1951

Bangor Hydro-Electric Company Regenerative Type Gas Turbine Installed

Bangor Hydro-Electric Company

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Came from a file in production area – "Gas Turbine History"

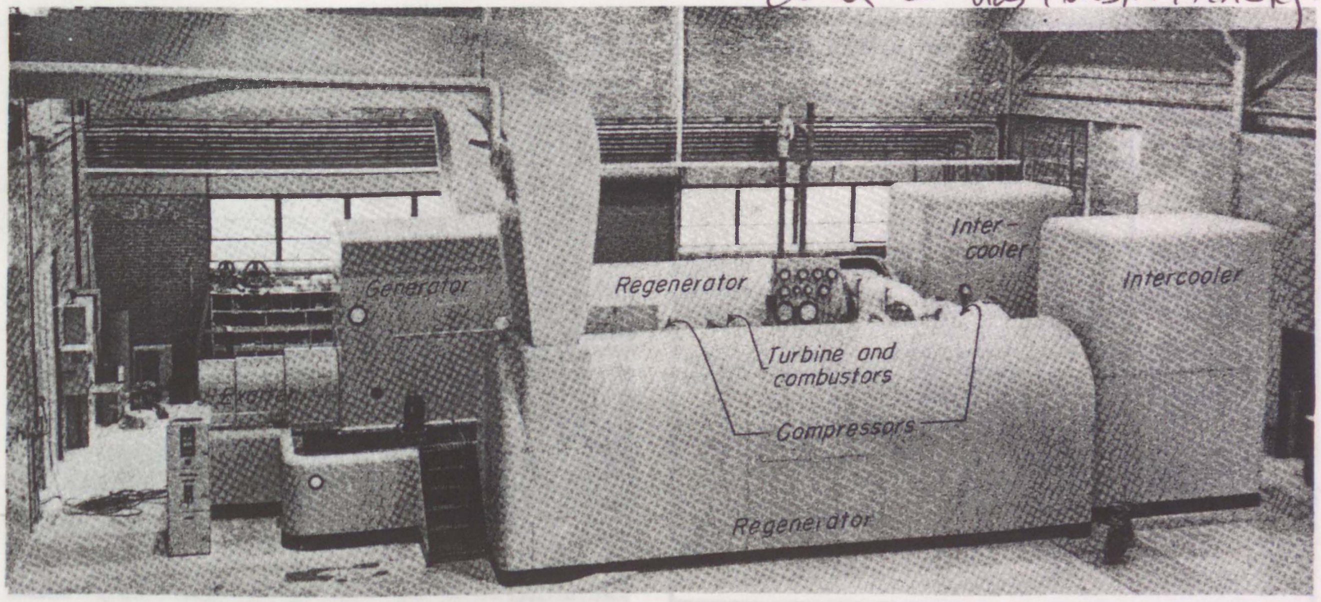

FIG 1—REGENERATIVE GAS TURBINE of 5,000-kw rating in compact arrangement has intercoolers and regenerators on one level. Turbine, compressors and combustors are between twin regenerators. Estimated cost is under $200 per kw

Regenerative Gas Turbine Efficiently Supplements Hydro

Bangor utility selects first of regenerative type gas turbines for its new Edward M. Graham station to provide standby and peak back-up for hydro in conjunction with diesel capacity

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The Bangor Hydro-Electric Co has recently completed the installation of the first regenerative type of gas turbine unit to go into central station service in this country. Operation of the unit was begun on Oct. 30, 1950.

Increased over-all efficiency is expected from the installation in comparison with non-regenerative equipment. This is due to utilization of a substantial part of the residual heat in the turbine exhaust to preheat the compressed air before it enters the combustion chambers. The initial unit (Fig 1) is rated at 5,000 kw by the manufacturer, but the expected maximum output at 70 F is 6,000 kw.

The machine was ordered in October, 1948. A new brick and steel structure (Fig 2) will house this first unit and provide space for a second of like design.' The new plant comprises the Edward M. Graham generating station, oil storage tank, cooling water intake, substation and interconnecting transmission facilities.

All-Hydro Generation Inadequate . . . Decision to purchase the gas turbine culminated a long series of studies by the company's engineering staff.

The company serves east central Maine, reaching about 100 communities having an estimated population of about 145,000.

Before December 1948, all system generation was hydroelectric. There are 11 hydro plants aggregating 39,570 kw effective capacity under normal water conditions. In 1948 three 2,000-kw diesel plants were installed. With the new gas turbine at Veazie the capacity of the thermal units will reach 12,000 kw, bringing total generating capacity to 51,570 kw. Individual hydro plants range in capacity from 320 to 9,300 kw. Normal heads range from 17 to 60 ft. Ten of the hydros are of the run-of-river type, operating under heads of 14 to 25 ft.

Many of the company's plants have the benefit of controlled storage on the principal branches of the Penobscot River totaling about 61.5 billion cu ft. Additional storage of about 6 billion cu ft is available elsewhere.

Studies by the Bangor company initiated as far back as 1937 weighed the relative economy of a steam turbine generating plant and further hydro development. Considering the power and process steam requirements of a paper mill customer it appeared that customer installation of a new boiler plant and high-pressure steam turbine installation would provide lower cost energy than any other type of plant then investigated, including undeveloped water power sites. It was

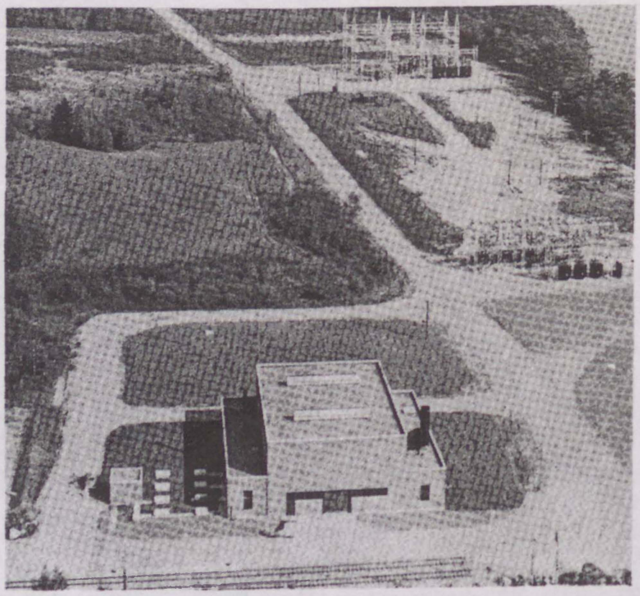

FIG 2—SIMPLE BUILDING of brick and steel adjacent to substations houses gas turbine with space for second unit

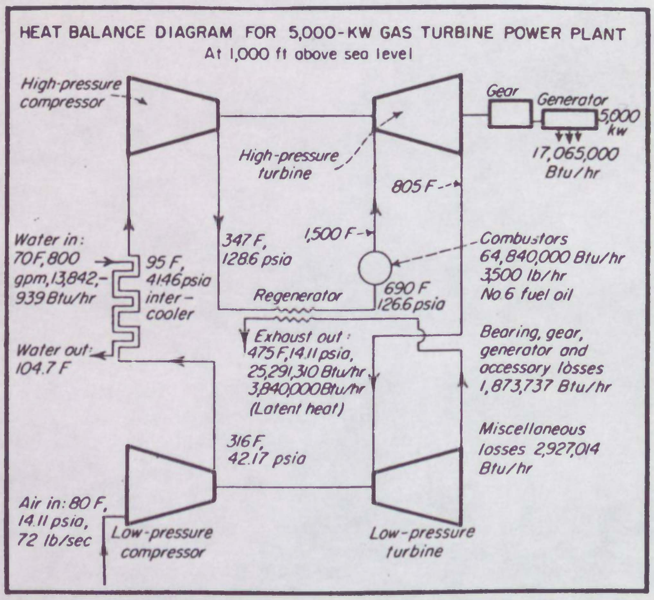

FIG 3—HEAT BALANCE diagram shows 17,065,000 Btu per hour output from 64,840,000 input in content of No. 6 fuel oil

also determined that the development of further increments of capacity at the company's existing run of river plants at Veazie and Milford, together with increased capacity at the Ellsworth hydro station could be done at comparably low cost. This held new capital investment to a minimum. Operating costs at the existing plants were not materially increased by the new capacity. This policy was adopted, and between 1938 and 1943 8,500 kw in hydro units were installed. When the new steam plant of the paper company went into service (see Fig 4) in the fall of 1947, its effect was to release about 10,000 kw of the utility's generating capacity for supplying the demands of other types of load and for meeting postwar growth. In so far as area power requirements are concerned this was the equivalent of a 10,000-kw addition by the power company itself.

Diesel Units Bought . . . Immediately following World War II the Bangor company experienced the same accelerated growth of domestic and other firm types of load as did other parts of the country. Coincident with this rapid rate of growth there began in July 1947 and extending to November 1949 a drought unequalled in any similar recorded period. It was clearly apparent that to guarantee continuous service to this firm type of load, thermal capacity was required on the system to back up the com-

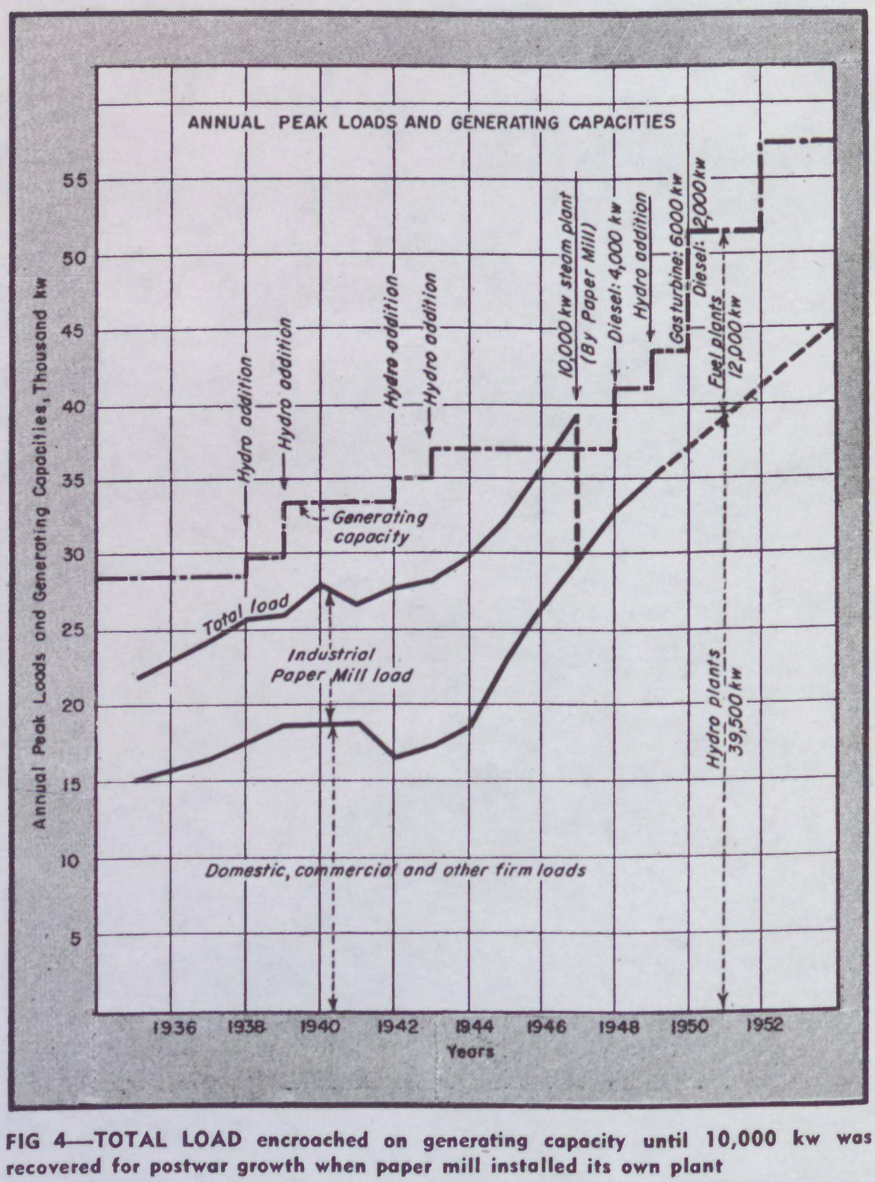

FIG 4—TOTAL LOAD encroached on generating capacity until 10,000 kw was recovered for postwar growth when paper mill installed its own plant

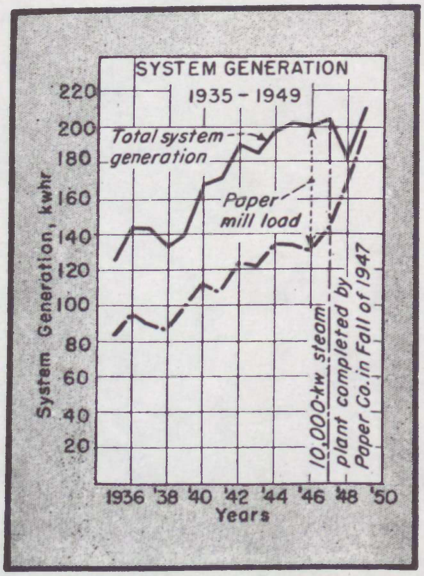

FIG 5—SYSTEM GENERATION PLOT discloses significance of paper mill load that was relinquished in 1947

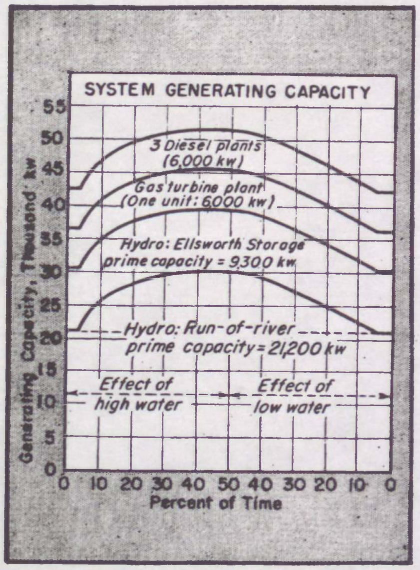

FIG 6—HYDRO AVAILABILITY under both high and low water indicates value of gas turbine and diesel increments

pany's hydros. The character of a part of the load was changing. Whereas formerly a substantial part of the company's generating capacity (Fig 5) was used to serve a paper mill load on the basis of secondary power subject to curtailment under adverse conditions if and when necessary, that type of load was now to be replaced by firm load requiring continuous service. The result was that the company could no longer rely solely on available hydro generation.

For the first step of thermal capacity three diesel plants were built, each having two 1,000-kw, 4-cycle, 1,425-hp engines. These were particularly useful in two locations in protecting service to fish packing plants and improving regulation on long transmission lines.

Gas Turbine Unit Selected . . . Early in 1948 President E. M. Graham decided, as a result of continued studies by the engineering department, that the next unit of generating capacity to be added to the system should be a thermal unit of not less than 5,000 kw. The development of the art of gas turbine manufacture had progressed to a point where the builder of the machine could guarantee equal or better economy in performance of such a unit than with a steam unit of comparable size. Tests were in progress at the time in the factory on a simple or single stage of gas turbine which indicated success in its performance beyond any reasonable doubt. Designs for the regenerative type of unit (Fig 3) had also progressed to the point where it was ready for commercial manufacture.

Although the gas turbine type of unit lacks the experience which the steam turbine and diesel types have had, it was deemed more advantageous than either steam or diesel in every other respect for the next step of generating capacity to supplement the company's hydro system. This conclusion was based on the following advantages of the gas turbine plant:

1. Its capital cost is estimated to be less than that of a steam plant of comparable size in this locality and when completed, with two units installed, is expected to be less than $200 per kw.

2. The power plant building and permanent structures are simple in character and less expensive than those of the steam plant.

3. The water requirement for cooling purposes is only from one-fourth to one-sixth that required for condensing purposes in a comparable steam plant. This factor was a major consideration in the location of a thermal plant in the vicinity of Bangor.

4. The thermal efficiency of the regenerative type of gas turbine unit is expected to be equal to or greater than that of a comparable steam unit.

5. The gas turbine will burn Bunker C or No. 6 oil, whereas diesel units require a lighter and more expensive oil. At present writing, the price of Bunker C oil is about two-thirds that of premium diesel fuel in Bangor.

6. The gas turbine unit may be placed on the line from cold conditions upon 30 minutes' notice. It does not require burning of fuel when out of service, as is the case of a steam plant where fires are banked and fuel is wasted in order to maintain the unit in a condition to be placed on the line in a reasonable time. This factor is of considerable importance to the Bangor company, since it is expected that the gas turbine plant will operate at a light load-factor on the peak of the load.

7. The gas turbine plant does not require highly specialized operating personnel and the number of attendants is expected to be less than would be required in a steam plant. This advantage should reflect substantial economy in operating costs.

8. The maintenance charges on the gas turbine installation are expected to be no greater and possibly may be less than those of either steam or diesel units of comparable capacity. This is due to the comparative simplicity and relatively small number of component elements of the gas turbine.

The accompanying chart (Fig 6) indicates the manner in which the thermal plants are expected to be operated to supplement the company's system of hydro plants.

Fig 6 shows the prime capacity of the so-called run-of-river plants on the system to be about 21,200 kw. With the Ellsworth storage plant the system has a prime hydro capacity of 30,500 kw. The capacity of the run-of-river plants is affected not only by low water but also by reduced head in time of high water. Thus, with hydro operating conditions represented as existing 50% of the time, flow in the Penobscot River at Veazie is about 9,000 cfs and the operating head 17 ft. Under that condition the only limitation on output is the installed generating capacity of the plant.

For the low-water-supply operating condition (Fig 6) wherein the flow at Veazie is 4,700 cfs for approximately 5% of the time, the plant output is reduced because of insufficient water to supply all the installed capacity. In high water periods usually occurring in the spring, the plant output is curtailed by a reduction in head caused by lowering the flashboards on the dams and raising of tailwater levels. For the condition indicated at Point C the flow at Veazie is about 40,000 cfs and the operating head for that flow is approximately 13 ft. The generating capacity indicated for the aforesaid limiting flow conditions is considered as prime capacity because of considerable diversity of flow conditions throughout the system and because the river flow at Veazie rarely exceeds those limits during the annual peak load period, usually occurring in December.

To meet the projected 1952 peak load of firm power customers with adverse water conditions wherein only the prime capacity of the hydro system is assumed to be available, the gas turbine plant is expected to operate on a daily load factor of not over 25%. This indicates the stand-by or peak load type of operation expected of the new plant, and because of the simplicity of its operation emphasizes its value to the Bangor system as compared to a steam unit.

It is furthermore expected that as load continues to grow, further hydro capacity will be added to the system so that in the years to come hydro and thermal capacity will keep pace in such a ratio as to afford the most economical over-all system operation.

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