

the older communities, where large systems have grown up, supplied from well-developed steam installations, water power supply may be obtained from local small sources, strictly supplemental to the steam plant, or may be brought in over transmission lines from some outlying water power system. In the latter case, the ideal would be obtained by a traffic agreement between the two companies by which the water power system could utilize to the full the capacity of the steam plant to relay its own system during low-water periods, and could furnish the steam plant in return surplus power to reduce the fuel consumption of the steam plant.

The author presents curves to indicate graphically, by a hypothetical case, how the system load would naturally be divided between the water power and supplemental plant. It is assumed that the water power plant has sufficient pondage to enable it ultimately to carry the daily peaks, leaving the base of the load to be handled by the steam plant. The curves represent the four stages indicated by functions I., II., III. and IV., expressed above and relate to the following cases:

(1) The system load is assumed to be equal to but not exceeding the low-water capacity of the water power plant.

(2) The load exceeds the low-water capacity and equals that of the water power plant. Steam supplement is required during low water.

(3) The load exceeds at all times the water power plant capacity calling for the daily use of the steam plant to carry part of that load. During normal water, water power takes the base reducing the hours of daily steam operation. During low water, when water is insufficient to carry the whole base to allow steam to operate on short hours, the capacity is used to better advantage by handling the base by steam.

(4) The load exceeds the water power capacity at all times to such an extent that steam dominates the output. The water power then, by taking advantage of its pondage provides the peak load capacity and reduces its hours of daily operation.

In order to illustrate what has been the general experience and practice of public service corporations utilizing water power in the eastern states, the author collected information from a number of the more important companies as to the general policy of the companies in utilizing the existing capacity in steam plants of their customers, also the general principles followed in the sale of power calling for supplement either by the customers for their own protection, or by the company for its own or its customers' benefit. The situation consists of three classes, somewhat at variance with the above ideal classification. They are:

(1) Markets already existing either wholly supplied from steam or with steam dominating, and gradually absorbing transmitted power.

(2) New, or recently developed water power installations or extensions seeking new markets are usually more or less supplemented by steam.

(3) Power sources extended either by re-development or by interconnection with other powers by means of electric transmission to better serve the territory covered.

The power customers having steam plants available for auxiliary use are of three classes:

(1) Public service railway, light and power companies.

(2) Mills having their own steam plants.

(3) Other water power developments having surplus steam plant capacity.

In addition, information was sought on the extent to which the various companies have found it advisable to relay their water power; the extent to which they had been able to obtain the use of their customers' steam capacity; the principal uses to which the supplemental plants had been put; the general location of supplemental capacity; the general method of getting and paying for the customers' supplemental capacity; the methods employed of quick steaming and starting; and the organization for, and time necessary to start and pick up the load.

A company operating about 50,000 kw. of water power capacity started out a few years ago with the idea of utilizing through contract agreements the steam capacity of its customers, and although unusually successful in carrying out this principle, nevertheless the company has found it advisable to provide its own supplemental plant to the extent of about 15 per cent. of its hydraulic capacity. In the last few years the proportion of its relay power has increased from about 2.5 per cent. to about 20 per cent. of the total kilowatt-hour generated, the latter figure representing the year 1914, which was a period of unprecedented drought. This company's ponds are sufficient to allow the water power plants to carry the bulk of the daily peaks making it necessary, as a rule, to call on the customers only at such times as they can spare the power.

The contracts with the customers furnishing supplemental power in general provide that, on request of the company, the customers shall supply power in such quantities and at such times as it may be required, provided this does not interfere in any way with their regular business. Such power is strictly "off peak" and requires no expense on the part of the customer for additional equipment.

The steam plants, of both customers and company, are used primarily for low-water supplement and only rarely for breakdown relay.

Another large company with about 5,000 kw. in water power started out on the assumption that what New England wanted was primary power, but it has seen fit to reverse its policy and now furnishes principally secondary power, depending on its customers to supply all the supplemental power required. In this way the company relays its water power to about 85 per cent. of its capacity. These customers are public service companies in general lighting and power business.

The principal use made of the customers' steam plants is for low-water supplement, although they are depended on for breakdown relay as well. Two have only enough capacity to handle their own loads and operate only when required to help out the water power. The third furnishes during low water the supplemental power required by the water power company in handling its other business. By an agreement with the first two customers the company furnishes them power at a price which warrants them in shutting down their steam plants, but does not require them to provide any additional capacity for the needs of the water power company. As the summer peak of the third coincident with the low-water period is only half their winter requirements they can furnish all the relay required by the company also without additional equipment. The company pays the customer a kilowatt-hour rate sufficient to give him a reasonable profit, but without any additional installation charge.