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Lecture

P O W E R.

By

Gen. Chas. Keller,
Ret'd.

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POWER.

There is no longer any question that modern war requires for its success the efficient coordination and use of all national resources, whether in men, material, transportation facilities, or instrumentalities of production. This efficient coordination and use upon a nation-wide basis implies something more than voluntary cooperation on the part of those who control such of these resources as are not actually incorporated in the military and naval arms of government and we now accept it as an axiom that, in some form, national control must be appealed to in order that the required degree of coordination, certainly of our major resources, may be attained.

Much of your time might be spent in seeking to inventory the resources that may properly be classed as of fundamental importance in war. I pass over this point since your studies qualify you for this inventory far better than I, but I feel that I am on safe ground in asserting that, among those industries on whose efficient and appropriate functioning our war-making capacity depends and will continue to depend, there is none more vital than the electric power industry.

At the risk of seeming to be unnecessarily specific, that there may be a clear understanding of what is meant by the term "electric power industry", I wish to say that by these words I mean public service corporations engaged in the operation of central stations for the generation and distribution of electrical energy.

Electrical energy, so generated, has to a large extent superseded energy individually generated and locally used, and it is because of this that efficient control of the electric power industry will help to enable the war-making arm of the government to bring into coordinated use important national resources.

As illustrating the growth in the use of central station energy and the corresponding decline in power capacity of local plants, serving particular industries only, it may be of value to you to consider the following facts, which are derived mostly from the U.S. Census Reports and were furnished me by Colonel Kelly, Director of Engineering of the National Electric Light Association.

The increase in the use of energy in the United States has been nearly directly proportional to the increase in population, so that since 1900 there has been added exactly one horse power of prime moving machinery for each unit added to the population. As shown in the table and in Fig. 1, most of this growth has been in central station plants whose capacity has risen from 1,845,000 H.P. in 1902 to 29,000,000 H.P. in 1925.

Such growth has been largely at the expense of the isolated factory power plant as is shown by the trend of the industrial primary curves on the diagram and by the fourth column in the table. Since 1919 the capacity of installed prime movers in industry has slowly decreased, while the total rating of electric motors operated on central station power has increased from 400,000 H.P. in 1902 to 15,400,000 H.P. in 1925.

The cross-hatched area on the diagram is notable in showing the extent to which electrical energy has been developed in the United States.

The departure of the curve of "total power" above the line of average trend is believed to be due to the fact that obsolete individual plants, now replaced by energy from great central stations, are still included in total capacity.

In any event official statistics show that in 1902 mechanical power, formerly exclusively used in manufacturing amounted to 11,000,000 H.P., while electrical prime movers, whether in industry or in central stations, had a total capacity of 4,800,000 H.P. Mechanical power reached its maximum, 14,800,000 H.P., in 1917 and has since declined, its estimated capacity being 12,500,000 HP in 1925, whereas electrical capacity has been steadily increasing at an accelerated rate, the 1925 total being estimated at 40,100,000 H.P., or 76.2% of all prime mover capacity in the United States.

The increasing use of purchased or central station energy in factory operation has been the principal cause of the growth of the central station industry. This is shown on the Figure 1A, both by the curves and the tables, which speak for themselves, though it may be noted that this particular fraction of the central station load grew from 441,589 H.P., or 27.7% of the electrical energy used in 1904 for manufacturing to 15,400,000 H.P., or 61.1% of the total.

This latter figure, "61.1% of the total electrical power used in manufacturing, now appears to be the limit for the reason that, in many great industries, heat not power is the

dominating consideration, as for example when exhaust steam is used for manufacturing purposes, or when the by-products of industry make available a great amount of energy at prices far below those of any central station. This situation is shown in Figure 2, which is based upon the experience of a variety of industries.

However, even though we have reached a percentage limit in the use of central station energy in manufacturing, it is clear that this class of energy is one of the major factors in our national life and we know that many of our most important war industries, particularly the electro-chemical group, for their functioning depends on central station energy exclusively. Moreover, the intimate way in which central station energy for domestic, business and street lighting, and for local transportation, enters into the everyday life of the people, renders it necessary that, when the nation is called on to exercise its war powers and every resource is strained to the utmost, effective control be exercised over the central station industry, and that every effort be made so that this, as well as all other important industries, be operated with the least possible strain on other resources, such for example as coal and transportation, and with the greatest possible efficiency from the standpoint of a well-rounded war program.

Our experience in 1917 and 1918 goes to prove the necessity and the wisdom of such control. The authorities were taken by surprise, without any preparation for the shortages and difficulties brought to them for remedy and, as a consequence, the system of control set up lacked much of being satisfactory. We have that experience and knowledge before us as a guide, and our presence here is proof of the fact that this living and constantly changing war problem will not fail of proper recognition and suitable treatment when the time arrives.

Without further argument, it may therefore be assumed that governmental control of the central station industry will be a necessity in future wars, and that continuous study of the relation of the industry to our war program will afford a satisfactory general knowledge of available installed capacity, of additional capacity under construction, and of plans for further construction, as well as of the extent of interconnection between adjoining systems and of further practical possibilities in this direction. Such information should include estimates of the time and money factors involved.

Assuming that, with knowledge of the details of the up-to-date war program, including the probable allocation of war orders and corresponding assignment of required electric energy, it is proposed to create an instrumentality for the support and control of the power industry, the form that such

an agency should take is fairly well defined. It cannot be doubted that the well-tried method of decentralized control by appropriate subdivision of the country into districts should be adopted, with a power administrator and a suitable staff in Washington to maintain general supervision and contact not only with the officers in charge of the districts but also with the fluctuating situation in Washington. The Power Administrator should preferably be an army officer of sufficient service and experience to enable him to deal on an equal footing with others in the government service who are charged with similar authority and responsibility. He should have a good general knowledge of the electrical industry, its existing condition, and its possibilities as regards the war program, but he need not be an electrical engineer nor an experienced operating man.

On the other hand, his principal assistant and adviser should be a man of superior technical equipment and of recognized position in the industry, one whose impartial judgment and good sense are conceded by all. This man need not be commissioned as an officer unless he desires to be. It will be wise to choose him from a list of names suggested by the industry itself as this is the best assurance that he possesses the requisite qualifications, both of character and of professional standing.

The remainder of the personnel of the office of the administrator should properly consist of temporary officers who are qualified technically and as electrical operators, and such men should also be chosen as district administrators.

This was the plan on which we operated quite successfully in 1917 and 1918. In view of your studies and preparations for another such emergency, it will be far easier now than it was then to set up a proper organization and to equip it not only with adequate personnel but with appropriate policies and instructions.

One advantage you now have is inestimable. Through your existing agents you are in constant close touch with the industry itself and are in a far better position than were we who had to make these contacts after trouble had begun. In fact there should be few emergencies connected with them and you should be able to give to your district executives a correct picture of the obligations resting on them and of the means at their command for meeting those requirements. What I have in mind is that the portion of the war program of production required at each industrial centre will probably have been agreed upon and that the district administrators can, as a result, be supplied with information of the portion of the program which they are expected to help accomplish as well as with schedules of priorities and allocations of electrical

power based on available and prospective power capacity. This kind of coordination was lacking in 1917 and 1918, and it took months to develop it in an informal way.

I have purposely refrained from repeating in detail our experiences upon which, in part at least, you are now endeavoring to build and to improve, for such experiences are now an oft-told tale. One point, however, may be emphasized and that is that not only did we find the industry helpful and responsive, but that we too were able to help the industry to do things which appealed to some of its members as desirable, but which they were, for one reason or another, precluded from doing themselves. For brevity, I cite merely two examples. One was a case in which a group of power companies was committed to contracts for the delivery of power which in their opinion and ours might much more advantageously have been applied to other uses. The companies desired to supply these other uses and this desire was by no means based on motives of profit, but they dared not break the contracts. We relieved them of their contract obligations by transferring liability to the United States, a step in our opinion unavoidable if production of war materials was to be stimulated.

In another instance there existed a surplus of water power at a development newly completed on the Klamath River in southern Oregon, while, at the same time, in Central California the largest power company on the Pacific had a shortage. Intervening between the territory of the former company and that of the latter as another company. The third company and perhaps the second one also were, for various reasons, unwilling to join in the interconnection necessary to bring the surplus energy to the market in need of it, while the water power company, for financial reasons, was anxious to have the connection made. While it would have been possible for our representative in California to have ordered the line built, he judged it better not to force an issue which might have caused his authority to be questioned. Accordingly, he joined the California Railroad Commission in urging the reluctant companies to cooperate and his influence proved to be decisive. The line was built and is now in use. Its construction put the water power company on its feet financially while the surplus power thus made commercially available was of great service to the original protestants when in 1919 they experienced a great power famine due to the low water of that year. The benefits of this judicious exercise of commanding influence have proved to be widespread and permanent, while their existence was obvious, it is probable that without the intervention of Major Sevier, our representative, they would have been impossible of realization.

In addition to the advantages you now possess in having knowledge of your problem, opportunity to study it, an example before you of a passably successful solution, and the deliberate and hearty cooperation of the industry itself, there is another gain of importance arising from the great growth of interconnection between adjacent systems by the construction of high-tension transmission lines.

In 1917 and 1918 such interconnection as existed proved of great value. For example, we were able to substitute energy generated at Wheeling in a certain measure for energy supplied by a company whose main plant at Pittsburgh had become greatly overloaded and in a somewhat different sense we were able in Western New York to place in commission once more steam plants that had been relegated to idleness by the introduction of Niagara water power, but no such general interconnection existed then as is now at your service, affording a degree of elasticity, of give and take not heretofore possible.

We hear much of super-power and of giant power. There is danger that fallacious generalities may lead to ill-founded conclusions. Neither superpower nor giant power, if those terms mean anything definite, can be relied upon to give you more energy than is actually susceptible of commercial use. My understanding is that these picturesque names mean interconnection and that usually, though not necessarily, they infer the existence of high capacity, long distance transmission lines. It may be taken as a fact that interconnection between adjacent systems is now being developed as quickly as the commercial and financial advantages to be gained justify, and that on no other basis than mutual profit will superpower, giant power, or interconnection ever come about.

The profit to be anticipated will arise from a cheaper power supply, either because of lower generating cost, better load factor, or smaller fixed capital invested in reserve capacity. In many cases both parties to an interconnection will in this way gain while incidentally putting to use facilities that could not otherwise be employed.

As examples of the favor with which interconnection is now viewed, let me cite two cases coming within the domain of operations of the company with which I am connected, the Standard Gas and Electric Company.

The first case is at Pittsburgh. You probably know that in 1917-18, Pittsburgh was one of our sore spots and that, due to causes arising before the war, up to the time that we intervened, there was but small cooperation between the two companies

serving that territory. Since then each of them has built a new steam power plant above the city on the Allegheny River. These plants are only two miles or so apart and they are both equipped with large units. As conditions were before the war, neither company would have paid much attention to what the other was doing, for they weren't the best of friends. Now, common interest has brought understanding and so at this very moment the Duquesne Light Company, which is now under our management, has an agreement with the West Penn Company calling for the installation of large units, 30,000 K.W. or more, alternately in each station, the surplus output of the last large unit installed being taken by the non-owning company. The result is to load each new unit more quickly than would otherwise be the case and at the same time to keep invested capital and reserve capacity at a minimum. Here interconnection is so intimate that, in the language of the head of one of the companies, the plants function as though operated from a single bus-bar.

The second case is that one of our companies in California which has two hydro-plants, operating in part on stream flow and in part on stored water, and a small steam plant. During periods of liberal river discharge, the output of the water power plants far exceeds the requirements of our own load. Unless the excess can be sold, it is wasted. In the later summer and fall, water power output is relatively small and our system must be supplied in some other way. The small steam unit would be expensive, but it would have to be resorted to were it not that we are interconnected with an adjoining great system.

This interconnection not only enables us to supply our shortage, but it also affords a market for our surplus and it gives us a standby to which we can resort when we have occasion to lay up or repair part of our water power capacity.

The situation is made clear on Figure 3 which shows what happened during the dry year 1924, at the beginning of which our El Dorado plant of 20,000 K.W. went into operation, giving us a surplus early in the year. Overlapping of energy purchased and sold is due mostly to the fact that the El Dorado plant was undergoing a process of trial and adjustment, so that occasionally it had to be shut down during the early months of the year. Later, shortage of water reduced our system output so that from about June 1 to about October 1 must of the energy distributed in the system had to be purchased. (Figure 3 shows production, power purchase and power sales during the year 1924).

The advantage of interconnection when a cooperative spirit exists on both sides needs no further illustration, but it may be illuminating to draw attention to what happens when cooperation is not complete.

We have, in the Middle West, a property whose main market is a large city which we supply with electrical energy from a steam station in the heart of that city.

Our system on the east and south adjoins territory supplied by a company whose plants, steam and water power, are connected with ours by a transmission line about 100 miles long. The agreement between us calls on our company to receive approximately 10,000 K.W. of energy and in turn to supply an equal amount in territory to the north of us, also belonging to our neighbor above referred to.

Assuming complete cooperating, the process would be advantageous to both companies. It happens, however, that our friend and neighbor has gotten into the habit of reducing suddenly and without notice the amount of energy delivered to us. The result is that, in order to be certain of giving satisfactory service to our customers, we have been forced to keep banked fires under boilers that would otherwise be cold and to operate excess generating capacity. We are therefore ready immediately to replace from our own station energy whose delivery has been cut off to us by our connection. The situation is shown under varying conditions of load on Figure 4, herewith. We figure that during the fall, when our load is greatest, the effect is to cause an excess consumption of nearly 21 tons of coal per day. This is not complete cooperation and, were all generating capacity loaded as in 1917 and 1918, such failure in cooperation would be embarrassing. At such a time, however, a competent district administrator would see that the plants of both companies were operated so as to produce the maximum amount of useful output.

High transmission lines are costly and they will be built only when the annual saving due to them exceeds their total annual fixed, operating and maintenance costs Moreover, they are subject to interruption, a factor that may well militate against their installation when the importance of continuity of good service is appreciated.

Notwithstanding these and other objections to interconnection between adjoining systems, such interconnection has been greatly increased since the war as a result of business necessity or advantage. Its importance in giving better control to the government in times of great national emergency cannot be questioned, though its limitations and weaknesses should be understood.

In a recently published statement, Mr. Alexander Dow of the Detroit Edison Company said that an investigation had prpved that, as between his system with a capacity of about 350,000 K.W. and a neighboring one of about 250,000 K.W., profitable interchange and therefore interconnection was

limited to about 10,000 K.W. Yet it is interesting to note that later in same paper he also says that during the war the intervention of the government had caused his company somewhat unwillingly to create interconnections which, since then, had proved to be very useful.

To sum up, conditions are favorable for an effective control of the power industry during a great national emergency, but such control should be based on and be simultaneous with an equally intelligent and satisfactory control of the allocation of war orders. Plainly war orders ought not to be placed without assurance of the existence of an adequate supply of power and, if that power must be brought in from a distance more or less in opposition to peace time possibilities, the government must in some way be prepared to pay for the transmission lines. The case is the same when additional capacity is installed locally to meet the emergency. Legislation defining the functions and authority of the Power Administrator should be studied and formulated, and it should include provision for defraying these and other costs not fairly chargeable to private individuals.

In the end, with past experience, your own current studies and the cooperation of the industry to build on, another war should find you amply prepared to handle your share of the task efficiently, remembering always that additional generating capacity, even transmission lines, cannot be improvised, and that your problem will be almost exclusively to use effectively the capacity already installed and available.