Power

ENERGY DISTRIBUTION
PRESENT AND PROSPECTIVE

BY
JULIAN C. SMITH

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IN the few minutes which have been allotted to me, I wish to bring to your attention some figures which are now a matter of record, showing the growth in the use of electric energy, and the result which it is having and will continue to have, on the development of electric stations.

As you know, the use of power began in the mining industry in the eighteen hundreds. It was as late as 1840 or 1850 before the development of steam engines had reached any considerable size, and from that time on the development has been extremely rapid.

Naturally, the first development was for each different user of power to instal his own equipment. This was in fact practically the only thing which could be done, as the sizes of the prime movers were small, and there was no means of transmitting power from one station to another except by means of belts, rope drives, etc.

About 1880 electric power first began to be used, and ten years later the first alternating current devices began to appear. From 1890 on to the present time, in a space of 27 years, there has been a continuous development on an increasing scale.

The total amounts of power, excluding railways and steamships, used in the United States at periods of the census taking, are as follows:—

1870.....2,461,000 H.P.	1900.....15,200,000 H.P.
1880.....3,617,000	1910.....23,300,000
1890.....6,315,000	1915.....30,000,000

The population of the United States has increased very considerably in this time, but the following table gives the amount of power used under the same conditions, that is exclusive of transportation and animal power:—

H.P.	Per Capita	H.P.	Per Capita
1870	.064	1900	.20
1880	.072	1910	.25
1890	.10	1915	.30

(Total power, including everything, 150,000,000 h.p.) in U.S. in 1915.

I have used the figures for the United States because they are more readily available, and illustrate the conditions which exist throughout the entire civilized world—that is, that there has been an increased use of power per capita, and that this increase is going on at a high rate year by year.

The following list shows the total kilowatt hours used per capita per year, as supplied by electric service companies for all purposes, except railways in certain representative communities:—

	K.W.H. per capita per year
State of New Jersey	180
Entire United States	230
Greater New York	225
Philadelphia	250
Boston	350
Baltimore	400
Cleveland	400
St. Louis	400
Minneapolis	450
Rochester	450
Pittsburg	500
Niagara Falls, N. Y.	33,000
Quebec City, Que	200
Toronto, Ont	700

	K.W.H. per capita per year
Montreal, Que.	700
Three Rivers, Que.	3,400
Shawanigan Falls, Que.	41,000

On broad lines this indicates that mankind has become more and more dependent upon the use of energy derived from waterpowers or steamplants, and with the data at hand we can make a fairly reasonable prediction as to what the conditions are going to be in five or ten years to come.

Thus the development has passed through three stages already:

(1) The use of small power units driven by steam, which were set up in the individual factories of the power users.

(2) The concentration of these units in large units of power, and the consequent concentration of the factory into such single large units.

(3) The development of the power business as a separate enterprise, and the distribution of this power to different industries.

We now seem to be reaching the fourth stage, and that is, the continued concentration of the power development in large units linked together for purposes of reliability, and the distribution of this power both in large units and in small units to each individual who requires power for any purpose.

It has only been within the last ten years that the average householder could utilize power of any kind in small units for various purposes in connection with his house or small industry.

Today in the United States and Canada, in those places where normal industrial life exists, the kilowatt hours used per year per capita amount to about 500. Of this amount 400 k. w. hrs. are used for factory purposes, outside of dwelling houses or residences of individuals, and 100 k. w. hrs. are used for housekeeping purposes, including princi-

pally light, and to a lesser extent heat and motive power.

With the increased use of the small accessories and almost certain development of electric cooking in the near future, we may readily look forward to a condition of affairs in five or ten years when the use of electric energy for the individual, that is leaving aside the industrial or factory use, will increase from the present amount of 100 k. w. hrs. to 300 k. w. hrs. per capita per annum, or an increase, as you see, of 200%. At the same time, the industrial use is bound to increase, and there is every probability that in ten years from today the use of electric energy will amount to twice as much as is used at the present time. This does not mean that every customer is going to take twice as much as he is now taking, but it does mean that on the average, over a considerable territory, located favourably for manufacturing, the use of power is is increasing at a very high rate.

The question naturally arises "What future developments may be expected in the production and distribution of power?" and this Association is vitally interested in the proper solution of these problems.

As regards the production of power, comparatively little time can be spent in this paper. The development of power by means of water power stations has reached such a high point of efficiency that very little can be hoped for in this regard. The efforts of our engineers and designers for the next few years must be devoted to those features of the problem of hydraulic power development which are involved in the reduction of costs.

The development of power in steam stations although rapidly increasing in efficiency, still offers the possibility of great reductions of present day costs when higher steam temperatures can be

employed, so that present day comparisons between the cost of steam generated power and hydro electric power, may be very much upset by the possible future advance in the art of steam power generation.

The financing of these enterprises must also be improved, so that the total cost of the hydraulic power development can be brought down to more reasonable figures, everything considered. The government authorities can assist in this matter by preventing the duplication of lines and systems and by the proper control of construction work, so that competitive systems cannot be constructed solely for the purpose of stock jobbing operations or for political benefits. It is inevitable in such cases that the burden of the increased expenditure must be carried finally by the population served, with the consequent result that the cost of the service rendered is increased.

The proper control of rates by the Government authorities, coupled with protection against competition and the assistance of the government in working out the true economic conditions in the development of these enterprises is, I am sure, the result earnestly hoped for by the members of this Association.

Wild promises made by people who have had little experience in the building and distribution of electric power, that power can be generated for a few dollars per horse power, and delivered to isolated farm houses or small communities, at prices very much below those current at the present time, only cloud the situation and postpone the proper solution of these problems.

We may some day see the time when practically everyone will obtain electric power as readily as they now obtain telephone service, or the service of good roads, but these problems cannot be solved without due regard to the factors involved, and

the sooner everyone realizes that such factors do exist, the sooner we may arrive at a solution of one of the most difficult problems which presents itself in the sale of electric power in small units.

A large hydro electric power station, financed under good market conditions, and protected against the hazard of intense competition, may be constructed in these days for about $100 per horse power, where the natural conditions are favourable. Usually such a power station is located at considerable distance from its market, and transmission lines are required. Such transmission lines vary of course very much in cost, depending on the distance, the amount of power to be transmitted, the character of the line, etc., but it would be a fair estimate to assume that such a line can be constructed for, say, $50 per h. p. This will deliver power from the hydraulic power stations to reasonably large communities at a capital cost of $150 h. p. in the shape of high voltage power. This power must be stepped down, must be fed into a distribution system at perhaps 12,000 volts, must be again stepped down to 2,200 volts, and fed into the usual distribution system which supplies the individual customer.

The cost of this distribution system again is difficult to estimate, except in individual cases, but it might be stated that the 12,000 volt system will cost $50 per h. p. with its transformers, switches, etc., and the low tension or 2,200 volt system with its transformers and low voltage conductors will cost anywhere from $75 per h. p. up to $150 per h. p.

Thus the total cost of delivering power from the hydro-electric power station to small consumers located in towns of from 2,000 to 3,000 inhabitants amounts to $300, and sometimes considerably in excess of this figure.

It should be borne in mind that this represents the actual investment of money, and that if the

rate of interest is based on 6% value of money, that the consumer must pay $18 per h. p., based on his maximum demand,to cover the interest charges on the investment involved. To this amount should be added the operating costs, which of course vary materially, but in the case of small customers would probably be upwards of $10 per h. p., and again there must be added items of insurance and depreciation, amounting to at least 5% more on the total investment, or $15, making the total cost $43.50 per h. p. on the maximum demand. Nothing is added in for the actual cost of the power, or the profit. Assuming that all of these items combined represent $5 per h. p., for water power plants the total cost is then $48.50 per h. p. per year.

The load factor of the average small consumer is very small, and consequently the rate per kilowatt hour must be made high, with a guarantee of a certain definite return, if the business is to carry itself.

I realize that the figures given above are open to very considerable debate, but even if the figures are modified considerably, the final result will in most cases arrive at a high figure.

This demonstrates what I have stated above, that one of the most serious problems facing any company engaged in the distribution of electric power, is the problem of selling power to the small customer where the density of business is small. As the average customer increases his use of power by taking on accessories, doing his cooking by electricity, the conditions may be benefited somewhat, although unfortunately a good deal of new business which will doubtless come on, has a comparatively poor load factor, and in many cases laps over the present lighting peaks.

In conclusion, I would sum up all I have stated above very simply:

(1) That we are in the midst of an enormous extension in electric power systems, and we may look forward to doubling the sale of electric energy in the next ten years. A good portion of the doubling will no doubt be in the large users of power, including perhaps the railways, but there will be a very large amount of increased power sold to individuals, due to the fact that the demand for each household using power is going to increase, and the use per capita from this cause alone will represent a very great number of kilowatt hours per annum.

(2) The problems of generation and transmission are fairly well solved.

(3) The problems involved in the organization of companies, in the reduction of expenses by the elimination of competition, and in the better co-operation of the government control, must all be met and solved successfully within the next few years, if the growth we see coming is to be realized in its greatest extent.

(4) One of the most difficult problems is the sale of electric energy in small quantities in isolated communities. This is of great importance because of the large number of people interested, and whose demands for such service must be taken into consideration. The problem must be solved by careful study and investigation, and by the recognition of all parties concerned that there are serious difficulties involved which necessarily cause the price of electric service delivered under these conditions to be high. The solution of these problems can only be satisfactorily arrived at by the co-operation of all of us, including the customer to whom we sell the power.

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