steam generating plants of the American Electric Power System is a definite factor of consideration in the selecting of a site for a proposed steam plant. Some of the plants are located only a few hundred yards from the mouths of coal mines, and in the cases of the Kammer plant, at Captina, West Virginia, the Muskingum River plant in southeastern Ohio, and the Windsor plant just north of Wheeling, West Virginia, a conveyor system is all that is required for coal delivery. Other plants receive coal by low-cost river barge, and still others are supplied by short-haul company-owned railroads. Only one of the fourteen existing steam-electric generating plants of the American Electric Power System, the Twin Branch Plant at Mishawaka, Indiana, is not located on or near coal reserves.

As stated previously, an abundant water supply is essential for electric power generation. All of the generating plants of the American Electric Power System are located on streams from which they draw their water supply. With the possible exception of three or four plants, depending upon an arbitrary definition of what is large, they are located on large rivers such as the Kanawha, the Muskingum, the Ohio, and the Wabash.

Although water is an essential raw material for generating electric power by steam plants, it is possible to devise equipment to counteract a deficiency of water when other factors are over-powering. Two of the fourteen plants of the American Electric Power System have such undependable water supplies as make necessary the use of cooling towers in order to recycle the water. The Clinch River Plant, located on the Clinch River, at Carbo, Virginia, is one such plant. To offset this deficiency, a series of six cooling towers, built of treated redwood, were constructed. Each tower is equipped with ten fans with twenty-two foot blades which can cool water a maximum of nineteen degrees at the rate of 55,000 gallons per minute. Another plant located on a river with a flow too small to meet the plant's water requirements is the Big Sandy Plant, located at Louisa, Kentucky. This plant overcame the condensing problem by constructing the world's largest capacity natural draft cooling tower (2).

Economic conditions of the area and political considerations played an important role in the locating of the Big Sandy Plant. The plant was located in that region partly because it was an economically depressed area. The many unemployed coal miners in the area were a factor in the cost of coal. The presence of an abundance of low-cost coal allowed the location of a plant in the area to be in agreement with the above conclusion about the importance of fuel as a locational factor.

The American Electric Power System does not now have a plant using nuclear fuel and, at the present time, it has no plans for building one. It does, however, now have under construction three new coal-burning steam-electric generating plants, one of which is a 1,230,000-kw unit, and is developing plans for three more 800,000-kw units, all of which are located in the Appalachian region (1). The principal factors affecting the location of these plants are proximity to large amounts of cooling water, nearby coal resources, and nearness to load centers.

Within the area involved in this study, though not a part of the American Electric Power System, it might be mentioned that Public Service Indiana unveiled plans September 28 to build a $119 million coal-fired generating plant on the Wabash River in Vermillion County, Indiana. When the plant is completed it will be capable of producing a million kilowatts of electrical power.

When in full operation, the plant is expected to consume three million tons of Indiana coal a year. Public Service has bought 866 acres of land for the new plant. According to the Terre Haute Star, company officials said the site was picked after consideration of such economic factors as fuel, transportation costs, and local taxes (6).

Conclusions

The steam-electric generating plants surveyed in this study, especially the more recently installed plants of the American Electric Power System, show a decided change in the relative importance of fuel and market as locational factors. Technological improvements, particularly in high-voltage transmission, now allow coal-burning plants to be located closer to the fuel supply while sending the power over greater distances by higher-voltage lines.

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