

THE ELECTRIC UTILITIES AND THE WAR

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The mobilization and intelligent use of the Nation's manpower is being emphasized by our national leaders as of extremely vital importance to the success of our war effort. That this problem would become all the more complex, were it not for the extensive electrification of industry and its resultant use of large quantities of electrical energy, is obvious.

As a result of the many new developments in the electrical field over the past decade, we have become increasingly dependent, in our domestic, social, business and industrial life on an adequate, firm and uninterrupted supply of electrical energy. The necessity of such a supply of electrical energy for the operation of the camps and training centers of our armed forces, to the production of food, to the maintenance of our communication systems, water supply and public health and safety became even more vital with the advent of war. Since industry has been charged with a great responsibility in meeting the production schedules established for war material, its electrical requirements have increased accordingly. In fact, in perhaps no other field of endeavor, is an ample, uninterrupted supply of electricity so essential today to the success of the war effort.

The electrical utilities are the chief source of supply of this electrical energy. Sales by the utilities to industry are indicative of the important function they are performing in the war program. This is readily illustrated by the growth of kwhr consumption by industry from the beginning of the defense effort up to December 7, 1941.

In January of 1938, industry was purchasing approximately 3½ billion kwhrs per month from the utilities. In the spring of 1940 this consumption had risen to approximately 4.6 billion kwhrs per month. By December of 1940 it had increased to 5.5 billion kwhrs and by December of 1941 to approximately 2.3 billion kwhrs since the spring of 1940. This of about 2.3 Billion KWHrs since the spring of 1940. This increase of approximately 61% can be largely traced to the effects of our defense program and our lend-lease agreements. Total energy delivered by the utilities to all classes of customers during the year 1941 was approximately 140 billion kwhrs, representing an increase of 18% over 1940.

With such a trend being established, the electric utilities and government agencies found previous estimates of required generating capacities rapidly being confirmed. Scheduled increases in plant for the year 1941 provided for net additions of approximately 3,112,000 kw but actual installations fell short of this by 600,000 kw. Delay in completion of some projects was the result of shortages of material, labor difficulties and heavy demands on turbine manufacturers for other products. Peak loads actually increased about 3,250,000 kw but the industry still had a reserve of better than 9,000,000 kw of capacity.

Coupled with these plant increases were the power pools and inter-connections being established throughout the country. In the State of California inter-connection of the systems of the

Pacific Gas & Electric Co., Southern California Edison Co., Ltd., California Electric Power Co., the San Diego Gas & Electric Co., the Los Angeles Bureau of Power and Light and some other municipally owned systems had already been established. These inter-connections were later reinforced to provide for the interchange of greater blocks of energy. Similar programs were being consummated throughout the country so that the possibility of power shortages in any area would be reduced to a minimum.

With the announcement of the Japanese attack on Pearl Harbor, no cause for undue concern over the utilities ability to supply power requirements arose. Instead, since no immediate impact was felt—insofar as system demands were concerned, time was available for a recheck on the estimated requirements during the ensuing years of conflict and the ability to schedule new plants to meet those demands. As a matter of fact a re-survey of scheduled additions was made by the industry as of December 1, 1941. The results of this survey appear in Table I.

SCHEDULED PLANT ADDITIONS 1942-44*

	1942 kva	1943 kva	1944** kva
Private Companies	2,384,000	1,958,000	963,000
Municipal Plants	123,000	117,000	90,000
Governmental	1,157,000	671,000	344,000
TOTAL	3,664,000	2,746,000	1,397,000

*For the entire country.

**Incomplete.

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The advent of the war caused further emphasis to be placed on the continuity of service provided by the utilities. Fortunately nearly all utilities had learned through experience the necessity of establishing rather elaborate emergency programs to meet the conditions encountered in major disasters. The disasters of fire, flood, wind and earthquake, visited upon us had resulted in extensive planning and programming of emergency measures designed to restore service as rapidly as possible. Many utilities had already inaugurated two-way radio communication between dispatching centers, substations and even on patrolmen's cars. Troublemen and line gangs had been schooled in a definite plan designed to restore service first to those customers whose needs were most vital such as hospitals, water supply systems, communication systems, etc. These programs coupled with the automatic switching equipment in use on all major transmission and distribution systems assured the restoration of service in the event of outage in a minimum of time.

The war, of course, brought new problems to be solved to assure the continued maintenance of the high degree of continuity of service already established. Perhaps most significant of these was the problem of providing protection against sabotage. To this end anti-subversive committees, composed of key per-

sonnel, have been established by some utilities, especially on the coast. Recommendations of the Federal Power Commission, the F. B. I. and the Army and Navy have been studied. As a result, further protection to plants and facilities have been provided by installing fences and floodlighting and by posting guards around plants and facilities; employees having reason to enter plants and sub-stations have been supplied passes for proper identification; trespass signs have been posted on all properties to keep loiterers away. The use of sand bags and revetments has been utilized to protect important equipment such as switchgear, transformers and rotating machinery from damage resulting from bombing and shelling. In such instances however, precautions have been taken to assure adequate ventilation for the equipment and thus prevent the occurrence of abnormal operating temperatures due to limited air movement. Protection to equipment from incendiary bombs has been provided in some cases through the installation of sloping "Durasteel" hoods over the equipment.

Stocks of major equipment such as transformers, oil circuit breakers, etc., are not as complete as heretofore due to the limitations placed on utility inventories by the War Production Board and the large number of new installations recently made to supply war projects. In order to be in a position to make such replacements as might be necessary in the event of sabotage or damage from bombings and other enemy action, one local utility maintains rather extensive files giving complete data on key installations and other records indicating idle or under-loaded equipment available for use in an emergency. Included in such data are records of primary and secondary voltages of transformer banks, kva of capacity, transformer impedance, physical dimensions, etc. This same utility recently made a survey of any idle and under-loaded transformers on its system for this specific purpose and also to obviate the necessity of making additional investments to supply new loads.

Many other emergency measures have been taken by the utilities, too numerous to mention. Coupled with the entire program, close cooperation with the F. B. I., War Department and other government agencies has been maintained. The importance of such a program becomes all the more obvious since approval can seldom be obtained from the War Production Board to install duplicate facilities even for war production plants.

So much for the contribution to the war effort being made by the utilities in furnishing an adequate, continuous supply of electric service to the public and to all projects engaged in the war program. This of course is their fundamental purpose and their chief responsibility. Nevertheless many other services are being rendered by the electric utilities which are of direct assistance to the nation's war effort.

In the fall of 1941, the utilities of Southern California cooperated with the W. P. B., then the Office of Production Management, in obtaining an inventory of machine tools, both idle and in use, in plants throughout this area. The purpose of this survey was two-fold; first to determine which plants were reasonably well equipped to undertake the production of defense materials and second, to acquire an inventory of idle or isolated machine tools which might be acquired by operators engaged in defense production. The results of this survey were

sent to Washington and no doubt influenced to some degree the large volume of war contracts awarded in this area. The local office of the War Production Board also utilized the inventory of plants thus obtained to good advantage as it assisted in locating not only those operators equipped to accept prime contracts but likewise was useful in putting prime contractors in touch with smaller operators capable of expediting the volume production of small parts and specialized items. The entire program of course accrued to the benefit of the utilities inasmuch as it assisted in keeping on the line, loads that might otherwise have become idle. Without question similar programs were carried out by other utilities throughout the nation in conjunction with the W. P. B.

As a further contribution to the war effort, the utilities are supplying their customers with the services of their engineers and other members of their personnel capable of rendering advice on power problems. In some instances engineers have even been loaned to industry at the request of the War Production Board or the Army and Navy.

In this same connection the personnel of the utilities have always included a group of men especially skilled in the application of electric service to industrial processes. It has now become their duty to assist customers in every way possible to utilize their electric service to the greatest and most economical advantage.

Some of the services performed are analyses of customers' power requirements, with recommendations for the most economical method of supply, and consultations on electrical equipment, selection of rate schedules, and maintenance facilities.

The rendering of these services to customers has been extremely valuable in getting plant production under way and in maintaining the continuous and efficient operation of the plant electrical equipment.

A similar staff of men especially skilled in illumination problems are maintained by nearly all electrical utilities. This personnel renders valuable assistance to plant operators in designing systems of illumination adapted to the plant's requirements, with special emphasis on speed of production and safety of workers. Similar advice has been given with regard to blacking out industrial plants without impairing production. Systems of protective lighting are designed and recommended to industrial operators by this same group of illumination engineers. Since the dimout restrictions imposed on the coastal areas have created new problems in the control of illumination, this group of men have devoted practically all of their waking hours to advising customers on ways and means of complying with the restrictions and yet retaining adequate illumination where needed. Close cooperation has been maintained by them with the Office of Civilian Defense and Army and Navy officials in order to expedite the accomplishment of the results desired.

The war has of course resulted in the electric utilities being faced with an unprecedented number of new problems of ever changing complexion. Included in these are the problems of plant protection and emergency maintenance already discussed herein. As is probably true of many industries, one of the most difficult problems facing the utilities is that of adjusting their

material requirements to the new conditions brought about by priorities. The jurisdiction of the War Production Board over the use of critical materials by the utilities has been so extended that many phases of the business are affected. Some elaboration on these problems may prove of interest.

Under the provisions of Preference Rating Order P-46, assigned to the utilities by the War Production Board, certain limitations are placed on the inventories of material and equipment which may be carried in stock. This limitation has been amended from time to time and is now such that on all major material the utilities are limited to an inventory equivalent to 60 per cent of the aggregate dollar volume of such material as in inventory on December 1, 1940.

Preference Rating Order P-46 does extend priority ratings (AA5) for general maintenance and a higher rating for emergency repairs. It also extends a blanket approval, where the net material value does not exceed \$1,500.00 for underground construction and \$500.00 for overhead construction, for reinforcing facilities to serve increased loads, for installation of facilities to serve Army and Navy projects, for the correction of overloaded facilities and for the installation of facilities required to serve new buildings and residences provided certain other stipulations are met. In all instances, however, line extensions are limited to not more than 250 feet.

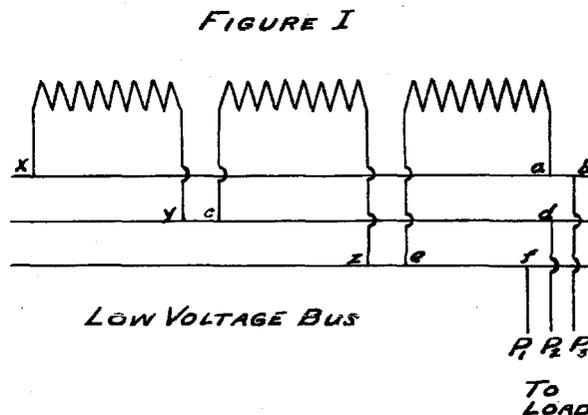
The majority of new loads being acquired by the utilities today, however, are in the heavy industrial classification, and as such require more extensive facilities than permitted under the blanket approval extended under PR-46. Special approval must be obtained directly from the WPB before the installation of facilities to serve such loads can be made. This requires the submission of a special application on each job of that character and, in order to be reasonably certain of approval, necessitates careful engineering in order to utilize as little critical material as possible. This has resulted in a tremendous increase in paper and clerical work and the burden has been spread to the commercial, operating, purchasing, stores and engineering departments of the utilities. Despite this fact, this work is being absorbed in stride by all organizations.

As pointed out in the brief discussion on priorities, new problems in engineering and design have resulted from the war. The solution of these problems rested primarily with the successful substitution of less critical materials where possible, the elimination of some protective devices or the limitation of such devices to a bare minimum, and finally more extensive studies in some instances of the existing load conditions on distribution substations and circuits.

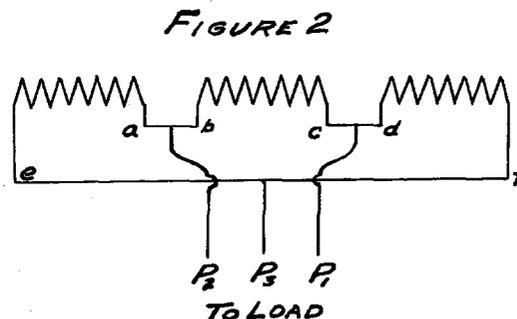
Prior to the war all substations of 450 kva and over installed on, or adjacent to, the customer's property were of steel construction. A concrete pad was required, on which the transformers, and sometimes the oil circuit breakers, were placed. A steel rack structure was constructed to support the necessary high and low voltage busses and in some instances the oil circuit breakers and current and potential transformers. The high and low voltage busses were usually constructed of copper bus. An enclosing fence of steel wire mesh surrounded the completed substation. Today the concrete pad is constructed as usual (with some minor changes in over-all dimensions), but the rack structure is designed to utilize poles, timbers, and cross

arms. Stranded copper is now substituted for copper bus.

A saving in copper is sometimes effected by connecting low voltage leads of delta connected banks of transformers as shown in figure 2 in lieu of installing a bus as shown in Figure I. In the latter case (Figure I) the conductor sections a-b, c-d and e-f have to carry full line current. Conductor sections a-x, c-y, and e-z need only carry the phase current in each respective phase.



Since the copper used is usually of uniform size for the entire length of the bus, more copper is used than needed to carry the respective currents and some copper is not actually needed at all. When connected as in Figure 2, short lengths may be used (a-b and c-d) by connecting between low voltage transformer terminals and then by connecting the low voltage services or feeders (P1, P2 and P3) to the mid-points of leads a-b, c-d and e-f, smaller size copper can be utilized as only the currents of the respective phases are carried by these conductors. Feeders P1, P2 and P3 carry full line current in both cases so no reduction in wire size can be made for them.



In one substation now under construction by one of the California utilities approximately 20,000 lbs. of steel would have been required for pre-war construction. The use of poles and timbers resulted in the requirement of only a few hundred pounds of steel. While the wood structure resulting is not as durable and is perhaps more subject to damage by fire, it will be adequate under most conditions for at least the duration of the war.

In one instance a utility was requested by the W. P. B. to substitute iron pipe for copper in the low voltage bus of a proposed customer's substation. Investigation revealed that the line current in the low voltage bus would be in the neighborhood of 2800 amperes. In order to use iron pipe it was determined that seven four-inch slotted iron pipes would be re-

quired per phase, or twenty-one four-inch pipes to complete the bus. Such a bus would be extremely bulky and undesirable in addition to requiring considerable more material to support it safely. As usual the utility scoured its inventory and located some copper tubing of adequate size which had recently been salvaged, and after designing special supports and connections for it, finally obtained W. P. B. approval to substitute it for the suggested iron pipe.

Rearrangements of conductors of different voltages on poles can result in savings of as much as 5 to 6 feet in height of pole required. Maintenance is usually not as conveniently handled, it being necessary to de-energize one or more of the circuits in order to work safely on other circuits, but it can be and is being done.

In areas where conductors are not subject to salt air and the resultant corrosive action, iron wire has been substituted for copper in some instances. For this purpose, 1/4-inch stranded galvanized guy wire is used. It is not very desirable as its resistance varies greatly with the load and it is only equivalent in current carrying capacity to about No. 14 copper. So far its use has been limited to short extensions of primary circuits.

Other problems facing the electric utilities are not unique to that industry. The conservation of rubber will be of course of prime importance. Personnel problems have multiplied. Both of these are being met satisfactorily as of this writing however. To conserve rubber, a large number of bicycles are being used for meter readers when working congested or urban areas. Some utilities are experimenting with a plan to read meters only every two or three months instead of monthly. Others are experimenting with a plan calling for the customer to read his own meter monthly and forward the reading on a specially printed post card to the utility. This latter plan will probably only be applied to rural areas.

Losses of personnel have been incurred as with other industries. These losses are represented by those employees drafted, or volunteering in the armed forces and those voluntarily migrating to war industries. This problem is being met by reorganization of departments, employee training and the elimination of as much non-essential work as possible. The number of employees carried on utility payrolls have probably shown a decline to date of about 10% or better but good service continues to be rendered although some of the special customer accommodation services have had to be eliminated.

Although the kwh sales of all utilities, located in or near areas of war production or where the training centers of our armed forces are situated, have risen, revenues have not risen at the same rate. An indication of this fact is found in the following data. The utilities reported kwhr sales to all classes of customers of 10,056,629,000 kwh for September 1940 and 12,122,268,000 kwh for September 1941 or an increase of 20.5%. For corresponding months revenues of \$204,434,000.00 and \$225,751,400.00 were reported, an increase of 10.4% as compared to the 20.5% increase in kwhrs. An analysis of more recent figures reveals that revenues had only increased about 3% (July 1942 as compared to September, 1941) whereas kwhr sales had increased 8.6%. This can be accounted for when one considers that certain conditions, brought about by the war, have a definite bearing on the

revenues of utilities, such as gradual increases in industrial operating hours, industrial expansion, as well as loss of some commercial and industrial lighting loads due chiefly to dimouts and blackouts.

Since most industrial rates incorporated in utility rate structures are of the load factor type and stipulate progressively lower costs per kwhr for increases in consumption in kw hrs per kw of demand, it will be seen that the average rate received for increased industrial sales would be on the downward trend with each increase in hours of use.

Similarly, lower rates prevail where larger blocks of power are involved in a single delivery. This also tends to reduce the average rate earned by the utilities. A typical industrial power schedule is shown in Table 2 and is illustrative of these points.

TABLE II
RATE SCHEDULE
INDUSTRIAL SERVICE

Applicable: To industrial customers for power, heat and incidental lighting purposes. Character of Services: A. C.: 60 cycles; 2,200 volts up to 25,000 volts.

RATE:
DEMAND CHARGE

1st 200 kw of demand or less.....	\$300.00 per mo.
Next 300 kw of demand.....	\$1.00 per kw per mo.
Next 500 kw of demand.....	\$0.75 per kw per mo.
Next 1000 kw of demand.....	\$0.60 per kw per mo.
All over 2000 kw of demand.....	\$0.40 per kw per mo.

ENERGY CHARGE

1st 150 kwh per kw demand per mo.....	0.7c per kwh
Next 150 kwh per kw demand per mo.....	0.5c per kwh
All over 300 kwh per kw demand per mo.....	0.4c per kwh

The monthly bill shall be the sum of the Demand and Energy Charges.

It is apparent therefore that despite substantial increases in sales of energy by the utilities, revenues have not kept pace proportionately. This situation, coupled with rising material costs, increased labor costs and in the case of privately owned utilities, substantial increases in taxes, may result in some instances in a reduction of net earnings. Economies placed in effect, together with a reduction in personnel as a result of the draft, etc., will tend to offset the increased expenses and to equalize the other factors adversely affecting net earnings. No specific conclusion can be drawn, however, with respect to the industry as a whole insofar as net earnings are concerned, since local factors may have a far more material influence on earnings than those outlined herein.

From the foregoing discussion it is evident that the impact of the war has resulted in the electric utilities being confronted with many new and complex problems. The industry has given ample evidence, however, of its customary ability to meet these new problems and to determine through individual and cooperative effort an intelligent and satisfactory solution to them. It is demonstrating once again its ability to perform its obligations as a servant of the public in providing an adequate continuous supply of electrical energy to our civilian and military needs in time of war.