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POWER IN WAR

by

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POWER

A. INTRODUCTION.

1. Modern war requires for its success the efficient coordination and use of all the nation's resources. The principal resources are men, materials, facilities for production, and transportation. In all facilities for production and in the many electrified transportation systems, power, that is electrical power, is the universal and basic requirement. As our industries are now developed they are even more dependent on power than on men and specific materials. I may cite that the essentiality of power for national defense "is one of the major justifications for the Tennessee Valley Authority" as claimed by the witnesses of the War Department in the recent court proceedings testing the constitutionality of the method of carrying on that Project. The importance of Power is obvious.

2. Power, as the word is used here, is either mechanical power produced by internal combustion or steam engines for direct operation of machinery or electrical power produced by generators driven by prime movers. The physical limitations on the transmission of mechanical power restrict its utilization to individual plants and the greater conveniences and economies of electrical power have practically eliminated mechanical power plants, except in a few specialized industries. Independent, small electrical power installations for serving individual manufacturing establishments and small municipalities constitute only about 25 per cent of the total installed generator capacity in the United States. What little excess capacity these types of installations have is usually needed for local fluctuations in demand. Further, these independent electrical power plants are, in general, neither susceptible to interconnection with, nor would they be capable of contributing much power if connected with one of the large power production and distribution systems. For the reasons just stated, mechanical power installations and small independent electrical power installations may be omitted from a discussion of Power in War.

3. The electrical power sources which we will be concerned with in a national emergency are the great interconnected power groups which produce and distribute the power supply essential to our industries and factories for their war time production load. The capacities of these existing installations place very definite limits on the maximum quantity of power available and the areas to which it can be distributed. It takes considerable time to increase these capacities. In time of war, therefore, we must be prepared to regulate, if it becomes necessary, the power demands of the production facilities and transportation systems.

B. General Characteristics of Electric Power Generation, Transmission and Distribution.

4. Generation. - The three general types of prime movers used to generate electric power, in order of their relative importance, are:

a. Steam plants burning coal, oil or natural gas.

b. Hydro installations.

c. Internal combustion engines.

The economic comparison of the three types of prime movers involves the consideration of a number of factors, among them: type and cost, including transportation of fuel obtainable; availability of water power including head, quantity, reliability and variation of flow; first cost of installation; maintenance and carrying charges; transmission costs, particularly as they are affected by the location of the plant; and the location of the market for the power, the quantity demanded and the load characteristics and variations. The transportation costs for fuel materially influence such economic studies. The first cost of hydro-electric installations, which usually involves dam construction, is relatively high. These high first costs for hydro plants with their consequent high financing charges are in some, but not in all cases, offset by the low operating cost, low, of course, because there are no fuel costs.

5. The output of hydroelectric plants is subject to the considerable variations of stream flow. Most hydro projects include storage reservoirs for the purpose of regulating these flows, but absolute uniformity is seldom practicable nor economically justifiable. The power that can be assured every day of the year, that is that produced by the minimum regulated flow, is called primary power, and the additional power that can be produced intermittently from the peak flows is called secondary power. The output of steam power plants is practically controllable and the relatively high operating expenses vary almost directly with the power produced. Therefore, it is advantageous to interconnect hydroelectric plants and steam plants so that the secondary hydroelectric power may be fully utilized, deficiencies in such secondary power being supplied from the steam plants. The more plants interconnected the greater the advantages of such interconnection in balancing the outputs and loads. The advantages of this pooling of power produced and markets served has resulted in the development of the great interconnected power systems.

6. Transmission. - Most large modern plants generate alternating current at a voltage varying from 6,600 to 13,200 at the generators. But as the transmission of power is always accompanied by line losses which vary directly as the current and the distance, and as alternating current can be easily stepped up or down, the voltage is stepped up by means of transformers as soon as it leaves the generators, sometimes to as high as 220,000 volts. Because of the danger from utilizing power at high voltage, the power must again pass through step-down transformers before reaching the customer.

7. There is, of course, a limit to the distance that electrical energy can be transmitted economically, the normal limit being from 200 to 300 miles, depending upon the cost of generation. It has become possible to generate electrical energy at a cost of 1 to 2 mils per kilowatt hour in the very large generating plants. However, this generating cost is a minor part of the total cost of the power, the major part being the cost of transmission, distribution and administration. Publication of these low generating costs often causes public dissatisfaction with the rates charged for power. Many people look at the great generating plants, hear of the low cost in mils at the switchboard and, not realizing the great transmission and distribution costs, become incensed at the rates the power consumer is charged. These transmission costs are what make it possible for steam plants close by to compete with water power plants far away.

8. Distribution. - The main difficulty in the operation of the electrical power distribution systems and the feature that tends to prevent economic and efficient operation is the fact that the load is not uniform. For example, in the average day of 24 hours there will be a relatively short time, say half an hour, when the power demand becomes extremely high; that is the period of peak load. Although the peak is of short duration it must be met. Therefore, the rate of generation during most of the period must be considerably in excess of the demand and the total generating capacity of the power plants must greatly exceed the average power used. The ratio of the average power generated over a period to the maximum power generated in the same period is called the load factor. The load factor can never equal unity or 100 per cent. The greater the diversion of demand, the greater the load factor and the more economical the system. If the load were constant the load factor would be 100 per cent and the economy would be at the maximum. If manufacturing requirements can be diverted to off peak hours, the economy of power production can be increased.

9. The interchange of power between the various companies operating in the United States is controlled by about 20 principal power dispatchers. A power dispatcher supervises the operation of all of the power plants

and interconnections over an area having a radius sometimes as great as 500 miles. In order that he may intelligently exercise this control, he must have before him every minute of the day the loads and the reserve generating capacity at every plant. He secures the most economical use and production of power throughout the system by ordering the starting or shutting down of generators and by manipulating the amount and direction of power passing through the connections between the transmission lines.

C. Experience during the World War.

10. After the United States entered the World War power shortages were encountered in some of the larger industrial areas, particularly in the Pittsburgh, Philadelphia and Buffalo manufacturing areas. When these power shortages became apparent, power administrators were appointed who took the following action in each critical area:

a. They made a survey to determine the power available and the means of its transmission.

b. They collected information as to the uses to which power was being applied.

c. They collected information as to the requirements for war industries.

d. They then prepared a policy to govern the allocation of power to various needs.

11. The difficulties encountered by the power administrators involved differences in cost of production, loss to private interests, shortage of fuel for steam plants, high cost of new facilities, and inability of private companies to secure the necessary capital for operation, maintenance and expansion. As a result of their experiences, the power administrators recommended the following measures as desirable in any future emergency of like character and extent:

a. The central government should assume control of power in all districts where the production of war materials is to be allotted.

b. Some regard to the capacity of the power production agencies must be considered in the allocation of war orders.

c. Where the demand for power is likely to be exceeded, measures must be taken in advance of the needs to increase the supply from adjacent districts and to increase the generating capacity. This must be done before any shortage appears if delay in manufacture is to be avoided.

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D. Plan for Meeting Power Situation in a Future Emergency.

12. In some respects the power situation is much better today than it was during the World War. Since the war consolidation of small companies and interconnection of their facilities has been greatly extended. There has also been a tremendous increase in the interconnection of adjacent systems. This change will materially increase the flexibility with which power shortages can be met from surpluses within a range of about 250 miles. However, coincident with this change the ratio of reserve generating capacity to normal load has been reduced in each system and there is actually less reserve capacity available in any one area under normal business conditions than there was fifteen years ago. Furthermore, due to the present economic situation there is an excess of power and no facilities for future expansion are being provided by private interests. Therefore a shortage in power is certain to develop in districts like Pittsburgh and Niagara during any emergency such as confronted the country during 1917-1919 unless early measures are taken to forestall a shortage.

13. In attempting to prevent a power shortage in any area in an emergency, the following facts must be recognized:

a. Since the construction of transmission lines is slow and expensive, and transmission of power for long distances is accompanied by large line losses, construction of extensive new transmission systems in time of war should not be counted on. The most practical method of providing additional power in a given area is by constructing new generating capacity in the area.

b. Since the construction of a large hydroelectric plant will require from 4 to 5 years, the main reliance for additional power must be placed on new fuel plants.

c. Unless prior plans and housing facilities exist, new steam generating equipment cannot be installed in less than 18 months. If such prior arrangements have been made, a limited amount of equipment could be built and installed in about 9 months.

14. The measures proposed by the Assistant Secretary of War for the handling of the power situation in war are:

a. To increase the production of power to meet all probable needs of industry and the civilian population.

b. To secure the most economical use of fuel in the production of power.

c. To conserve transportation in obtaining the fuel supply.

d. To distribute power to industrial districts where there is an anticipated shortage.

e. To refrain from interference with power systems not necessary in the production of war materials.

f. To completely control plants wherever their output is necessary for war purposes.

15. In any major emergency it will be necessary to control the power resources of the country to insure that sufficient power will be available to meet the demands for war production and essential civil use. This control will have to be in the hands of an individual who will be, in effect, a power administrator. When this power administrator finds power shortages unavoidable, it will be necessary for the procurement agencies to adjust their war time industrial loads so that the power demands will not exceed the power supply, if procurement is not to be delayed. The close cooperation and coordination which will be necessary between the power administrator and these agencies can only be obtained by the power administrator being a part of the war procurement machine. A power administration relatively independent and uncoordinated with the procurement agencies will only result in confusion. The plans for war time procurement should provide for a power administrator who is familiar with our power organization, in touch with the power situation, and in close contact with the procurement agencies.

16. The power administrator must have an organization through which he contacts the power systems, obtains the necessary power information, and controls the production, transmission and distribution of power. The only sound and logical way to secure an efficient organization in an emergency is by expanding an existing organization. It takes too long to train a newly created organization to function properly. We now have a power organization designed for expansion into the war time power control agency.

17. The policy must be the avoidance of unnecessary interference with the power companies but in critical war production areas there must be absolute control of power by the government. This does not mean that existing power organizations will be destroyed or in any way disorganized. But it does mean that they will take and implicitly execute orders received from the proper governmental agency. If they do not do so those in high executive control will be displaced by those who will take and execute orders. Of course, the relations between the power people and the local representatives of the power control agency will be friendly, close, and with mutual understanding, but the grip of the government will be absolutely secure and certain. This result can best be obtained by the continuance during war of the channels established during peace.

18. The necessity for control will begin as soon as the emergency appears imminent. If we had close and powerful enemies the control would doubtless be kept fully organized in peace time. However, in our situation we merely plan and collect data and rely on the time element to give us the opportunity to completely organize and perfect our war time control agencies. Sound principles dictate that the peace time planning and data collecting organization should become the war time control organization.

19. If an unavoidable shortage can be foreseen at the beginning of the emergency, immediate orders will be placed for boilers and power generating machinery to augment already existing plants. The necessary capital not produced by the industry must be supplied by the government. Again, only an organization in existance at the time can have the requisite information readily available to foresee a shortage and on which to base recommendation for increase of facilities.

20. In consonance with the war time requirements for power control just discussed and our military policy, it is obvious to me that we should have a skeleton power organization during peace time which collects and keeps up to date the power data and maintains contacts with the power people and which would in war time be expanded into the power control ageney. For this purpose the Chief of Engineers, upon the approval of the Assistant Secretary of War, has set up an organization which now conducts an annual Power Survey and which is designed to be utilized as the power controlling agency in an emergency.

E. <u>The Power Survey.</u>

21. This map shows our territorial power organization. The United States has been divided into 4 power zones, the boundaries and war time headquarters of which coincide with those of the 4 War Department procurement zones. These zones and respective headquarters are (Point them out on map):

1st Zone - New York, N. Y.

2nd Zone - Chicago, Ill.

3rd Zone - Birmingham, Ala.

4th Zone - San Francisco, Cal.

Tentative Organizations for the power zone headquarters have been set up. The peace time chiefs of the power zones are Regular Officers of the Corps of Engineers on duty as Division Engineers of the River and Harbor organization. They are:

For Power Zone No. 1 - The Division Engineer, North Atlantic Division, located at New York, N. Y.

For Power Zone No. 2 - The Division Engineer, Upper Mississippi Valley Division, located at St. Louis, Mo.

For Power Zone No. 3 - The Division Engineer, Gulf of Mexico Division, located at New Orleans, La.

For Power Zone No. 4 - The Division Engineer, South Pacific Division, located at San Francisco, Cal.

It is planned that there shall be sufficient overlap between the appointment of the war time chiefs and the relief of the peace time chiefs to provide for a smooth transition from the peace to the war time basis. Competent reserve officers who are familiar with the power question and who are in touch with the power systems have been selected and assigned to the power zone headquarters organizations to form a nucleus for the war time expansion.

22. The power zones are subdivided into 12 power districts. The district areas and headquarters are shown on the map. (Point them out). A single power district, in general, embraces one complete interconnected power system. The peace time chiefs of these power districts are the Regular officers of the Corps of Engineers on duty as District Engineers in our River and Harbor organization.

23. By means of this organization and the facilities of the River and Harbor organizations to which the power zones and districts are tied in time of peace, the Chief of Engineers makes an annual survey of the power situation and reports the results to the Assistant Secretary of War. In general, the purpose of this survey is to ascertain the capacity of the major power systems and the industrial areas they serve, to forecast their reserve capacities and to determine where additional generating capacity will be necessary to meet a war emergency. From this information, plans may be made for the rapid installation of additional generating capacity in the areas indicating deficiencies.

F. Present Power Situation.

24. This chart shows graphically the compilation of the data for each power district obtained by the power survey. As the legend indicates,

blue represents hydroelectric plants and red represents fuel plants. The total installed generator capacity for each district is so plotted that the portion of reserve capacity necessary for maintenance and repair is shown below the zero line and the maximum capacity available to fill the peak load is shown above the zero line. The surplus of this assured peak generating capacity over the present peak loads is indicated by cross-hatching. The total installed generator capacity for the 12 power districts is approximately 27 million kilowatts of which approximately 5 million kilowatts is reserved for maintemance and repair purposes and the balance of approximately 22 million kilowatts is the total assured peak generating capacity. The cross-hatched areas on the chart indicate that present peak loads are considerably below the peak generating capacity, with the consequent relatively large surplus capacity available in addition to the necessary reserve for maintemance and repair. The total of this surplus capacity is about 7 million kilowatts. However, since this surplus is due largely to the present economic situation, and the normal increase in generator capacity in the United States between 1926 and 1930 exceeded 2 million kilowatts annually, it appears that a return to normal industrial activity would very rapidly entirely absorb it.

25. Theinitial generator installation in all of the hydroelectric power projects now under construction by the Federal Government on the Columbia, Colorado, Missouri, Ohio and Tennessee Rivers will amount approximately to but 1 million kilowatts. The estimated ultimate generator installation in these developments is approximately 5-1/2 million kilowatts. However, these plants are not generally located in industrial areas and therefore they may not have any marked effect on the commercial electrical industry as it applies to war conditions.

26. Therefore it appears that in the event of a major emergency power shortages are most certain to develop.

27. Thus far there has been no attempt in our procurement planning to adjust the war load allocated to various industrial areas to the power capacities of these areas. Were it possible to definitely check the power required for our allocations against the power which is surplus to commercial requirements, it no doubt would be found that certain areas will be as grossly overloaded as they were during the World War. For example, it has been found that the Philadelphia Engineer Procurement District, which formerly included the southern states, was placing very few allocations in the Tennessee-Alabama area where a considerable surplus of power is available. To correct this situation, a separate engineer procurement district was established for the Birmingham area.

28. It has been claimed that it is impossible to estimate the power load to be placed on any area, first because manufacturers cannot estimate the power required for their allocations and a second because any such

estimate would not provide for the power required for the manufacture of contributory items which may be produced in an entirely different area. It must be admitted that these are serious difficulties. However, it is certain that some areas, notably in Pennsylvania and Ohio, will be grossly overloaded unless some attempt is made to adjust the war load to the reserve power capacity. It has been suggested that all war planning agencies secure from manufacturers their estimates of the amount of power required for their war allocations and that the sum of these estimates be compared with the reserve power as indicated by the power survey. Neglecting the power requirements for contributory items, we could determine ratios between power required and surplus power for each industrial area. A comparison of these ratios would indicate the areas which are being overloaded. If this phase of the problem continues to be neglected, the next emergency will find us unprepared and since we cannot increase the power production within less than 9 to 18 months, production in the vital areas will be greatly interfered with. The seriousness of this situation and the necessity for the preparation of plans to cope with it, should be evident. The preparation of estimates of the power which will be required for the allocated production by the procurement planning agencies is the first step which should be taken.

G. Conclusion.

29. In conclusion, I wish to emphasize the importance of power in war time. Our past experiences and our annual surveys have shown that we may expect difficulties and shortages in power in various areas in the event of a major emergency in the future. We must not only continue our present planning activities but we must improve on them in every way possible.

30. The annual power survey must be continued. Our power organization and method of conducting the survey must be revised from time to time as becomes necessary by reason of the rapidly changing power set-up of the country. The preparation of power requirements by procurement agencies should be initiated as soon as possible.

31. Adequate plans for handling the power problem is one of the most important steps in planning for war. In order to be adequate these plans must include first, what is needed, that is power requirements; second, what is available, that is the up-to-date power set-up obtained by means of the power survey; and third, an organization and a plan for adjusting discrepancies between requirements and available supply. These power plans merit serious consideration by those responsible for industrial planning for war.