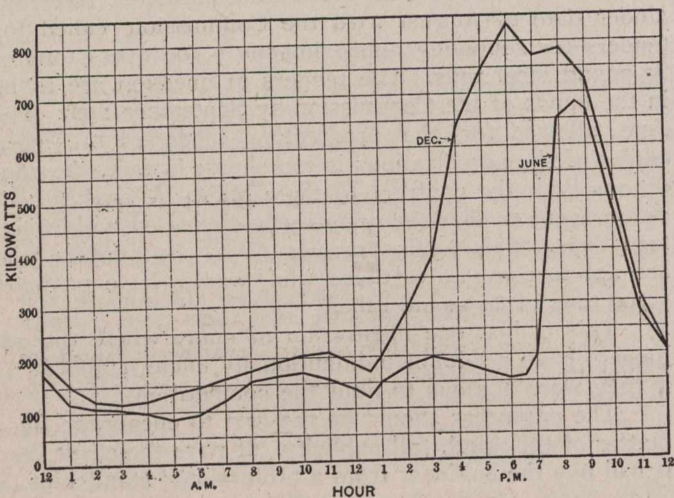
DIVERSITY FACTOR.*

By H. B. Gear.

In the distribution of electricity for lighting and power purposes over a large city, the maximum demand of the day upon the distributing system varies from day to day during the week, and from month to month during the year. The varying length of the day due to changing seasons, the habits of the population served, and the character of the district, whether residence, mercantile or manufacturing, combine to produce this situation.

In residence districts, for instance, the use of light is such that the maximum demand comes at about 7.00 p.m.



in winter, and at 8.30 p.m. in mid-summer, as shown in the load curves in Fig. 1. In outlying business districts in the large cities and in the central business districts of the smaller cities, the maximum demand comes from 5.30 to 6.00 p.m. in winter, or at 8.30 p.m. in summer. It is usually heavier Saturday than other nights of the week. In the central business districts of cities like Chicago the maximum demand comes from 5.00 to 5.30 p.m. in winter, and at various other hours in summer. Here the Saturday load is less than that of other days because of the early closing of offices and shops that day. This is also true of manufacturing districts, where the load is chiefly power. In a purely manufacturing district, the maximum load occurs at about 10.00 a.m., the afternon load being from 15 to 20 per cent. less than the maximum of the morning. The load curve in Fig. 2 is that of a power circuit which carries some lighting and so has a 5.00 p.m. maximum.

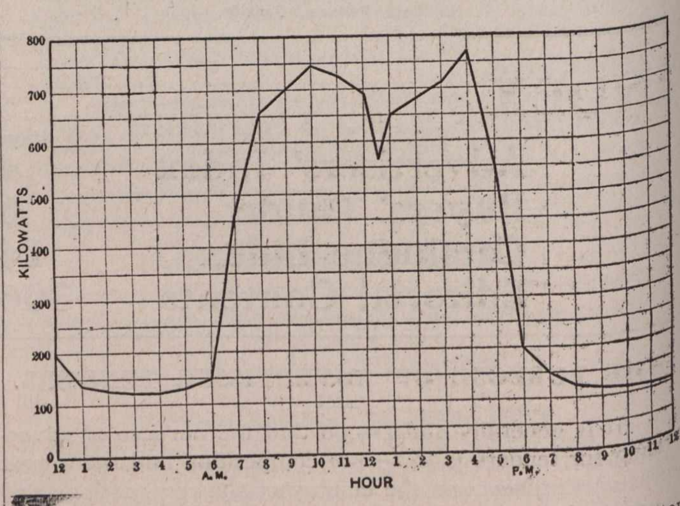
In the larger cities the conditions vary in all of these classes of service more or less with the character of the population. The habits of the people in the foreign populated wards are different from those bordering on the boulevards, and the requirements of dwellers in apartments are different from those living in houses. In the outlying districts of Chicago, stores are closed Wednesday and Friday evenings, while in downtown districts very few stores are open evenings at all and the use of electricity is limited largely to show window and display lighting. During the summer the loss of demand in residence districts is partially made up by the requirements of the pleasure parks. The combined curve for these various classes of service is shown in Fig. 3.

The combined effect of all these influences is to produce a smaller maximum demand at the generating station than elsewhere in the system. That is, the sum of the maximum demands of the transformers and distributing mains is greater than that of the feeder. The sum of the feeder maxima is greater than that of the substation, and the sum of the substation maxima is greater than that of the generating station.

The ratio of the sum of the maxima of the subdivisions of the distributing system to its actual maximum demand as observed at the point of supply is called the diversity factor. Thus, if the sum of the individual maximum loads on the ten feeders of a substation is 1200 kw. and the coincident maximum of the feeders is 1000 kw., the diversity factor is $\frac{1200}{1000}$ or 1.20.

The study of diversity factors is of great importance from a commercial point of view as well as being an interesting engineering problem. The investment required by the central station company in the various parts of its operating system for each kilowatt of maximum demand, determines the fixed charges which must be considered in determining costs and in making an equitable system of rates.

The existence of a diversity factor between the demands of a large number of consumers permits the central station company to supply their demands with a much smaller investment in generating capacity and at a lower cost of production than would be possible if these consumers were operating individual generating plants. This difference must be sufficient to enable the central station to add the financial burden of a distributing system and yet have a margin upon which to sell its product economically to its consumers. The effect of the diversity factor is therefore a subject of interest to both producer and consumer of electricity.



The larger the system the greater the diversity factor and our study will cover an alternating current system supplied by substations, feeders, mains, transformers, etc., as shown in Fig. 4. An alternating current system has been selected for analysis as it is somewhat easier to observe than a direct current low tension system because of the presence of transformers whose load may be measured. The loads on the distributing mains of a low tension feeder are not so easily measured, and observations, therefore, cannot be readily made.

The consumer being the originator of the demand for electricity, the development of the diversity factor logically proceeds in the reverse direction from the flow of energy.

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