16

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POWER IN WAR

by

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516

TABLE OF CONTENTS

A Introduction

B. Scope

C. General Characteristics of Electric Power.

D Experience during the World War

E. Present Power Situation.

F Power Survey

G. Plan to meet the Power Situation

H Conclusion.

A. INTRODUCTION

1. The subject "power in War" embraces the availability of power facilities, that will be needed to produce War Requirements in an emergency, and the steps that can be taken to guard against power shortages

2 Modern war requires for its success the efficient coordination of all the nation's resources in order that a sufficient number of men, with an adequate supply of materiels and auxiliary facilities may be made available for combat in the shortest possible time.

3. Modern civilization is characterized by the general and increasing use of power and as our industries are now developed they are even more dependent on power than on men or specific materials

4 The high speed production of commodities, with a minimum number of men engaged in civil activity, is a war necessity and depends on the availability of an adequate power supply.

5. Power is therefore a basic military requirement, since it has a distinct bearing on the availability of men, materiels, the time required to mobilize and equip a modern mechanized army, transport it to the Theatre of Operations and, maintain and supply it in combat. The importance of Power is obvious

B. SCOPE.

6. Power as the word is used here means the energy produced by prime movers actuated either by fuel or water-power The physical limitations on the transmission of mechanical power restrict its use to individual plants making it of minor importance as compared with electric power. Because electric power is generated in large central plants and can be distributed over a large area, it has great advantages over mechanical power in cost and efficiency of application Electric power has now largely supplanted direct connected mechanical power

7 A comprehensive study of the entire power situation would, of course, include the production, transportation, conversion, and application of all the energy used in the entire country whether derived from Coal, Oil, Gas, Water Potential, or other sources.

8 This discussion is limited to consideration of Commercial Electric Power, generated by the major interconnected groups of Public Service Companies, which must be depended on to furnish most of the processing power required to convert basic materials into the final articles required for war

9. The primary industries engaged in initial production of basic commodities such as metal billets, portland cement, wood-pulp-paper, chemicals, glass, quarry products, etc., generally have private power facilities and are now independent of Public Service Power. However, the present trend, particularly for industries located near industrial centers,

is to buy power, as their own plants become obsolete. Further, any additional power required by these basic commodity producers in an emergency, must be supplied by Commercial Power Industry since there will be no time to construct new power plants

10. The electric power produced by individual manufacturing plants, railroads and municipal transportation companies and non-manufacturing communities for their own use does not come into the picture. The small amount of surplus power available over and above fluctuations in local demand and the physical limitations on transmission in general renders this class of power installations unavailable for war production. Examples of the power installation included in this classification are the individual mill-power-plants in New England States, the aluminum industry in Tennessee and North Carolina, the large transit facilities contributory to the New York City area, and the municipal plants of isolated non-industrial communities and other similar installations. The electrical power installations for serving individual manufacturing establishments and small municipalities constitute only about 25 percent of the total installed generator capacity in the United States.

C. GENERAL CHARACTERISTICS OF ELECTRIC POWER GENERATION, TRANSMISSION AND DISTRIBUTION

11. 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.

12. 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 as-

sured 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 advantage 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.

13. 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.

14. 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.

15. 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 percent. 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 percent 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.

16. 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

D. EXPERIENCE DURING THE WORLD WAR.

17. 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.

18. 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 allocated

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

E. PRESENT POWER SITUATION

19. In some respects the public service power situation is much more serious today than it was during the World War. The reserve generating capacity, available for use in an emergency, has decreased materially during the last five or six years. New construction, by commercial power companies, slowed up in 1930, due to the economic situation and the temporary large excess of generating facilities. For various reasons, the public utility companies are still cautious about initiating new construction in anticipation of future requirements. The public service load which dropped off alarmingly in 1929 - 1930, has now climbed back to a new all time high, 99 billion kilowatt hours were sold in 1935. The power companies have met this situation with increased efficiency in distribution. This has been effected by establishment of many new interconnections between the larger transmission systems and by raising main line voltages which permits transmission to greater distances. Also, an appreciable part of this increase is due to a more general use of electrical appliances, such as household equipment, and air conditioning and refrigerator equipment, which use power more constantly rather than at peak times of day only, that is, better "load factors" are prevailing. The reserve generating capacity over the current peace-time load has thus become so reduced that continued general business improvement may use up the reserve capacity, in some areas, faster than the power industry can build new plants. In these locations the sudden arising of a national emergency would find insufficient reserve for the war-time load. The average annual increase in commercial generating facilities between 1917 and 1930 was about 2 million kilowatts. The additional generator capacity installed, by the commercial power industry, during the calendar year 1935, was only approximately 386,000 kilowatts and only about twice this amount of new construction 769,000 kilowatts is scheduled for installation this year. These estimates do not include the generator capacity to be installed in large hydroelectric projects now under construction by the Federal government which will get into operation in the next 3 or 4 years. The Passamaquoddy, T V A., Fort Peck, and Columbia and Colorado River Projects, will have a total initial installation of approximately 1,500,000 K.W.

F. THE WAR DEPARTMENT POWER SURVEY

20. A report showing location and capacity of electric power facilities in the United States is compiled annually by the Chief of Engineers from data obtained from The Commercial Industry. For the conduct of this survey, the country has been divided into 4 Power Zones, which are subdivided into 12 Power Districts corresponding with the major territorial divisions of the Commercial Power Industry. The boundaries and war-time headquarters of the 4 Power Zones coincide with those of the 4 War Department Procurement Zones. The Power Zones and War-time Headquarters are:

1st Zone - New York, N. Y.
2nd Zone - Chicago, Ill.
3rd Zone - Birmingham, Ala.
4th Zone - San Francisco, Calif.

21. 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, Calif.

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.

The peace time chiefs of the power districts are the Regular officers of the Corps of Engineers on duty as District Engineers in our River and Harbor organization.

22. 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 infmroation, plans may be made for the rapid installation of additional generating capacity in the areas indicating deficiencies.

23. The wall chart shows graphically a compilation of the data obtained by the 1935 power survey.

a. The installed generator capacities are shown by power districts

As the legend indicates -

The entire length of the colored blocks represents the total capacity of the installed generators, the part of the colored blocks below the Heavy Zero Line represents inactive (stand-by) generator capacity used to replace active units when they are withdrawn for repair, the part of the colored blocks above the Heavy Zero Line indicates the assured peak generator capacity available for primary power production, red shows fuel generator capacity, blue shows hydro generator capacity, the hatched area at top of colored blocks shows surplus generator capacity over and above the actual peak load.

b. At right hand side of the chart we have a composite picture showing the installed capacities, the 1935 load, the maximum capacity for the same type of demand, and the off-peak power possibilities in Power District No. 4 which embraces the Pittsburgh Industrial Area. It is of interest to note that the percentage of the total generating capacity of installed facilities used, depends on type of demand and that the killowat hour output might be expanded horizontally (over more hours) in an emergency.

G. PLAN TO MEET THE POWER SITUATION.

24. The formulation of a plan to meet the power-procurement situation requires

a. Knowledge of Requirements.
b. Knowledge of Power Resources.
c Consideration of the action which may or should be taken when power requirements exceed power resources.

25. Thus far, no practicable means has been evolved to estimate the power load to be placed on each procurement district. The main difficulties in estimating power requirements appear to be the complexity and number of the power consuming operations involved in the manufacture of most commodities and the lack of data, on accumulative power requirements. Without a knowledge of the power requirements, it has not been possible in our procurement planning to adjust the war load allocated to various industrial areas, directly to the power capacities of the areas. However, the policy of the Assistant Secretary of War against too great a concentration of procurement allocations to the congested War Department Procurement Zone No. 1, while not based primarily on the power situation, is, in effect, a step tending to avoid the creation of a power shortage in this area. The importance of the problem is obvious and efforts to find a solution which will permit direct comparison between power requirements and power resources should continue

26. The existing power resources in each procurement district are compiled annually and can be obtained from Electric Power Survey. When Power Requirements exceed the amount of power that can be made available for War production one or more of the following steps may be taken to avoid the power shortage or supply the additional power necessary.

a. Reallocate part of the war requirements assigned to overloaded procurement district to a suitable industrial area where they can be produced without overloading the power facilities.

b. Provide for distribution of power to overloaded industrial areas when practicable.

c. Provide new power facilities where needed to carry war load.

27 The reallocation of procurement schedules to avert a power shortage prior to an emergency is dependent upon the computation of the power requirements. Until the problem is solved we must remain in the dark, to a great extent and wait until the shortages develop or are imminent Then the most obvious and least disrupting solution will be to attempt to provide the power and only to resort to the shifting of production to the less loaded areas when the power cannot be provided.

28. In attempting to provide additional power when a shortage develops in any area in an emergency, the following must be borne in mind.

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 plants 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.

d. The capacity of the manufacturing companies capable of producing suitable boilers, turbines, generators and other heavy equipment is decidedly limited.

29. The distribution of power to overcome shortages, the installation of new power facilities, and the distribution of their output, to meet the demands for war production and essential civil use can only be accomplished by control of the power industry by the Federal Government. This control will have to be in the hands of an individual who will be, in effect, a power administrator.

30. The necessity for control will begin as soon as the emergency appears imminent. 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. 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

31 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.

32. The limited capacity of the manufacturers of large power plant boilers, generators and allied equipment, is another factor of the power problem which must be considered. In our procurement planning we give considerable thought to the problem of when the factories which will have war orders, are going to get those essential raw materials and indispensable tools, the supply of which is limited. I refer to our studies on such things as gauges, jigs, dies, special machine tools, optical glass and other critical commodities. We must similarly plan for power plant equipment to assure that the limited manufacturing capacity remains unimpaired and that the power administrator when he orders new installations will be able to tell the power companies where they can get the equipment.

33. When the 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. This will require close cooperation and coordination between the power administrator and those agencies which 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.

34. The National Defense Act and related Acts of Congress charge the Assistant Secretary of War "with supervision of the procurement of all military supplies and other business of the War Department pertaining thereto and the assurance of adequate provision for the mobilization of materiel and industrial organizations essential to war-time needs". Under this general law the Assistant Secretary of War has directed the Chief of Engineers to conduct The Annual Power Survey and to keep him informed, by an Annual Report, as to the existing Electric Power resources of the country in order that he may carry out the duties assigned to him. The Chief of Engineers has established a power survey organization which I have previously discussed, to collect the power data in the field. The Procurement Planning Branch of the Office of the Chief of Engineers supervises the power survey, compiles the annual report, and studies the available resources from which power plant equipment can be procured. Consequently, we have a skeleton organization which has established understanding contacts with the power industry, and which through its affiliation with the Planning Branch of my office has knowledge of the sources of power plant equipment and is an integral part of the Assistant Secretary of War's procurement planning organization. Therefore, this skeleton organization appears to me to have all the necessary qualifications for the immediate expension when the emergency occurs, into an organization under the Assistant Secretary of War for the control of power and the eventual development into the Power Administration under the War Resources Administration.

H. CONCLUSION

35. 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

36. The seeking of a practicable method for estimating of power requirements by procurement agencies should continue. 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. Our procurement planning should include plans for securing new power producing equipment for the manufacturers.

37. 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.

INDUSTRIAL COLLEGE

DISCUSSION FOLLOWING LECTURE "POWER IN WAR"

by
Colonel Warren T. Hannum, C. E.
for General Markham
April 20, 1936

Q - In connection with the power survey, how serious are the shortages which you expect in the next emergency?

A - We can tell only proportionately; in the last war we met power shortages and the reserve now available is less than it was at the outbreak of the last war.

Q - With regard to the allocated facilities, suppose that we take only 50% of the plant, how are you going to distribute power in these plants when 50% of their capacity is devoted to Governmental work and 50% to civilian contracts?

A - I don't think you will be able to control power in that way. I don't believe you will be able to limit civilian demand; you will have to give them all they want. The job will be to provide power - not to limit its use - but to produce it. Of course if you can't, the civilian requirements will have to give way to the war requirements We want to disorganize the civilian set up as little as possible.

Q - Will the new hydro plants now being constructed have any effect on the war load? Are they not in areas that will not help us very much?

A - They are in areas which are distant from the present consuming markets; the first area is important (Passamaquoddy is right here)(cha but the main manufacturing facilities are too distant for economical transmission of power and unless the industries move to the power plant before the next war its facilities will not be of material assistance in our war

planning unless they find some more economical means of transmission. The Grand Coulee dam is on the Columbia river around Spokane, Washington. That is not an industrial area now but it may develop. The Fort Peck dam is on the Missouri River in Montana, there is a market for that power now if it is turned over to the Montana Power Company. Boulder Dam, down on the lower Colorado River, is not in the vicinity of any big industrial area except Los Angeles and while it is pretty far for transmission they can get something out of it. The Tennessee Valley Authority is in a small industrial area which may increase in size with the furnishing of cheap power. The St. Lawrence development, if it goes through, will be able to supply some power economically to part of the industrial district in New York State. I think the Niagara power is about developed to its maximum extent now.

Q - Does the Government contemplate distributing power as well as producing it at these various plants? Who will distribute it?

A - That depends on laws that have been or may be passed and their constitutionality I think undoubtedly the Tennessee Valley would distribute to places like Tupelo and give power to the cities where it is taken from the T.V.A. transformers.

Q - I wonder what agency, if any, is preparing estimates for the war-time power requirements? Under the existing set-up, allocations of facilities for certain material are sent to the O.A.S.W. and the procurement-district sends in a list of all requirements If that practice is not uniform, the thought has occurred to me as to how it is possible to make an estimate for war-time requirements of power unless all manufacturing requirements are centered in some central agency.

A - I think it would be very difficult to make any accurate approximation of war-time requirements, the best thing you can do is to make an

estimate. For a number of years there has been a movement afoot to get the procurement services to compute their requirements of materials and power. No one has yet found out how to do it, other than just an estimate. During the past year we have had a man tinkering with schemes for computing power requirements. I am not convinced enough to put it out but he thinks he has a basis. The weight of material is one factor; another is the ratio of raw materials cost to finished products cost which would reflect the number of processing steps, and then there is a factor of kilowatt hours for each processing step for each type of material. If we could find that factor so we could take so many tons of locomotives and so many steps, we might do it, but we are not ready to put is out as yet. If we do develop such a thing we will ask the other supply services to compute power requirements at the same time they compute material requirements.

Q - Is there any possibility of utilizing inte connected groups to make available a surplus power in the Tennessee Valley?

A - I think the T.V A. itself will have a surplus of power which should be turned over to be distributed around as needed in that area.

Q - What I meant were interconnecting transmission lines suitable to utilize power generated for war purposes in that area and boosted by intermediate stations.

A - That has been done, when Muscle Shoals operated under the Engineer Department we got something like $800,000 a year for that. It can be done.

Q - Along the same lines of that question, in considering the limitation of transmission at two or three hundred miles, I don't see how interconnection would be of much assistance on war production

A - (Pointing to chart) If you have a power plant here supplying this area, and another here, and another here 200 miles further, and some surplus here, you can send it 200 miles into this area and that generator can send it 200 miles into this other area. So you can send it actually 400 miles, it depends entirely on the demand.

Q - When it gets into the second 200 miles do you have anything left?

A - Yes, it is stepped up again.

Q - Is the correct interpretation of that chart that the areas of maximum effort in the country have a minimum of hydro-electric power and is not stepping up made to increase it to the maximum areas of production? In other words, take that 6th district around Chicago; there is almost no hydro-electric power there at all. Are there any available areas in the Lakes that make it possible?

A - There are no other water facilities for the development of power in the Lakes region The fall between the lakes is not sufficient to generate much power. The upper Mississippi would be the closest source, probably. There is some power at Lockport.

Q - Are we approaching anywhere near the limit of use of the total water power capacity?

A - No; there is a good deal more capable of development but not economically at the present time. In most cases the location of the water

power is too far from the consuming market. That is one great advantage of having industries spread out over the country.

Q - For short distances steam plants can generate power more cheaply. Can you tell us what percentage of hydro plants have been replaced by steam plants?

A - I don't think steam plants have replaced any economical hydro plants anywhere. The hydro plants are used in connection with steam plants. One of the greatest costs is to meet the interest on investments.

Q - For short transmission I was under the impression that steam had replaced hydro in congested areas.

A - Philadelphia gets a great deal of its supply of electricity from Conowingo dam and Safe Harbor dam on the Susquehanna River. They use that in connection with steam plants. They have big steam plants in Philadelphia too. There they have gone to water power to meet increased demands in a large industrial area

Q - What is meant by the term "Washington plan" when used in relation to the subject of power?

A - It is a question of adjustment of rates; it was a plan developed here for the determination of rates to be charged consumers. It is a local application of a principle for determining rates to the consuming public under which the power company is allowed to make 7% on their investment and of anything in excess, one-half goes to the power company and one-half is used in reduction of rates. That is administered by the local utilities commission.

Q - You said that distribution was the largest cost in power. Is there any indication that it will be reduced?

A - I think the big power companies are making a research in an effort to find a solution to that problem. I think their efforts are very much greater than any we could make. In other words, we have to depend on them for leadership in that because it means money to them. I think aluminum wire in place of copper wire is coming into more general use due to the lower cost. When they put in the power line for transmission of electricity 18 miles at Fort Peck Dam they found the low bidders were the producers of aluminum wire instead of copper but in order to keep the copper industry going they awarded it one-half to aluminum and one-half to copper.

Q - Would you care to say something about the Pittsburgh District? What must we expect out of Pittsburgh? It is such an important district to us.

A - They have had a flood and that will probably result in a good many reservoirs for flood control. If they build them so they will have water that may be used for power development, it may be that the power will be increased that way. On the other hand, steam power should be low in cost out there on account of the availability of cheap coal. Captain Holle, what are the possibilities of meeting demands that may arise in the Pittsburgh district?

Captain Holle I think we will probably have to rely on steam plants, that would be the economical solution. I don't think we will get much more water power

Q - Are any plans being made for installation of additional steam plants that you know of?

A - No, nothing more than to meet peace-time requirements

Q - The chart shows power capacity of the first district approximately equal to the power capacity of the seventh district - the first being New England and the seventh being out in the agricultural states of the middle west. It seems to me that in order to determine the industrial capacity an area can produce to meet the demands of an emergency we would have to know the horse power in private industry in addition to the public utilities. I wonder if the Chief of Engineers has made any study to show the total horse power installed in these different areas in private industry. Most of the big companies have their own power installations.

A - These independent installations have only sufficient power for their normal needs and many are changing over to the commercial electrical industry so they cannot be depended upon. Their reserve is very small. At the present time the total capacity of these independent generating plants is only 25% of the plants of the commercial electrical industry whose business it is to produce electricity rather than manufacture commodities.

Q - Would you care to make any remark on the Passamaquoddy project?

A - All I know is what the President announced to reporters - that he did not intend to make any further appropriations for it or for the Florida canal. There has been nothing done on the project which will produce electricity

Q - Do you know if there is any surplus power in the Susquehanna Dam that could be sent to Pittsburgh? Is there any surplus in the three dams in that vicinity?

A - There is a surplus now; I think the Pennsylvania Railroad is

now using it for operation between Havre de Grace and Washington for their electric trains. Pittsburgh is some distance off from the Susquehanna River, it would not pay to get power that far.

Q - Are there any interconnecting transmission lines so it could be boosted into the district?

A - Undoubtedly the interconnections that could be quickly set up would make it possible to get more electricity in Pittsburgh. That is quite a dense area and there are one or two large companies that are closely interconnected and others have been bought in because it is cheaper

Major Kelton. I may add something to the question about transmission. The latest development is that of using vacuum tubes and they can transform frequency for power at as high as 600 kilowatts. If they can do that and change the frequency from 60 cycles down to zero they can reduce transmission costs. General Electric is working on this at the present time. Just how soon and how expensive it is going to be to develop these tubes is a question. The man working on it believes that by the use of vacuum tubes they can reduce transmission costs and bury cables underground and transmit power much further.

Q - In making calculations of peak load is credit taken for the possible production of commercial and civilian demands on power?

A - You expect a reduction in civilian demands, you expect people to use less electricity for power appliances during war than they do in peace. That would have to be done but you had better reserve it as a last resort. The less distress the more popular the war will be.