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# ECONOMIC INTELLIGENCE REPORT

# HIGH-TENSION TRANSMISSION NETWORK OF THE URALS AREA

CIA/RR 18

19 January 1953

## CENTRAL INTELLIGENCE AGENCY

### OFFICE OF RESEARCH AND REPORTS

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SECURITY INFORMATION

ECONOMIC INTELLIGENCE REPORT

# HIGH-TENSION TRANSMISSION NETWORK OF THE URALS AREA

CIA/RR 18

(ORR Project 7-51)

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## Maps

# HIGH-TENSION TRANSMISSION NETWORK OF THE URALS AREA*

## Summary

The estimated generating capacity** of the Urals area power stations is 4.7 million kilowatts (kw), or about 20 percent of total capacity in the USSR. Prior to the building of the first long transmission lines, the capacity was installed adjacent to the industrial centers that it supplied. The largest industrial centers were those built up around the iron and steel plants. Bringing these ferrous metallurgical centers into a single network was the primary aim when the network was first built, before 1940. Power generating capacity increased 280 percent between 1940 and 1951 in response to a rapid expansion of industries using large quantities of electric power. The ferrous and nonferrous metals industries were the most important in this development. Additional trends have been the building of large power stations near the major coal basins of the Urals area and the electrification of the railroads leading from these coal basins. These factors brought a probable strengthening of the earlier lines and the building of new lines radiating out from them.

The network now connects power centers accounting for about 90 percent of the electric capacity installed in the Urals area. This set-up permits a pooling of generating equipment and enables the power system to use existing capacity more intensely and thus save additional outlay of money, time, and material on generating facilities. Long-distance transportation of fuel to power stations has been reduced about 15 percent as a result of the transmission of power from power plants operated on local fuel to localities without good fuel resources.

* This report contains information available to CIA as of 1 July 1952. The Urals area referred to in this report is synonymous with Economic Region VIII on provisional map USSR Economic Regions, CIA 12048, Sep 1951. See also Map A, Urals Area: Electric Power Centers and High-Tension Transmission Network, 1951, following p. 80. Map B, Uralenergo Electric Power Supply System (also following p. 80), based on German documents, is included for purposes of comparison (see Appendix E).
** For the purposes of this report, the term "generating capacity" is construed to mean the rated capacity of the electric generators installed in the electric power stations.

In the future, capacity probably will be increased in proportion to industrial expansion, which is expected to continue at the same rate and along similar lines as in the period since 1940. The tendency to locate the capacity at the best energy sites is expected to favor Molotov Oblast, where there are large coal reserves and a major portion of the water power resources in the Urals area. The USSR has recently begun exploitation of these resources.

The Urals area network is not now connected with other regional networks. It is expected, however, that when the 2 million-kw hydroelectric plant now under construction at Kuybyshev is completed, lines will be built to connect with the Urals area network. This will increase the supply of power to the southern section of the Urals area, where at present the electric power system is poorly developed. Lines may also be built from the Urals area network to other neighboring regions, but it appears that the flow of power will be outward instead of inward.

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## 1. Introduction.

A high-tension transmission network* is important to the economy of an area for four principal reasons. Transmission of electric power is more economical than transportation of fuel; the best energy resources are utilized despite their distance from power consuming centers; the interlocking of power stations requires less reserve generating equipment to meet fluctuating power loads; and equipment failures cause fewer work shutdowns, since the network provides alternative sources of electricity supply.

The USSR has recognized the importance of high-tension transmission networks in the industrial exploitation of the Urals area. Faced with tremendous transportation problems inherent in the vastness of the

* A high-tension transmission network consists of one or more circuits by means of which power is transferred from one point to another at voltages higher than 15,000. The amount of power transmitted over a circuit varies directly with the voltage and the diameter and quality of the conductors and inversely with the length of the line. Large conductors and high voltages are needed for long-distance transmission of large blocks of power, whereas small conductors at low voltages will satisfy distribution needs over short distances, such as within a city.

territory, as well as with a requirement to economize on electric generating equipment, the USSR began the building of the high-tension transmission network in the Urals area before 1940.

An efficient electric power network is particularly valuable in the Urals area, where good energy resources as well as natural resources are widely dispersed.

By 1941, much of the network as it appears today had been built. The most important additions since then have been the Zlatoust-Ufa, the Kushva-Krasnotur'insk, the Chelyabinsk-Magnitorgorsk, and possibly the new Krasnokamsk-Berezniki connections.

In the early design and development of the electric power system the power requirements of the ferrous metallurgy industry played the most important part because iron and steel plants were the basis of most of the earlier industrial centers needing electric power in large amounts. More recently the rapid expansion of the nonferrous industry, railroad electrification, and the greater use of power transmission to save coal transportation costs have been responsible for the strengthening of the older connections, the extension of the network to cover a larger area, and the building of loops which guaranteed better service within regional subdivisions of the total area covered by the network.

Most of the Urals area network operates at 110 kilovolts (kv). Lines connecting Magnitogorsk with Chelyabinsk and Zlatoust use 220-kv current, while 25- to 35-kv lines are usually employed to tie outlying towns to the main power centers.

The network is featured by a backbone line which connects Krasnokamsk, Molotov, Chusovoy, Kushva, Nizhniy Tagil, Sverdlovsk, and Chelyabinsk. Attached to this backbone are several loops: (a) Chelyabinsk-Magnitogorsk-Zlatoust-Chelyabinsk, (b) Chelyabinsk-Miass-Karabash-Kyshtym-Chelyabinsk, (c) Sverdlovsk-Degtyarka-Revda-Pervoural'sk-Sverdlovsk, (d) Sverdlovsk-Asbest-Yegorshino-Nizhniy Tagil-Sverdlovsk, and possibly (e) Krasnokamsk-Berezniki-Kizel-Chusovoy-Krasnokamsk. The other two major parts of the network are an extension of the Chelyabinsk-Zlatoust line to Ufa and a line from Kushva to Krasnotur'insk. 50X1

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It is estimated that power centers accounting for about 90 percent of the total generating capacity in the Urals area are connected to the network. The largest concentrations of this capacity are at the important coal and metallurgical centers of Chelyabinsk and Krasnotur'insk; the large coal centers at Kizel; the metallurgical centers of Nizhniy Tagil, Magnitogorsk, and Sverdlovsk; the chemical and magnesium center of Berezniki; and at Molotov, Krasnokamsk, and Ufa. Kamensk-Ural'skiy is one of the two aluminum production centers in the Urals area and has one of the largest power stations. It may be connected to the network, but, there being no concrete evidence, it is assumed to be separate.

It appears from a study of generating capacity and industry in the Urals area that possibly 85 percent of the power is produced close to the points of consumption. This means that the network is used regularly to transmit about 15 percent of the total power generated in the Urals area to those districts which do not generate sufficient power to meet requirements. Most of the generating capacity supplying this 15 percent is believed to be located at the Chelyabinsk and Kizel-Gubakha power centers. Krasnotur'insk, Sverdlovsk, Krasnokamsk, Nizhnyaya Tura, and Yegorshino also send power into the network for long-distance transmission.

Industrial centers receiving power from the network are believed to be located in the vicinity of Berezniki and Solikamsk, between Krasnokamsk and Lys'va, between Chelyabinsk and Sverdlovsk, between Chelyabinsk and Ufa, and between Chelyabinsk and Magnitogorsk. The block of electric power sent from Chelyabinsk to Magnitogorsk constitutes the largest single transfer of power. Here it is estimated that 120,000 kilowatts (kw) are transmitted via a 220-kv line over a distance of approximately 150 miles. By comparing the geographical location of power centers which export power with those areas which must receive supplementary power from the network, it is concluded that the Kizel-Gubakha and Krasnokamsk power stations support the network in its northwest section; the Krasnotur'insk and Nizhnyaya Tura stations, in its northeast section; the Yegorshino and Sverdlovsk stations, along the central section; and the Chelyabinsk station, in the southern section.

The power centers having the most surplus power are those situated at the coal basins. Two of these, Chelyabinsk and Kizel-Gubakha, are near the end points of the backbone of the network and may supply as much as 75 percent of the power transferred by the network. Two other coal centers at Krasnotur'insk and Yegorshino contribute a relatively small proportion of the power carried by the network but are important for strengthening it in the vicinity of these two places.

2. Recent Industrial and Electric Power Developments.

The Urals area was one of the first important industrial regions to be developed in the USSR. In the last century, when charcoal was used almost exclusively in steel production, it was the leading producer of ferrous metals. Development of the coking coal industry then gave the advantage to the Ukraine. The decision to exploit the extremely high-grade iron ore reserves in the Urals area, using Kuznetsk and Karaganda coal, and the rapid expansion in the use of nonferrous metals revived the industrial possibilities of the Urals area. The German occupation of the western regions of USSR in 1941-42 and war demands for guns, airplanes, and explosives enhanced the region's industrial significance. In 1942 the Urals area produced the following percentages of total Soviet production: pig iron, 65 percent; steel, 56 percent; rolled iron, 58 percent; zinc, 35 percent; blister copper, 52 percent; and refined copper, 90 percent; and its share of the magnesium and aluminum output reached 100 percent. 1/*

Even with the restoration of the western regions, the Urals area has maintained a high position in the economy. Recent estimates credit to this area the following percentages of total Soviet production: iron and steel, 41 percent; blister copper, 60 percent; zinc, 25 percent; aluminum, 65 percent; and magnesium, 100 percent. 2/

In modern technology, electricity is essential to the production of aluminum, refined copper, magnesium, and high-grade steel and is by far the most economical and practical form of energy used in many of the other industries in the Urals area. A rapid expansion of generating capacity was required to satisfy industrial need for electric energy Generating capacity in 1951 is estimated to have been 380 percent of that installed in 1940. The comparable figure for all the USSR is about 221 percent, 3/ with generating capacity in 1940 at 10.5 million kw and in 1951 at 22.3 million kw. 4/ At present, it is estimated that the Urals area has 20.9 percent of the total generating capacity in the USSR. These figures reflect not only an industrial expansion accelerated by war but also the concentration in the Urals area of those industries consuming large quantities of power.

Although the information concerning the transmission network is not so reliable as that concerning the generating capacity, it appears that transmission facilities have expanded, particularly in the postwar

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period, but probably not at the same rate as generating facilities. In 1941 it was estimated that power centers connected to the network accounted for approximately 80 percent of the capacity of the Urals area, whereas in 1951 the figure had risen to 90 percent as a result of the inclusion of Ufa, Krasnotur'insk, and Serov. Large power centers believed not to be connected to the Urals area network are Orsk, the Oktyabr'skiy-Tuymazy-Urussy district, the Ishimbay-Sterlitamak district, and possibly Kamensk-Ural'skiy.

It is assumed that the 250,000-kw power station at Kamensk-Ural'skiy, not far from Sverdlovsk, is not tied to the network, but its proximity to other large power centers makes such a connection desirable. If Kamensk-Ural'skiy is not considered, the only power centers outside of the network that are believed to have received a substantial increase in generating capacity since 1941 are the Oktyabr'skiy-Tuymazy-Urussy and the Orsk -- Novo-Troitsk power centers. There is no information to show that the generating capacity in the Ishimbay-Sterlitamak area has been increased since that time.

3. Basic Industry Studies.

a. Ferrous Metallurgy.

The iron and steel industry of the Urals area has been the principal factor determining the growth of the Urals area electric power system. It had a head start over the other basic industries and has become very large, reaching a point in 1951 where it contributed 41 percent of the total iron and steel produced in the USSR. 5/ Ferrous metallurgy became the base upon which many of the present large industrial centers grew. Before the building of the Urals area network, power stations were built to satisfy all the local electric power demands in these industrial centers. This dependency on local supply is still heavy despite the number of industrial centers that are tied to the network. Almost every industrial center not immediately adjacent to another one has one or more power stations which provide a major part of the power needed in the immediate area. The most important exception is Magnitogorsk.

Because the power stations at the ferrous metallurgical centers were in most instances the first large ones put into operation, they became the first to be tied together by a network. The backbone of the Urals area network was built through many of the more important early metallurgical centers, from Molotov through Chusovoy, Kushva, Nizhniy

Tagil, and Sverdlovsk to Chelyabinsk. More recently, lines extending from this backbone have connected the power stations serving almost all the other iron and steel plants to the network. It is estimated that the capacity of power stations at industrial centers where the most important basic industry is ferrous metallurgy now constitutes about 50 percent of the total capacity in the Urals area.

The generating capacity at ferrous metallurgical centers is not necessarily proportionate to the level of iron and steel production at these centers, as can be shown by examining the three largest iron and steel centers, at Magnitogorsk, Nizhniy Tagil, and Chelyabinsk, which contribute about 60 percent of the total production of iron and steel in the Urals area. 6/ The metallurgical plants at these three places are all modern, integrated plants with their own coking plants and steel mills. The amount of electric power required for the blast furnaces, open hearths, Bessemer converters, coking plants, and steel mills and for fuel handling and ore mining is assumed to be proportionate to the level of iron and steel production, while the amounts of power required by electric furnaces may vary. Without any allowance for electric furnace capacity, about 73,000 kw are required for each 1 million tons of steel per year. On the basis of recent estimates for steel production at these three centers, 7/ the following generating capacity is required: Magnitogorsk, 300,000 kw; Nizhniy Tagil, 150,000 kw; and Chelyabinsk, 87,000 kw. The actual generating capacity existing at these power centers is believed to be, respectively, 133,000 kw, 315,000 kw, and 640,000 kw. By showing the disproportionate amounts of capacity at these centers, these figures go a long way in explaining (1) why a synthetic nitrogen plant has been installed at Nizhniy Tagil and not at Magnitogorsk; (2) why Chelyabinsk has the only large ferrous alloy plant as well as industries normally requiring high-grade steels; (3) why Magnitogorsk is so dependent on outside sources of power; and (4) why the USSR has found it necessary to export crude steel shapes from Magnitogorsk instead of building industries which could consume the steel on the spot as at Nizhniy Tagil and Chelyabinsk.

The future growth of the electric power system and the future growth of the iron and steel industry will affect one another, but it is a question whether the expansion of an iron and steel plant will cause an expansion of a local power station or an increase in transmission of power. The answer to the question depends on several economic factors such as the losses involved in transmission, the cost of building new transmission facilities, the expense of transporting fuel, and the ease with which various iron ores found in the Urals area may be processed. The geographical relationship of iron ore deposits to coal deposits and the quality of the iron ore deposits will strongly influence the future development of the Urals area electric power system. Examples of the various solutions which the Soviet government has adopted for varying sets of conditions are found at Chelyabinsk, Magnitogorsk, and Orsk. At Chelyabinsk there are deposits of good iron ore and plenty of coal for power station use, but coking coal for steelmaking must be imported. Both iron and steel production and local power-generating facilities have been expanded rapidly. At Magnitogorsk, there is an excellent local supply of iron ore but no coal. The USSR has felt justified in building a long, costly transmission line to Chelyabinsk in order that the Magnitogorsk production of iron and steel might be expanded. It is believed that no generating units have been added at Magnitogorsk since the war, although iron and steel production has doubled. At Orsk the contemplated vast exploitation of the good iron ore deposits has been postponed. 8/ Iron and steel are being produced on a relatively limited scale. It is probable that the expense of building transmission lines from other power centers and the lack of good supplies of local fuel for power stations and industry are partly responsible for causing the USSR to give priority to other projects.

b. Nonferrous Metallurgy.

Nonferrous metallurgy in the Urals area is generally of more recent origin than ferrous metallurgy. Because of the extent to which it has developed and the large quantity of electric power needed for the mining and refining of nonferrous metals, this type of metallurgy, like ferrous metallurgy, has resulted in the growth of industrial centers which are among the strongest power centers. In some localities, nonferrous metallurgy is not the only basic industry, but in most instances it is the principal consumer of electricity and is, therefore, the controlling influence in the development of the local electric power systems. The principal exceptions to this statement are industrial centers where ferrous metallurgy is also located, such as Sverdlovsk, Chelyabinsk, and Orsk, and the major chemical center of Berezniki.

Whereas most iron and steel plants have become the basis for the growth of many other industries in the immediate area of the iron and steel plant, nonferrous metals, after they have been processed near the source of the ore, are ordinarily distributed to manufacturing plants throughout the USSR. These centers of nonferrous metallurgy, therefore, unlike centers of ferrous metallurgy, usually require only the electricity needed for mining and refining the ore.

The Urals area leads all other economic regions in the USSR in the production of nonferrous metals. In 1951 it produced the following percentages of the Soviet production: aluminum, 65 percent; magnesium, 100 percent; copper, 60 percent; and zinc, possibly 25 percent. 9/

Most important of the nonferrous metals from the point of view of electric power are aluminum and magnesium, since the production of either requires about 22,000 kilowatt-hours (kwh) per ton, as much electricity as it takes to furnish the daily electric power requirements of 4,400 average American homes. 10/

Aluminum production is concentrated at Kamensk-Ural'skiy and Krasnotur'insk, each aluminum plant being served by its own power plant. Total capacity of the two plants is 533,000 kw; of this total it is estimated that a capacity of 370,000 kw is being used for aluminum production alone. The Krasnotur'insk power center has recently been connected to the backbone of the Urals area network, but there is no reliable information to indicate that the Kamensk-Ural'skiy power center has been so connected.

The advantages to the USSR in extending the network to Kamensk-Ural'skiy are such as to suggest the possibility that it has been done. It is assumed that both aluminum plants could draw substantial amounts of electric power from the Urals area network, should a rapid expansion in aluminum production be necessary. It is thus concluded that information showing expansion of power stations at either Kamensk-Ural'skiy or Krasnotur'insk would indicate an increase in aluminum production.

The magnesium industry is located in the adjacent cities of Berezniki and Solikamsk. In both places there are power plants which are almost large enough to supply the magnesium industry as well as other industries in the area. These power plants are connected to the Urals area network not far from Kizel, where recently there has been considerable expansion of generating facilities. This suggests the possibility that the magnesium industry also has been expanding in the last few years.

The copper, zinc, and lead industries depend heavily on electric power but not so heavily as the aluminum and magnesium industries. Mining, smelting, and refining of these metals are done in localities near the backbone of the Urals area network in the vicinity of Chelyabinsk and Sverdlovsk. Most smelters are supplied with electricity by small local power plants supplemented by the network.

c. Electrified Railroads.

In mileage of electrified railroads and in tonnage of freight carried by them, the Urals area leads all other regions in the USSR.

Circumstances which have led to the rapid expansion of the electric power system also have caused the Soviet government to make the heavy investments required for electrification of the railroads, and there has developed a certain interdependency between the transportation and power systems. The coal found in the Urals area is generally of low quality, and most of it is mined at three widely separated points: Kizel, Karpinsk (near Krasnotur'insk), and Chelyabinsk. Since the coal is not a satisfactory fuel for locomotives, because of its inferior grade, but is an economical fuel for power stations, electric motive power in the Urals area railroads is preferable to steam motive power.

This same characteristic of Urals area coal has also encouraged the Soviet government to transmit the electric power where power is needed, because of the great expense of transporting low-grade coal.

Not only have circumstances been somewhat parallel in the development of the transmission of electric power and electrified railroads, but also the two are physically connected. On the basis of the information available, it is concluded that every electrified railroad is paralleled by a section of the Urals area network which helps to supply power to the railroad. Electrified railroads in 1945 included the Kizel-Chusovoy-Goroblagodatskaya*-Sverdlovsk, Chusovoy-Molotov, Chelyabinsk-Zlatoust, and Zlatoust-Berdyash lines. 11/

All these railroads, except the last one, are known to have been paralleled by high-tension transmission lines in 1945. Work has been proceeding more recently and now may be completed on the electrification of the Berdyash-Ufa, Sverdlovsk-Chelyabinsk, and Goroblagodatskaya-Krasnotur'insk railroads. It is known that transmission lines connect

* Located 3 km south of Kushva.

Sverdlovsk and Chelyabinsk and that transmission lines have been built to parallel the other railroads. With the completion of the electrification of the Sverdlovsk-Chelyabinsk and the Goroblagodatskaya-Krasnotur'insk railroads, the USSR will have connected the three major coal basins and all the major intervening industrial centers in the Urals area.

Railroad electrification has not been extended to the southern part of the Urals area. This again shows the interdependency of the electric power system and the electrified transportation system because this is also the region where there are longer distances between power stations, the power network not being so well developed as in the area north of Chelyabinsk.

By using US parallels, it is estimated that generating capacity required by railroads in the Urals area amounts to 25,000 kw for every 100 miles of electrified double-track line. A tentative estimate of electrified trackage in the Urals is 1,236 kilometers (km) of double-track line and 349 km of single-track, corresponding to 1,411 km, or 876 miles, of double-track equivalent.* Such a length of electrified trackage might, therefore, require 220,000 kw, or about 5 percent of total generating capacity of the Urals area.

Much of this power is supplied from the large power centers such as Chelyabinsk, Sverdlovsk, Krasnokamsk, Kizel, and Krasnotur'insk, but in certain stretches of the transmission line which are particularly long, power stations, such as the Nizhnyaya Tura and Kropachevo power plants, have been built whose primary purpose is to supply the railroad. The inclusion within the network of all plants known to be supplying the railroads shows how railroad electrification has served to strengthen the electric power system in the Urals area and that railroad electrification is well integrated with the Urals area network.

d. Coal Mining.

The coal mining industry in the Urals area is in a very favorable position with respect to electric power supply. More than 90 percent of

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* The following electrified railroads were assumed for this estimate:

Molotov-Goroblagodatskaya-Sverdlovsk-Chelyabinsk, 756 km (double-track);
Chelyabinsk-Ufa, 480 km (double-track);
Chusovoy-Kizel, 113 km (single-track); and
Goroblagodatskaya-Krasnotur'insk, 236 km (single-track).

the coal production is in the Kizel, Chelyabinsk, and Krasnotur'insk districts, and the power stations in these districts can be easily supplied with fuel. The USSR has taken advantage of these conditions to electrify coal mining.

It is estimated that an average of 13 kwh, including power station use and losses, is required to mine 1 ton of coal in the Urals area. It is reported that 36.3 million tons were mined in the Urals area in 1951. 12/ The resulting electric power requirement is, therefore, 472 million kwh. This corresponds to about 120,000 kw, or only about 2.6 percent of total generating capacity. Thus the requirements of the coal mining industry for electric power are not a direct determining influence on the development of the electric power system. However, the advantage of generating power at the coal deposits and thus saving heavy transportation costs has caused the Soviet government to build some of the largest power stations adjacent to the coal mining areas. Generating capacity at Chelyabinsk and Krasnotur'insk and in the Kizel coal area is estimated at 1,267,000 kw. At Yegorshino, the fourth largest coal producing center, a generating capacity of 69,000 kw is installed. The total corresponds to 28 percent of the total generating capacity in the Urals area.

These four coal and electric power centers are joined to the network and supply most of the electric power which is transmitted via the Urals area network to places where there is an insufficient supply from local power stations. Since World War II a high proportion of generating capacity in the Urals area was installed at these four points, and it is likely that they will receive continued emphasis in the future. The geographical location of these major Urals area coal centers, but not the demand of the coal industry for power, has played and will also continue to play a strong role in the development of the electric power system.

e. Chemical Industry.

Except for the electricity used in the production of coke chemicals, and that used in a possible synthetic nitrogen plant at Nizhniy Tagil, requirements for electric power in the chemical industry of the Urals area are concentrated in small districts that include Berezniki and Solikamsk. It is estimated that practically all the chlorine and caustic soda and most of the synthetic ammonia and soda ash produced in the Urals area are produced in these districts. There are many other chemical plants scattered throughout the Urals area, but they may be disregarded in a consideration of the electric power system, as they use such a small proportion of the total electricity supplied to the chemical industry.

US factors of consumption are utilized in estimating requirements for electric power in the major USSR chemical industries. Total consumption requirements were estimated at 1,200 million kwh in 1941. 13/ This total was distributed as follows: 730 million kwh in the Berezniki-Solikamsk district; 297 million kwh in the production of coke chemicals at Chelyabinsk, Gubakha, Magnitogorsk, Nizhniy Tagil, and Orsk; 150 million kwh in probable synthetic ammonia plants at Nizhniy Tagil; and small amounts at Sterlitamak and Kirovgrad. In terms of generating capacity, 1,200 million kwh equal possibly 240,000 kw, or about 5 percent of the total generating capacity of the Urals area.

Chemical production is the most important industry and the heaviest power consumer in the Berezniki-Solikamsk district, and the power plants there primarily serve that industry. These power plants are connected to the Kizel-Gubakha power center so that the electric power supply to the chemical plants can be quickly increased if necessary.

There appears to be not quite enough generating capacity at Berezniki and Solikamsk to meet the electric power requirements for chemical and magnesium production, as well as for municipal, domestic, and commercial use. It is probable, therefore, that additional power is imported via the network from the Kizel-Gubakha power center. Recent additions of generating capacity at Kizel suggest the possibility that the flow of power northward to Berezniki and Solikamsk has been increasing. Such an increase is additional evidence of a tendency to rely more heavily on generating power where fuel is locally accessible and transmitting the power to industrial consumers in other localities.

Power consumed in the production of coke chemicals is proportionate to the size of the coking plants, the capacities of which are in turn ordinarily determined by the capacity of the iron and steel plant with which they are associated. The electric generating capacity required to meet the demands of the coke-chemical plants may equal 60,000 kw, but inasmuch as production of coke chemicals is distributed among five plants, there is not a very large demand at any one place. The location of the coke-chemical plants in the stronger power centers means that power supply to the coke-chemical industry is relatively secure.

Information on the production of synthetic ammonia from coke-oven gas is scanty, and the estimate for the requirements of electric power for such production is correspondingly weak. A recent estimate indicates that a synthetic ammonia plant exists at Nizhniy Tagil but none at Magnitogorsk. 14/ The good position of Nizhniy Tagil with respect to supply of electric power and the known tendency of the USSR not to increase power requirements in Magnitogorsk beyond what is needed for efficient exploitation of the iron ore deposits tend to support such an estimate. Since, however, the production of synthetic ammonia requires substantial amounts of electric power, the Soviet government may increase ammonia production by the water-gas process at Berezniki or from coke-oven gas at Bakal near Chelyabinsk, because cheap electric power could be supplied at both places in large quantities.

f. Oil Production and Refining.

The lack of good information on supply of electric power to the oil industry in the Urals area prevents reasonably accurate estimates of the generating capacity required to serve the industry or the extent of integration of the industry into the Urals area power network.

The oil industry in the Urals area is less integrated with the electric power network than any of the other basic industries. It is believed that oil refineries and producing regions near Krasnokamsk, Ufa, Molotov, and Chusovoy-Gorodki are the only oil centers tied to the network. In all cases where there is no tie-in, the Soviet government has had to install generating capacity sufficient to meet the entire local demand.

Oil is generally refined at industrial centers which are also good transshipment points. Perhaps as much as 66 percent of the refining capacity is located at Ufa and Orsk. In the past, power plants were built as integral parts of the refineries and were large enough to supply all refinery requirements. If this is still true, it would mean that about 66 percent of the generating capacity supplying oil refineries in the Urals area is located at Ufa and Orsk.

The principal oil fields in the Urals area have their own power plants. The tendency is toward utilizing central power plants large enough to supply individual oil regions. Nothing is known about the possible enlargement of the electric power supply for oil production in the Ishimbay-Sterlitamak district or at Krasnokamsk, but information does show the addition of possibly 36,000 kw in the last 5 years at Urussy (near Tuymazy) and 12,000 kw at Buguruslan. 15/

Soviet authorities have recently complained of a shortage of electric power in the oil producing district in the southwest part of the Urals area. This district, known as the "second Baku" area, includes most of Bashkir ASSR and Chkalov Oblast. The electric power system is poorly developed in this district, but it is believed that the USSR has been able to install enough generating capacity to keep up with the growing demands of the oil industry. These demands probably do not exceed 200,000 kw, or 4.2 percent of the total capacity of the Urals area. Consequently, even with allowance being made for a rapid expansion in oil production, satisfactory power supply to the oil industry can probably be maintained.

Since the oil industry is one of the few industries in the southwest part of the Urals area, it has had a large influence on the development of electric power supply in this area. The location of the larger oil refineries in the larger cities of this area has contributed to the concentration of power generation at these points. On the other hand, the geographical dispersion of the oil drilling regions has resulted in a series of widely scattered, medium-sized power centers which are not sufficiently powerful to justify their being tied together into a network. It is expected that within 5 to 7 years, when the gigantic hydroelectric plant now under construction on the Volga at Kuybyshev will have been completed, high-tension lines will be built to bring cheap power into the region as a substitute for electric power now largely generated on the basis of natural gas and expensive fuel oil. These high-tension lines probably will also connect with the main Urals area network, with the consequence that a sufficient and reliable supply of electric power will be assured to the oil industry of the Urals area for the future.

4. Future Developments.

The USSR has demonstrated a desire to substitute electric power transmission for fuel transportation and to employ the best energy resources. Furthermore, the Soviet government is now working energetically, with the help of German technicians, to design transmission lines up to 600 miles in length and with a voltage of 400 kv, which is as high as that attempted anywhere else in the world.

The growth of the Urals area network will depend principally on where new generating capacity is installed. Such expansion is expected to be accomplished at the larger power centers. Especially large additions will probably be installed at those closest to the coal deposits and at the best hydroelectric sites. More transmission facilities will in turn be required not only for the transfer of increased quantities of power from source to user but also for voltage regulation purposes. The future thus should see additional circuits from Kizel, Molotov, Krasnotur'insk, and Chelyabinsk and others between the larger power centers. These new circuits probably will in most cases parallel existing lines.

The number of circuits now constituting the backbone of the Urals area network is not accurately known. Because of the importance of this backbone and the probability that it will have to carry additional power generated in Molotov Oblast and at Chelyabinsk for intermediate points, additional circuits will no doubt be added to parallel the existing ones.

If the Kamensk-Ural'skiy power center has not yet been brought into the network, it probably will be in the near future. Construction of lines from Kamensk-Ural'skiy to Sverdlovsk and to Yegorshino is feasible.

Little development is expected in transmission lines south of the Ufa-Chelyabinsk line until the Kuybyshev hydroelectric plant is completed. Before World War II a 220-kv line was built to connect Magnitogorsk and Zlatoust, and at some time after the beginning of the war it is probable that another 220-kv line was built between Magnitogorsk and Chelyabinsk. There were also indications that a Magnitogorsk-Ufa line was planned. These existing and proposed transmission lines show that the USSR has been intent on tying Magnitogorsk closely to the network. However, the lack of industry between the Chelyabinsk-Ufa line and Magnitogorsk gives the impression that the Magnitogorsk-Zlatoust line was unwarranted and that the USSR instead of making additional investments in transmission lines in this region is more likely to spend its money in other areas.

Unlike the other major networks in the USSR, such as those in the Central Industrial, Northwest, Ukraine, and Caucasus economic regions, hydroelectric power in the Urals area has played a very minor role in the development of the electric power network. Probably no more than 5 percent of the electricity is so generated. The Soviet government, however, has worked out a long-range plan to exploit the water-power resources of the region. This plan includes the building of dozens of small and medium hydroelectric power plants, with a combined generating capacity of 670,000 kw, 16/ on some of the many streams flowing off both sides of the Ural Mountains Divide and the construction of two large stations on the Kama River at Levshino near Molotov and at Solikamsk. The generating capacity of the latter two plants is planned for 400,000 kw and 200,000 kw, 17/ respectively. This capacity, totaling about 1,270,000 kw, is to be distributed as follows: Molotov Oblast, 745,000 kw; Sverdlovsk Oblast, 80,000 kw; Chelyabinsk Oblast, 66,000 kw; Chkalov Oblast, 40,000 kw; and Bashkir ASSR, 340,000 kw. 18/

This plan is being realized very slowly, with possibly only 15 percent of the generating capacity planned for the small and medium projects being installed.* The Solikamsk project has not been started. The Levshino hydroelectric plant near Molotov, the construction of which began in 1948, 19/ probably will not be ready for the installation of its first units until 1953.

In considering the effects that these hydroelectric plants will have on the development of the network, it should also be mentioned that Molotov Oblast contains 65 percent of the water power in the Urals area, 60 percent of the coal, and 50 percent of the peat, as well as a number of big oil fields. 20/ The use of peat and oil for power stations has been and will be very small, but, as has been mentioned, the Soviet government has shown a tendency to concentrate generating capacity, particularly that required for the operation of the network, at the coal basins.

Because of the combination of good water and coal resources, Molotov Oblast not only will have sufficient power to supply expanding industry but also will be able to take over the supply of an increasing portion of the Urals area network. Without discounting the coal basins near Krasnotur'insk and Chelyabinsk, it would appear that, from the point of view of electric power, the area bordered by the Kama River and the Molotov-Chusovoy-Solikamsk railroad is the best site in the Urals area for power-hungry atomic energy installations.

The small- and middle-sized power stations are well dispersed throughout the Urals area and will serve a useful function in regulating the network and in lessening the need to transport coal to areas a long distance from the coal basins. Thus in one sense these plants will

* Estimate made on the basis of plants said to be under actual construction in 1945 21/ and assumed to be finished at this time.

strengthen the network, but in another they will limit its expansion by permitting a cheap local supply of electric power without the necessity of tying out-of-the-way localities into the network.

At present the Urals area network is not tied in with any power stations outside the region. Furthermore, there are presently no large-capacity generating stations or networks near enough to the Urals area system to warrant the expense of interconnection. In the more distant future (1955-60), however, the completion of the gigantic hydroelectric projects on the Volga, particularly the 2-million-kw plant at Kuybyshev, would justify the construction of power lines to connect the Volga region with the Urals area network, probably at Ufa.

Additional transmission lines may be built from Molotov to Kirov and then to Gor'kiy after the completion of the Levshino and Solikamsk plants and the hydroelectric plant now being constructed at Gor'kiy.

Such connections would be part of an enormous ring which may eventually bring together the Urals, Central Industrial, Ukraine, and Volga economic regions. Such a ring would make it possible to supply the presently under-developed southwest part of the Urals area with cheap hydroelectric power from the Volga region and permit the transmission of power from Molotov Oblast, with its good energy resources, to the northeast section of the Central Industrial Region, where peat is the only local fuel of importance.

There is also a possibility that Orsk might be linked to Aktyubinsk to the south in Central Asia, that a transmission line might be extended from Magnitogorsk through Kartaly towards Akmolinsk, and that Chelyabinsk might be tied in with some of the industrial centers along the railroad leading from Chelyabinsk through Kurgan and Petropavlovsk to Omsk. Information was not collected on areas outside of the Urals area, so that it is difficult to judge whether these speculations are completely justified. They are suggested merely as possibilities in light of the Soviet practice of bringing as many industrial centers into a single network as is practicable in order to obtain the advantages of conservation of generating equipment and reduction of transportation loads by the substitution of power transmission.

The importance of the Urals area network in the future will depend on the industry which it serves and the amount of fuel transportation which it is able to save. The fact that as much generating capacity was added between 1946 and 1951 as between 1940 and 1946 indicates that the circumstances peculiar to World War II were not the only factors causing rapid electric power and industrial expansion in the Urals area. The postwar expansion shows that the USSR considers it an economic advantage to continue to exploit the rich metal and mineral deposits in the area. There is no reason to believe that expansion of any of the six basic industries will slow down. Expansion of these industries will result in the building of additional plants to convert the basic products into finished goods. For these reasons, the existing industrial pattern probably will not change very much. Generating capacity will have to be added at a rate proportionate to industrial expansion, some measure of which can be gained by examining the level of production of the basic industries.

Where industrial expansion takes place in any of the larger power centers, an increase in generating capacity can be expected. However, an increasing proportion of electric power will be transmitted via the network and consumed at industrial centers which are more than 50 miles from good fuel or water-power resources.

# APPENDIXES

## Introduction

The appendixes are designed in such a way that practically all the substantive material which contributes to the conclusions in the text is included in a convenient form which permits the addition of new data by any analyst. Appendixes A, B, and C summarize information on generating capacity and industrial requirements. Appendixes B, C, and D contain information on transmission of electric power, which is summarized in the form of a map following the appendixes (Map A). Except as otherwise noted, estimates in the appendixes reflect conditions at the end of 1951.

In order to clarify certain terms used and to help the reader to evaluate the information, the following explanations are presented, in the order in which they appear in the appendixes.

The figures in Appendix A for generating capacity and production of electric power are given only for those years where fairly reliable information could be collected. The margin of error is 5 percent for all figures. Rural electric power stations are not included.

The term "power center" in Appendix B refers to a geographical area in close proximity to electric power stations that are so near one another that the generating capacity in the power stations may be considered as being installed in one power plant. It excludes large rural areas where electric power is unimportant. Such a term is convenient where two or three towns within a few miles of one another are engaged in similar production and where the power stations may be assumed to be under a single operating control.

[redacted] 50X1
50X1 The population figures are out of date, and their reliability is considered to be poor.

The term "basic industry" refers to six industries which provide most of the raw materials and semifinished products for the manufacturing and fabricating industries. Except for electrified railroads and a small portion of the chemical industry, these basic industries have the common characteristic that a metal or mineral is extracted from the ground and by means of such processes as cleaning, crushing, smelting, and refining is converted into a product useful for other industries.

Under "other industry" are grouped those industries which are believed to absorb a sizable fraction of the electric power available at any particular locality.

Generating capacity figures are the totals of all electric power plants within an individual power center. [redacted] 50X1 50X1

In many cases, reports on the consumption of fuel by a particular power plant or the size of a building were used in making the estimate. Appendix C includes generating capacity figures taken directly from German documents, but, in accordance with the method used in writing this report, the German documents were used only for purposes of comparison or where there was absolutely no other information on a plant. For the smaller plants the margin of error may approach 100 percent. The margin of error decreases according to the size of the power center.

Estimates of transmission line routes and voltages should be treated with the greatest reserve. Appendix B includes only those lines reported in Soviet publications or by postwar observers. In many instances a connection was assumed on the basis of a report by an observer that he saw a line leading in a certain direction from the town where he was stationed. Reference was then made to a map to see whether another town was located at a reasonable distance and in the direction reported. Transmission lines have in general not been cross-referenced, so that the reader will find it helpful to refer to Map A.

It was felt that inasmuch as generating capacity was expressed in kilowatts and no attempt made to convert each capacity figure into a production figure (kilowatt-hours), consumption should also be expressed in kilowatts. Ordinarily power consumption figures are given in kilowatt-hours. Kilowatts usually are employed as a measure of the peak load, average load, or potential load which any particular consumer might put on an electric power system. In this report, however, consumption is expressed in kilowatts and includes not only the average load of a consumer but also the generating capacity required to make up for power station use of electricity and losses in the system. In other words, the kilowatt figures represent what generating capacity must be added to a system if a consumer is connected. Power station use and losses were applied across the board, as insufficient information is available to calculate the variations throughout the system. In effect, the terms "consumption" and "power requirements" are used interchangeably throughout this report.

Most power center studies include an estimate of power requirements by municipal, domestic, and commercial users. These estimates are extremely unreliable because of an almost total lack of details as to use in these categories. They were based on the following reasoning: (1) that 16 billion kwh were consumed by municipal, domestic, and commercial users in 1951; (2) that 40 percent of the approximately 200 million people in the USSR live in urban centers; (3) that only urban centers consume electric power domestically or utilize electric power in municipal and commercial establishments; (4) that municipal, domestic, and commercial use may be assumed (for purposes of this report) to be proportional to the urban population; and (5) that capacity supplying the power operates an average of 4,000 hours per year. Dividing the urban population of 80 million people into 16 billion kwh consumed gives 200 kwh per person. This figure was multiplied by the population of each power center, and the product was then divided by 4,000 hours to give the generating capacity required for municipal, domestic, and commercial users.

APPENDIX A

## GENERATING CAPACITY AND PRODUCTION OF ELECTRIC POWER IN THE URALS AREA, 1940-51

| Year | Capacity (Thousand Kw) | Production (Million Kwh) |
|---|---|---|
| 1940 | 1,220 a/ | 6,200 a/ |
| 1941 | 1,257 b/ | N.A. |
| 1942 | 1,700 a/ | 9,000 c/ |
| 1943 | 2,068 d/ | 10,500 c/ |
| 1944 | N.A. | N.A. |
| 1945 | N.A. | N.A. |
| 1946 | 2,800 e/ | N.A. |
| 1950 (Plan) | 4,600 a/ | N.A. |
| 1951 (Estimate) | 4,677 f/ | N.A. |

[redacted] 50X1

f. This estimate represents a summation of the generating capacity figures appearing in Appendixes B and C and an assumption of 175,000 kw unreported generating capacity.

## APPENDIX B

## POWER CENTER STUDIES

1. Beloretsk.

a. Location [redacted] 50X1

b. Local Population. 1932: 32,000; 1949: 45,000. 27/

c. Local Industry. Basic: ferrous metallurgy (including mining, pig iron and steel production, electric furnace). Other: steel cable and wire.

d. Generating Capacity. 11,000 kw, including 5,000 kw hydroelectric.
The new hydroelectric plant was reported without any statement as to generating capacity. 28/ The capacity was estimated at 5,000 kw because this station is far upstream on a tributary above two proposed hydroelectric plants that are to have a generating capacity of 14,000 kw and 15,000 kw. 29/ The estimate for the generating capacity of the thermal electric station (TETS) is based on a statement that it is for emergencies 30/ and on a figure of 5,000 to 10,000 kw given by another source. 31/

e. Transmission. There is one line of 110 or 220 kv with a single or double circuit from Magnitogorsk. (Available information favors a double-circuit 110-kv line.) 32/

f. Consumption. Municipal, domestic, and commercial users are estimated to require 2,250 kw. Level of steel production may be the indicator of the level of industrial activity, as it probably influences the amount of ore mined and the quantity of steel available to the cable and wire factory. Steel production is estimated at 197,000 metric tons, 33/ or about 2 percent of total steel production in the Urals area. The existence of a possible double-circuit line to Magnitogorsk would suggest that power is being imported from that point. However, an examination of Magnitogorsk reveals that it must import about 120,000 kw from Chelyabinsk, so that it is assumed that no power is transmitted from Magnitogorsk to Beloretsk. If it is assumed that the steel production and the generating capacity figures are correct, there would be insufficient power to operate the steel plant and the wire and cable plant. It is impossible at this time to decide which estimates are wrong.

2. Berezniki.

a. Location. [redacted] 50X1

b. Local Population. 1946: 150,000. 34/

c. Local Industry. Basic: chemicals (chlorine, caustic soda, synthetic ammonia, soda ash) and nonferrous metallurgy (magnesium plant).

d. Generating Capacity. 178,000 kw. This estimated generating capacity is believed to be installed in four power plants. The estimate for this capacity was made by assuming that three out of the four plants reported as existing during the war 35/ were still in existence, that the fourth was dismantled, and that a new plant of 50,000 kw was added in the postwar period. 36/ This new plant has been reported to have 25,000-kw units. 37/

e. Transmission. There is no reliable postwar information concerning transmission lines at this location, but information on Solikamsk and Kizel reveals that there is a transmission line running from Kizel through Berezniki to Solikamsk. A large transformer station to the east of Voroshilov Chemical Works is reported and is obviously an important substation in the Urals area network. 38/ The information given below suggests that the area has no power available for export.

f. Consumption. Berezniki is the largest producer of basic chemicals in the Urals area. Consumption of electric power by the chemical industry at Berezniki has been estimated at about 650 million kwh, 39/ which corresponds to a generating capacity of approximately 130,000 kw. No estimate of production by this plant has been found, although it is one of the two large magnesium producers in the Urals area. Inasmuch as magnesium is an extremely heavy consumer of electric power, it is reasonable to assume that it requires all the power available which is not being used by the chemical industry or by municipal, domestic, and commercial use. Assuming that the latter category accounts for 7,500 kw and using 130,000 kw for the chemical industry, there would be 41,000 kw available for the magnesium plant, without making any assumption for electric power imported or exported from the area.

3. Chelyabinsk.*

a. Location. [redacted] 50X1

b. Local Population. 1950: 725,000. 40/

c. Local Industry. Basic: ferrous metallurgy, nonferrous metallurgy, chemicals, coal, and electrified railroad. Other: tractors and agricultural equipment, armaments, tanks, pipe, motor vehicles and abrasives.

d. Generating Capacity. 640,000 kw.
Most of the capacity is installed in three plants: 150,000 kw in the Chelyabinsk GRES (Government Regional Electric Station), 41/ 120,000 kw in the Bakal TETS (thermal electric station), 42/ 350,000 kw in the Chelyabinsk TETS, 43/ and 12,000 kw in a plant at Kopeysk. 44/ 18,000 kw were added to the estimate to make allowance for possible old DC generating units and small emergency power units. Because of a lack of good reports of recent origin, the total may be low bv 25 percent.

e. Transmission. Chelyabinsk is a terminal point for the Urals area network, 45/ which is reasonable in view of the fact that it is the largest power center in the area. Transmission lines radiate out in all directions, and it is safe to assume that any point of industrial importance within 100 miles is connected in some way to the power stations in Chelyabinsk. The following lines are known: (1) Chelyabinsk-Miass 46/; the voltage and number of circuits is not known; best estimate is a double-circuit 110-kv line. (2) Chelyabinsk-Kyshtym 47/; this may also be double-circuit line at 110 kv. (3) Chelyabinsk-Plast 48/; a 25-kv line which may run off the Chelyabinsk-Magnitogorsk line. A Chelyabinsk-Magnitogorsk line is estimated from fragmentary information.

f. Consumption. Municipal, domestic, and commercial requirements are estimated at about 36,000 kw. This would leave 594,000 kw for industry and transmission to other areas. The Chelyabinsk center is one of the most important zones of basic industry in the Urals area, producing 10 percent of the steel and 80 percent of the ferrous alloys of the region. It is estimated that 840,000 tons of steel are produced at Bakal and 290,000 tons at the pipe plant. 49/ The ferrous alloy plant appears to be the only large plant of its kind in the Urals area. Production was

* This power center includes Chelyabinsk, Bakal, Gornyak, Kopeysk, and Korkino.

estimated at 300,000 tons in 1946 50/ but has presumably increased in the same proportion as the aircraft, motor vehicle, tank, and tool industries which it supplies. All of the lead and zinc refined in the Urals area is produced in the Chelyabinsk center, as well as about 9 percent of the coke chemicals and 33 percent of the coal production. The power center is the terminus for two electrified railroads extending to the west and the north, two of the most heavily used lines in the Urals area. 51/

A large power plant of 120,000 kw was built as an integral part of the Bakal steel combine, which is located north of the city of Chelyabinsk and where possibly 66 percent of the steel producing capacity and the entire coke-chemical production of the city are situated. The rolling mills and a large electric furnace associated with this steel combine and the ferrous alloy plant would be the largest consumers. It may be assumed that most of the 120,000 kw is consumed by the Bakal plant except for a small amount sent over the Urals area network.

A power station with a capacity of 150,000 kw was the first large power plant built in the area and had to supply most of the industry existing in the vicinity of Chelyabinsk as of 1937, when the last units were installed. The major industries at that time were the large ferrous-alloy plants, the abrasives plant, and the lead and zinc plant. It was called a regional power plant and presumably still supplies areas to the west, including Miass and Zlatoust.

The third power plant of large size was begun just before the war and was expanded during and since the war up to a generating capacity of 350,000 kw. In the immediate vicinity of this plant are located tractor, armament, tank, pipe, and motor vehicle plants which were built and expanded at the same time. It is assumed that this power plant and the small Kopeysk plant supply these industries, in addition to the large coal mining areas at Kopeysk and Korkino and the electrified railroad. These power plants also probably transmit a large amount of power to the south to Magnitogorsk and probably support the other two power plants in supplying the areas to the west and north of the city of Chelyabinsk.

4. Chkalov.

a. Location. [redacted] 50X1

b. Local Population. 1949: 200,000. 52/

c. Local Industry. Basic: oil refining. Other: aircraft, motor vehicle parts, machine tools, and locomotive repair.

d. Generating Capacity. 45,000 kw, in three plants: 36,000 kw at Krasnyy Mayak, 53/ estimated 3,000 kw at the municipal plant, 54/ and estimated 6,000 kw at the locomotive works. 55/

e. Transmission. There is no evidence to indicate that this power center is tied into any network.

f. Consumption. Only 35,000 kw are available for industrial use when 10,000 kw are subtracted for municipal, domestic, and commercial use.* Chkalov is an example of a regional center with a population of considerable size that must specialize in industries not requiring large quantities of electric power, there being no large energy resource base which could support large power plants. It is also too distant from the principal electric power centers to receive power via transmission lines. The industries here, therefore, are those emphasizing hand labor, with the exception of the oil refinery, which evidently does not require much electric power.

5. Chusovoy.

a. Location. [redacted] 50X1

b. Local Population. 1950: 50,000. 57/

c. Local Industry. Basic: ferrous metallurgy (including mining, iron and steel production, and mills), oil refinery. Other industry is insignificant.

d. Generating Capacity. 36,000 kw (including 20,000 kw hydroelectric). This is a very weak estimate. It is based on the assumption that there are three plants: (1) one old 4,000-kw plant 58/; (2) a recently built 12,000-kw plant 59/; (3) a 20,000-kw hydroelectric plant which was reported as under construction in 1944 at Ponyshsk, 25 km from Chusovoy, for the supply of that city's industry. 60/ It is assumed to be completed by now, but there has been no further information.

[redacted] 50X1

e. Transmission. Chusovoy is tied in with the Urals area power transmission network, 61/ presumably with Kizel and Molotov.

f. Consumption. The amount of generating capacity and transmission is not sufficiently well known to permit an estimate as to how much power is available for industry. The only industry requiring a large quantity of electric power would be the metallurgical plant with an estimated production rate of 750,000 tons of steel per year. 62/ A threefold increase in industrial expansion during the war period coincided with the expansion of local power facilities. The oil refinery in the area is small and would not be an important consumer.

6. Ishimbay-Sterlitamak.

a. Location. Ishimbay: [redacted] Sterlitamak: [redacted] 50X1

b. Local Population. Ishimbay: no estimate available; Sterlitamak, 1947: 35,000. 63/

c. Local Industry. Basic: oil. Other: oil drilling and refining equipment.

d. Generating Capacity. 72,000 kw. This figure has a wide range of error. It includes two power plants on which there have been no recent reports. 64/

e. Transmission. There is insufficient information. It is probable that the two towns of Ishimbay and Sterlitamak are connected, but there is no evidence that these localities are connected to any other major town.

f. Consumption. There is no evidence of network connection from this power center. The estimate of generating capacity is weak. Oil production and its associated industries are the only important industries in the Ishimbay-Sterlitamak district. Therefore, if generating capacity were known, electric power consumption by the oil industry could be estimated with reasonable accuracy. This district contains about 20 percent of the crude-oil distillation capacity of the Urals area and has facilities for thermal conversion. 65/

7. Izhevsk.

a. Location. [redacted] 50X1

b. Local Population. 1949: 200,000.

c. Local Industry. Basic: ferrous metallurgy. Other: metal products plant (including tool plant).

d. Generating Capacity. 55,000 kw (including 5,000 kw hydroelectric). 66/

e. Transmission. An area with a radius of 50 km is connected to this power center. 67/ This would include Votkinsk, which is a town about a fourth as large as Izhevsk but with similar industry.

f. Consumption. Izhevsk has a remarkable resemblance to Chkalov, having about the same size, type of industry, and generating capacity. Like Chkalov, it is the administrative center for a large, slightly industrialized region and contains numerous industries processing the products of the farms and forests in the vicinity. It was also used during World War II for war industries requiring a large labor force but little electric power. The largest plant is the metal products plant, which is also the largest consumer of electric power in the area. 68/ Assuming 10,000 kw for municipal, domestic, and commercial use and 10,000 kw for outlying localities and small industries in Izhevsk, there is estimated to be 35,000 kw available to the metallurgical and metal products plant. 69/

8. Kamensk-Ural'skiy.

a. Location [redacted] 50X1

b. Local Population. 1939: 50,000. 70/

c. Local Industry. Basic: nonferrous metallurgy (aluminum). Other: industries using aluminum and steel, such as cable, pipe, aircraft parts, and tank parts.

d. Generating Capacity. 1939: 25,000 kw 71/; 1949: 250,000 kw. 72/

e. Transmission. There is no information.

f. Consumption. No figure for municipal, domestic, and commercial consumption of electric power can be estimated without a postwar population figure. The aluminum plant, producing about 60 percent of the aluminum in the Urals area, 73/ consumes the bulk of the power generated at Kamensk-Ural'skiy. Without knowing the size of the other industries, it is estimated that the aluminum plant uses about 200,000 kw.

9. Karabash.

a. Location. 50X1

b. Local Population. 1948: 40,000.

c. Local Industry. Basic: nonferrous metallurgy (copper mining and smelting).

d. Generating Capacity. 6,000 kw. 74/

e. Transmission. A single-circuit 110-kv line connects with the Urals area network, probably at Kyshtym, by which means the town imports power from the Chelyabinsk power center. 75/ There is also a probable 110-kv line from Miass. There is considerable information on transmission lines at Miass, but it presents a confused and contradictory picture. Two sources report a line which is estimated at 110 kv leaving Miass to the north-northeast in the direction of Karabash and Kyshtym. 76/

f. Consumption. Two thousand kw are estimated as the requirement for municipal, domestic, and commercial use. A substantial but unknown amount of electric power is available to Karabash because of the existence of the 110-kv connection to the Urals area network. Most of this power is consumed by mining. It is estimated that 1,260,000 tons of copper ore, about 12 percent of the total in the Urals area, are being mined each year. 77/ Copper ore then goes to a smelter, where it is converted into blister copper preparatory to being refined at Chelyabinsk or Verkhnyaya Pyshma. Most copper refining is done at large power centers where there is no need for long-distance transmission and where the copper refining plant can better serve its users.

10. Kirovgrad.

a. Location. 50X1

b. Local Population. 1946: 37,000. 78/

c. Local Industry. Basic: nonferrous metallurgy (copper mining and smelting).

d. Generating Capacity. 6,000 kw. 79/

e. Transmission. There are one line to Sverdlovsk 80/ and one line to Nizhniy Tagil. 81/

f. Consumption. Municipal, domestic, and commercial use is estimated to require 1,900 kw. Mining is the principal electric power consumer. It has been estimated that about 2,620,000 tons, or 25 percent, of the copper ore extracted in the Urals area comes from Kirovgrad. 82/ This copper ore is smelted locally and then sent to Sverdlovsk for refining. The area has great similarity to Karabash in size and type of industry except that the amount of copper ore mined in Kirovgrad is twice that estimated for Karabash. No estimate for electric power consumption can be made on the basis of availability, inasmuch as this town is connected to two of the largest power centers in the Urals area at Nizhniy Tagil and Sverdlovsk.

11. Kizel-Gubakha.*

a. Location. Kizel: [redacted] Polovinka: [redacted] 
Gubakha: [redacted] and Kospash: (several kilometers to the east of Kizel). 

b. Local Population. 1949: 200,000. One source gives a 1949 population estimate of 160,000 for Kizel, Polovinka, and Gubakha, but the fact that a fairly large area around these towns is being considered encouraged the estimate of 200,000.

c. Local Industry: Basic: coal mining, chemicals (coke chemicals), and electrified railroad.

d. Generating Capacity. 344,000 kw.
This estimate includes the following power plants: (1) Kizel GRES at Gubakha, with a capacity of 98,000 kw. 83/ (2) Kizel GRES II, located south of Kizel. This plant was being finished in 1950. 84/ The estimated capacity is 100,000 kw. (3) New power plant north of Kizel. Information is poor on this plant, but an estimate of 100,000 kw to be

* This power center includes Kizel, Polovinka, Gubakha, and Kospash. They are being treated together, since they are all within the limits of a large coal mining area and are closely knit together by electric power transmission lines.

installed by 1952 was made on the basis of observation in 1949. 85/ (4) A hydroelectric plant in Kizel, with an estimated capacity of 10,000 kw. 86/ (5) A 25,000-kw hydroelectric plant called Shirokovsk GES (Hydroelectric Station) which was just recently completed. 87/ (6) An 11,000-kw hydroelectric plant called Vilukhinsk GES. 88/ It is believed that only the Gubakha plant and the Kizel hydroelectric plant existed prior to World War II.

e. Transmission. Transmission lines connecting the towns in this power center are well reported. 89/ There is a considerable amount of exportable electric power in this area. This power is sent to the south into the main backbone of the Urals area network and to the north to Berezniki and Solikamsk. The line to the south has been reported as a double-circuit line. 90/ The line to the north may be a double-circuit line. 91/ It is believed that the voltage of these lines leaving the Kizel-Gubakha power center is 110 kv, since this is the usual transmission voltage for this area.

f. Consumption. Municipal, domestic, and commercial use is estimated at 10,000 kw, leaving 334,000 kw available for industry and transmission. The district is the largest single coal producer in the Urals area, accounting for about 37 percent of the total production. Generating capacity required to meet this demand is probably not more than 50,000 kw.* Another consumer is the coke-chemical plant at Gubakha, but, according to estimates, this is a relatively small plant, accounting for only about 9 percent of the total production of coke chemicals in the Urals area. Demand for power would probably not exceed 10,000 kw. 92/ More important as a consumer of electric power are the electrified railroads. The railroad is now electrified from Kizel south to Chusovoy and from that point west to Molotov and east to Sverdlovsk. A transformer station at Kizel appears to be a major supply point for the railway. This station has been heavily expanded recently, indicating further railway electrification of the main lines in the north part of the Urals area.

* This maximum estimate is based on 16 kwh per ton of coal mined (including power station use and losses) multiplied by 13 million tons of coal mined per year and divided by 4,000 hours.

Assuming that 200 km of double-track railroad are supplied with electricity from this area, the demand might be about 30,000 kw.* Even with a large range of error in the above estimates, a large quantity of power is available for transmission to other districts. Using these estimates and allowing 20,000 kw for all other industrial uses in the area, such as repair shops and manufacture of explosives, it is estimated that 224,000 kw are available for transmission outside the district, or a figure almost equal to the generating capacity of the hydroelectric and thermal power stations installed at this power center since 1949.

12. Krasnokamsk.

a. Location. [redacted] 50X1

b. Local Population. 1949: 50,000. 94/

c. Local Industry. Basic: oil and electrified railroad. Other: paper and cellulose.

d. Generating Capacity. 1939: 50,000 kw; 1952: 150,000 kw. The generating capacity available at Krasnokamsk is installed in one plant. The plant was begun in 1935. The fourth, fifth, and sixth turbines were added during the period 1946-50. It is possible but not proved that only two turbines were installed by 1939. Since all units appear to be 25,000 kw, the 1939 generating capacity is estimated to have been 50,000 kw. 95/

e. Transmission. There are two 110-kv single-circuit lines to Molotov, 96/ possibly one 110-kv single-circuit line to Berezniki, 97/ and possibly a line to an unknown destination to the westward. 98/ Reports are extremely contradictory concerning number and destination of lines. Only one 110-kv single-circuit line to Molotov is certain.

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*. Only the roughest sort of estimate is possible here, since there are so many factors to take into consideration. Such factors are the amount of traffic, grade of track, and track miles, as well as route miles supplied from one point and type of traffic. The type of traffic in the Kizel-Gubakha region is similar to that carried by the route of the Norfolk and Western Railroad from Bluefield to Iaeger, West Virginia. The figures for consumption by the US route were used for making the estimate of 30,000 kw for the USSR route. 93/

f. Consumption. Consumption of electric power by the oil industry at Krasnokamsk is believed to be small, since distillation capacity is only about 6 percent of the total for the Urals area. Some thermal conversion capacity exists but no catalytic cracking. Too little information has been collected to estimate the power requirements of the oil industry here. Krasnokamsk is reported to be a supply point for the electrified railroad which runs from Molotov to Kizel via Chusovoy. 99/ How many track miles this plant supplies is unknown. It probably supplies less than Kizel. Assuming that only 75 miles is supplied and using 25,000 kw per 100 miles of line, the power requirement would amount to 18,000 kw. The paper and cellulose plant may be the largest single consumer in Krasnokamsk. It is said to be the second largest paper mill in the USSR. 100/ Insufficient information has been collected to justify an estimate. Although there appears to be no way of estimating the amount, it is certain from reports by observers both at Krasnokamsk and at Molotov that this power center exports power to Molotov. 101/ The rapid expansion of the Krasnokamsk power plant during 1939-50 seems to indicate increased needs on the part of the paper and cellulose plant and Molotov.

13. Krasnotur'insk-Karpinsk.*

a. Location. Krasnotur'insk: [redacted] Karpinsk: [redacted] 50X1
[redacted] and Volchanka: [redacted] 50X1

b. Local Population. 1949: At least 120,000. Includes an estimated 50,000 at Krasnotur'insk, 50,000 at Karpinsk, and 20,000 at Volchanka. 102/ This estimate is probably low for this area, since early postwar expansion is believed to have continued up to the present time.

c. Local Industry. Basic: nonferrous metallurgy (aluminum) and coal. Other: minor industries such as mining equipment, repair facilities, and installations necessary for construction activities.

d. Generating Capacity. 283,000 kw.
This estimate includes three power plants: Krasnotur'insk TEZ (250,000 kw), 103/ Krasnotur'insk GES (30,000 kw), 104/ and the mobile power station at Karpinsk (3,000 kw). 105/

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* Krasnotur'insk, Karpinsk, and Volchanka are considered as one power center because of their proximity, their strong dependency on the large Krasnotur'insk power station, and the fact that they all sit on the same coal basin.

e. Transmission. Krasnotur'insk, Karpinsk, and Volchanka are tied together by a 35-kv ring. 106/ There are probably a 35-kv line to Serov from Karpinsk, probably through Krasnotur'insk, and probably a line to Severoural'sk from Volchanka.

f. Consumption. An allowance of 6,250 kw for municipal, domestic, and commercial use leaves 277,000 kw for industry. The aluminum plant at Krasnotur'insk is the largest power consumer in the area. It is estimated to produce about 55,000 tons per year, or approximately 40 percent of the total aluminum output of the Urals area. This production would require approximately 173,000 kw of capacity.* According to estimates, this district also accounts for about 24 percent of coal production in the Urals area. Most of this is produced at Karpinsk and Volchanka, where substations receiving power from Krasnotur'insk have been expanding. A maximum amount of 13,000 kw may be used for coal mining.** The minor industries may require substantial quantities of electric power, particularly the cement and concrete plants, but it is doubtful that they require more than 20,000 kw. These rough estimates of industrial electric power requirements give a total of about 205,000 kw, which would leave nearly 72,000 kw for transmission outside the power center. The estimated line to Serov may take some of this, but it is probable that some power is also transmitted north to the Severoural'sk area, where the principal industry appears to be the mining of bauxite.

14. Krasnoural'sk.

a. Location [redacted] 50X1

b. Local Population. 1946: 37,000. 107/

c. Local Industry. Basic: copper. Other: insignificant.

d. Generating Capacity. 12,000 kw. 108/

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* Aluminum production requires about 20,000 kwh per ton. This was multiplied by the estimated production figure. The resulting figure was then divided by 7,000 hours, which is the number of hours per year during which the generating capacity is assumed to operate (usually called "hours of use"); 15,000 kw were added to allow for losses and station use.

** Seven kwh per ton of coal mined are assumed (this includes power station use and losses), since strip mining requires less power than shaft mining. This was multiplied by 7.5 million tons and then divided by 4,000 hours of use.

e. Transmission. There is a single-circuit 110-kv line to Kushva via Verkhnyaya Tura. 109/

f. Consumption. Municipal, domestic, and commercial consumption probably does not exceed 1,850 kw. The copper industry is believed to be the only important electric power consumer. It has been estimated that about 15 percent, or 1,644,000 tons, of all copper ore mined in the Urals area is extracted here. 110/ Presumably this copper ore is also smelted in Krasnoural'sk, but there is no electrolytic refining. Although no accurate estimate is possible, it appears that this area is not a large electric power consumer and probably could get along with what power is available locally, with the transmission line in a position to serve in case of an emergency.

15. Kropachevo.

a. Location. 50X1

b. Local Population. Unknown.

c. Local Industry. Basic: electrified railroad.

d. Generating Capacity. 50,000 kw. 111/

e. Transmission. There is no information.

f. Consumption. It is reported that the above generating capacity will primarily serve the Ufa-Chelyabinsk Railroad. 112/ The generating equipment was just recently installed and may supply the entire Zlatoust-Ufa section of the line, although one postwar observer states that the power plant will serve only 100 km of track. The town of Kropachevo is located halfway between Ufa and Zlatoust, which are 320 km, or about 200 miles, apart. If the estimate for generating capacity and the assumption that this plant will supply the entire Zlatoust-Ufa section are correct, then it may be concluded that 50,000 kw are required for 200 miles of heavily traveled track.

16. Kushva.

a. Location. 50X1

b. Local Population. 1946: 37,000. 113/

c. Local Industry. Basic: ferrous metallurgy. Other: equipment repair facilities.

d. Generating Capacity. 9,000 kw. 114/

e. Transmission. At least two lines of 110 or 165 kv (probably 110 kv) pass Kushva, coming from Sverdlovsk. 115/ There is, in addition, a single-circuit line to Krasnoural'sk 116/ through Verkhnyaya Tura, and a single-circuit line connects installations at Kushva to the main 110- or 165-kv (probably 110-kv) trunk line. 117/

f. Consumption. Municipal, commercial, and domestic requirements are estimated to be 1,850 kw. The only industry here is the mining, crushing, and smelting of iron ore. One source reports two blast furnaces. 118/ An estimate puts the steel production rate at 200,000 tons. 119/ It is doubtful that the local power plant can satisfy these requirements, and it is probably necessary, therefore, for Kushva to tap the 110- to 165-kv lines for additional power.

17. Kyshtym.

a. Location. 50X1

b. Local Population. 1948: 60,000. 120/

c. Local Industry. Basic: copper. Other: graphite, kaolin (porcelain), corundum, and a plant engaged in secret production.

d. Generating Capacity. 5,000 kw. 121/

e. Transmission. There are a double-circuit 110-kv line to Chelyabinsk and a single-circuit line to Sverdlovsk via Polevskoy. 122/

f. Consumption. Three thousand kw are estimated to be required for municipal, domestic, and commercial use. Basic industry at Kyshtym does not require much electric power. The copper electrolytic refinery produces about 10,000 tons of refined copper, or 8 percent of the total for the Urals area. 123/ This requires not more than 1,000 kw if the USSR is following the US practice of 315 kwh per ton of refined copper. The graphite, kaolin, and corundum plants and mines are believed to require not more than 4,000 kw.* No estimation of the secret plant requirements can be made, but the transmission lines appear to have sufficient capacity to supply a large quantity of electric power if it is required and if Chelyabinsk and Sverdlovsk power centers can make it available.

18. Magnitogorsk.

a. Location. 50X1

b. Local Population. 1949: 200,000.

c. Local Industry. Basic: ferrous metallurgy and chemicals. Other: subsidiary industry to the metallurgical plant and construction industry.

d. Generating Capacity. 133,000 kw. This capacity is installed in two plants: Magnitogorsk station (123,000 kw) 126/ and a 10,000-kw power station which has not been reported by postwar observers. 127/

e. Transmission. There are a single-circuit 220-kv line (operated at 110 kv) to Zlatoust 128/ and a single-circuit 220-kv line to Chelyabinsk. 129/

f. Consumption. Municipal, domestic, and commercial requirements are estimated to be 10,000 kw. Industrial activity in Magnitogorsk is almost exclusively related to ferrous metallurgy. The chemical industry operates on the by-products of the coke plant which serves the blast furnaces, whereas the construction industry exists to take care of the expansion of the metallurgical industry and to provide living quarters for the population. About 33 percent of the steel production in the Urals area 130/ is estimated to be located at Magnitogorsk. The iron and steel plant is a large integrated operation with cokeries, blast furnaces, converters, electric furnaces, rolling mills, and associated installations for production of ore, lime, and firebrick. Recently a

* A description of the transformers supplying electric power to the graphite plant 124/ indicates that the plant requires no more than 1,000 kw. The existence of only a single 3-kv line leading to the kaolin plant 125/ shows requirements to be no greater than 2,000 kw. Since these two installations along with the copper refinery are considered by postwar observers to be the more important ones in the town, it is felt that all other consumers, except the secret plant, require small amounts of electric power.

new wire and cable plant has been put into operation, and a large area was being cleared in 1947-49 in the middle of the city for new rolling mills. This last operation necessitated the transfer of a large segment of the population across the river to Novo-Magnitogorsk, where extensive civilian housing has been constructed. Since most of the industrial activity in the city is integrated to the final output of steel and rolled steel products, it is practical to relate all the generating capacity and imported electric power to steel production, with the only exceptions being the power reserved for municipal, domestic, and commercial use and the small amounts for construction activity, which is not intimately connected with the steel plant. A US plan drawn up in 1931 for an integrated steel plant at Magnitogorsk envisaged an average demand of 85,000 kw for the production and rolling of 2.1 million tons of steel. 131/ Average demand must be converted to the generating capacity that is required. This demand may equal 150,000 kw. Recent estimates place present production at about double the amount originally planned for by the Americans. 132/ Doubling the 150,000-kw figure would mean that at least 300,000 kw are required by present steel operations. If it is assumed that 30,000 kw in addition are required for all other industry, such as the steel wire and cable plants, and for the construction industries, the total requirements of the city would be in the neighborhood of 340,000 kw, or about 200,000 kw in excess of generating capacity. The only power center capable of meeting these requirements is at Chelyabinsk. Although 200,000 kw of generating capacity are required, only an average of 120,000 kw need be transmitted from Chelyabinsk to Magnitogorsk. Since the reliability of this estimate depends on the estimates of steel production and the generating capacity at Magnitogorsk, the estimate is admittedly weak.

19. Molotov.

a. Location. [redacted] 50X1

b. Local Population. 1949: 500,000.

c. Local Industry. Basic: chemicals and ferrous metallurgy. Other: armaments, aircraft engine and component parts, munitions, electrotechnical, and machine building.

d. Generating Capacity. 325,000 kw. Capacity estimates are extremely weak. It is assumed that there are two large power plants, several small plants attached to various industries, and one municipal plant. These include a 150,000-kw plant at the site of the AC engine plant No. 19 133/ and a 75,000-kw plant close to the telephone factory. 134/ Other small plants are believed to be located at Gun Factory No. 172, at the Kirov chemical and munitions plant, and at Plant No. 33. These smaller power plants are assumed to total 75,000 kw. There is also assumed to be a 25,000-kw municipal power plant in the residential section of the city.

e. Transmission. There is a double-circuit 110-kv line to Krasnokamsk. 135/

f. Consumption. Molotov is too large, and the information on generating capacity is too weak for consumption estimates. There is a certain similarity to Sverdlovsk, since both cities are of respectable size, their principal industries require large quantities of iron and steel, and the industrial processes in each city require a great deal of forging, casting, and machining.

20. Nizhniy Tagil.

a. Location. Nizhniy Tagil: [redacted] 50X1

b. Local Population. 1949: 200,000. 136/

c. Local Industry. Basic: ferrous metallurgy and chemicals. Other: railroad cars, aircraft frames, and munitions.

d. Generating Capacity. 315,000 kw. This capacity is installed in five power plants: a 100,000-kw plant at the railroad car factory, 137/ a 125,000-kw plant at the Novo-Tagil (new) iron and steel works, 138/ a 25,000-kw plant near blast furnaces for the Novo-Tagil iron and steel works, 139/ a 50,000-kw plant at the Kuybyshev iron and steel plant, 140/ and a 15,000-kw plant at the munitions plant. 141/

e. Transmission. This power center is connected to the Urals area network at a point east of the railroad car plant. The power lines of the network appear to run in a southwest-northeast direction until they enter the substation east of the railroad car plant and proceed to the north-northwest. 142/

f. Consumption. On the basis of the above population figure, which is believed to be low, municipal, domestic, and commercial requirements are estimated to be greater than 10,000 kw. One source reports that the population was expected to reach 800,000 by 1949. The ferrous metallurgical plants at this power center have the second highest output in the Urals area; estimated steel production is 2,062,000 tons. Without any allowance made for electric furnace capacity, such a level of steel production would require about 500 million kwh per year in addition to about 30,000 kw for blast furnace draft.* Translating the kilowatt-hour figure into generating capacity and adding the blast furnace requirement give 130,000 kw. Integrated with the metallurgical industry is the production of coke chemicals and synthetic ammonia. These make use of the by-products of the coke ovens and the blast furnaces but also require substantial quantities of electric power. Production of coke has been estimated at 2 million tons, which would enable this center to produce about 12 percent of the coke-chemical output in the Urals area and would require possibly 66 million kwh, or 11,000 kw. Synthetic ammonia production is supposed to be 42,000 tons, or 30 percent of the total output in the Urals area. This output would normally require 150 million kwh, or about 25,000 kw, of generating capacity. The other principal consumer is the railroad car plant, which is the largest producer of railroad cars in the USSR. It may also be engaged in the production of aircraft frames and gun carriages. Power requirements are extremely difficult to estimate for such a plant, but it is possible that the 100,000-kw power plant built as a part of this combine has sufficient capacity to meet the demands. Nothing is known as to the size of the munitions plant located south of Nizhniy Tagil, but it is believed that the 15,000-kw plant located on its grounds is able to meet its electric power requirements. On the basis of sketchy information, it is concluded that each of the major industrial plants at this power center has a power station capable of meeting its normal demands, that these power stations are tied together in order to take care of load fluctuations, and that the power center balances the power taken from or sent into the Urals area network.

21. Oktyabr'skiy.**

a. Location. Tuymazy: Oktyabr'skiy: 22.5 km 50X1
southwest of Tuymazy; Urussy: about 15 km west of Tuymazy.

* A US engineering consultant company was asked to draw up plans for a steel plant at Nizhniy Tagil with a capacity to produce 1,775,000 tons of pig iron, 1,703,000 tons of steel, and 1,250,000 tons of rolled products. This company estimated that such a plant would require 420 million kwh in 1 year and, in addition, would need a 24,000-kw unit for blast furnace draft. The consumption of 500 million kwh is derived from a use factor developed from these plan figures.

** This power center includes Tuymazy, Oktyabr'skiy, and Urussy.

b. Local Population. Not available.

c. Local Industry. Basic: oil (production and pumping).

d. Generating Capacity. 1946: not over 20,000 kw. 1952: 50,000 kw. The capacity is installed in three old but recently enlarged plants (two in Oktyabr'skiy and one in Tuymazy), none of which appears to be larger than 5,000 kw, and a recently built plant is estimated at 36,000 kw. There may also be some diesel-generated power supplying the oil fields. 143/

e. Transmission. Although 35-kv lines connect the three towns included in this power center, there is no known tie to other cities.

f. Consumption. The population estimate for the entire electric power center is not available. Descriptions of the area give the impression that it is quite backward and that transformation from an agricultural to an industrial center began with the relatively recent exploitation of the oil deposits. Probable major consumers are the pipeline to Ufa and the water-pumping system which forces water into the ground to increase oil production. Since the oil industry is the only one in the area, it would be possible to obtain a factor of consumption by relating the generating capacity to the oil production if there were a figure for the latter available. However, oil production has been estimated only for a larger area of which this power center is only a part, so that a factor has not been calculated.

22. Orsk.*

a. Location. 50X1

b. Local Population. Orsk, 1948: 100,000 (estimate includes Novoorsk); Novo-Troitsk, 30,000.

c. Local Industry. Basic: ferrous metallurgy, chemicals, and oil. Other: heavy machinery and meat combine.

* Includes Orsk, Novoorsk, and Novo-Troitsk.

d. Generating Capacity. 1949: 102,000 kw, consisting of capacity in two plants: 78,000-kw power plant at Novoorsk 144/; 24,000-kw power plant at oil refinery. 145/ 1952: 182,000 kw, assuming the completion of a 30,000-kw hydroelectric station 60 km up the Ural River 146/ and the installation of two 25,000-kw units in a newly built plant at Novo-Troitsk which was unequipped as of 1949.

e. Transmission. There is some information concerning a 35-kv line connecting the three towns within the power center but none relating to connections with other power centers. 147/

f. Consumption. With a population of 130,000, 6,500 kw are estimated to be required for municipal, domestic, and commercial use. Orsk is one of the newer large industrial centers in the Urals area. Beginning as an important regional center in which the principal industries were transportation and processing of agricultural products, Orsk then developed as a nickel producing and oil refining center. A few years before World War II, construction began on an iron and steel plant and a large machine building or heavy equipment plant. With respect to industry, Orsk appears to be similar to Chelyabinsk except that it is smaller and is of more recent origin. Another difference is that Orsk is also an important oil refining center. In comparing the two cities it might be noted, however, that whereas the ratio of steel production between the two cities is 3 to 1 in favor of Chelyabinsk, the ratio of generating capacity is probably close to 5 to 1. The difference in the ratios can be explained by the fact that the Chelyabinsk power center helps supply a larger district and also must supply electrified railroads, which do not exist in the vicinity of Orsk.

23. Pervoural'sk-Revda-Degtyarka.*

a. Location. Pervoural'sk: [redacted]; Revda: [redacted] 50X1
Degtyarka: [redacted] Bilimbay: [redacted] 50X1

b. Local Population. 1949: 100,000. Population estimates for Pervoural'sk, Revda, and Degtyarka total 95,000. 148/ This figure was rounded off to 100,000 to take Bilimbay and Magnetka into account.

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* This power center includes Pervoural'sk, Revda, Degtyarka, and Bilimbay, and also Magnetka, which is located to the southeast of Pervoural'sk. All these towns are grouped together because of their common interest in copper mining and because they are closely tied together by a distribution network.

c. Local Industry. Basic: nonferrous metallurgy (copper mining and smelting), ferrous metallurgy (iron ore mining and crushing), and chemicals.

d. Generating Capacity. 24,000 kw installed in two plants. Half of this capacity is located in the building that also is the central heating plant for the Sums copper smelting works near Revda, and the other half is installed in a so-called municipal plant located in the northwest part of Revda. 149/ A prewar source 150/ reported a 10,000-kw power plant at the Pervoural'sk tube mill, but this is discounted, since no postwar observer in the area reported it. There are believed to be other small generating stations at various mines in the region, but it is assumed that these are too old to be of service at the present time.

e. Transmission. There are a 110-kv single-circuit loop (Sverdlovsk-Pervoural'sk-Revda-Degtyarka-Sverdlovsk) 151/ and a 35-kv single-circuit line from Pervoural'sk to Bilimbay. 152/

f. Consumption. Requirements for municipal, domestic, and commercial use are estimated at about 5,000 kw. Most of the electric power available in the area is probably consumed in the mining and milling of copper ore. It has been estimated that 3,350,000 tons of copper ore is extracted in the area each year. 153/ Assuming 40 kwh per ton of ore mined and milled, 134 million kwh, or a capacity of about 35,000 kw, would be required for these operations. The copper smelting plant near Revda is similar to that at Kirovgrad in that it has a power station immediately adjacent to it. It is assumed that most of the power generated by this power station of 12,000 kw is used in the mining and milling operations rather than in the smelting plant. One source reports that the iron ore mine has a transformer station with 6,000 kva of transformer capacity. 154/ It might be assumed, therefore, that electric power requirements come to about 3,000 kw for this industry. The Khrompik chemical plant located near Pervoural'sk is a small consumer of electric power, as its products are dyes, acids, salts, and other chemicals which do not require much electric power. The pipe factory, with its own steel plant, probably consumes a significant amount of electric power. Their location, adjacent to a transformer station stepping down 110-kv current from Sverdlovsk, is an indication of this, but there is insufficient information to estimate the electric power requirements for these three plants. Unless the estimates for generating capacity are badly in error, it is obvious that this district is heavily dependent on the Sverdlovsk power center for power supplies, perhaps to the extent of 50 percent.

24. Serov.

a. Location: [redacted] 50X1

b. Local Population. 1946: 75,000. 155/

c. Local Industry. Basic: ferrous metallurgy. Other: not well known (probable production of railroad cars and possible production of armaments).

d. Generating Capacity. 61,000 kw. 156/

e. Transmission. There is a line to Krasnotur'insk. 157/ Serov is the center of a "regional" net. 158/

f. Consumption. Municipal, domestic, and commercial requirements are estimated to be about 4,000 kw. Very little is known about this power center. The iron and steel plant has an estimated production rate of 614,000 tons of steel per year. 159/ This output presumably is utilized in forging, casting, and metalworking processes in the reported railroad car and armaments plants. The industrial production is similar to that at Nizhniy Tagil but much smaller and less diversified. A transfer of power from Krasnotur'insk amounting to 30,000 kw would make the ratio between Serov and Nizhniy Tagil for electric power consumption about 1 to 3, about the same as for population and steel production. 50X1

25. Solikamsk-Borovsk.

a. Location. Solikamsk: [redacted] Borovsk: [redacted] 50X1

b. Local Population. Solikamsk, 1945: 47,000; Borovsk, 1949: 20,000. 160/

c. Local Industry. Basic: chemicals and nonferrous metallurgy (magnesium). Other: paper and cellulose.

d. Generating Capacity. 72,000 kw. This capacity is installed in a 48,000-kw plant at Solikamsk 161/ and a 24,000-kw plant at Borovsk. 162/

e. Transmission. There are a double-circuit line probably of 110 kv from Berezniki to Solikamsk 163/ and a line with an unknown number of circuits from Solikamsk to Borovsk. 164/

f. Consumption. Municipal, domestic, and commercial use is estimated to require 3,000 kw. The major consumer in the district is the magnesium plant, which also produces chlorine, at Solikamsk. Two recent estimates state that this plant produces 12,000 tons of magnesium and 14,000 tons of chlorine per year. Assuming a consumption of 22,000 kwh per ton, the production of magnesium alone would require 264 million kwh annually, or a generating capacity of 42,000 kw.* The chlorine production, assuming a consumption of 3,200 kwh per ton, would require 45 million kwh annually, or a generating capacity of 7,000 kw.* It is assumed that the paper and cellulose plant at Borovsk requires almost all the 24,000 kw installed there. These requirements total up to approximately 72,000 kw, or the estimated generating capacity of this power center.

26. Sverdlovsk.**

a. Location. [redacted] 50X1

b. Local Population. 1941: 585,000 165/; 1950: 600,000. 166/

c. Local Industry. Basic: nonferrous metallurgy (copper) ferrous metallurgy, and railroad electrification. Other: armaments, machine tools, equipment manufacturing (electrical, textile, communications, chemical, and construction), ball bearings, tires, and instruments.

d. Generating Capacity. 399,000 kw. This capacity is installed in eight plants: 285,000 kw at Sredneural'sk 167/; 20,000 kw in Kuybyshev plant, in the western part of the city, on the south side of Nizhniy Isetskiy lake 168/; 28,000 kw in a plant which is adjacent to the south side of Uralmash (Ural Machinery Plant) 169/; 4,000 kw in a plant serving an electrical equipment plant near Uralmash 170/; 50,000 kw in a plant in the southeast corner of Sverdlovsk 171/; 60,000 kw in a plant in a suburb of Uktus 172/; 2,000-kw hydroelectric plant in a suburb of Aramil' 173/; and 4,000 kw in a plant at Berezovskiy. 174/

e. Transmission. There are a line to Nizhniy Tagil 175/ and a line to Yegorshino. 176/

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* Using a plant factor of 7,000 hours per year, the demand for magnesium production would be approximately 38,000 kw, and that for chlorine production would be 6,000 kw. In order to obtain the necessary generating capacity required, the maximum demand was increased by 10 percent to account for station and transmission losses.

** This power center includes Sverdlovsk, Berezovskiy, Verkhnyaya Pyshma, and Sredneural'sk.

f. Consumption. Municipal, domestic, and commercial use is estimated to require a generating capacity in excess of 30,000 kw, since the older, larger cities in the USSR are known to have better living conditions than the average. This situation would mean more electric energy per inhabitant. In Sverdlovsk, there is again the problem of a large number of industries without sufficient information as to size, products, and processes to establish power requirements. The largest electric power consumers are believed to be Uralmash, the Viza (Verkhne Isetskiy) steel works, the Verkhnyaya Pyshma electrolytic copper works, and the electrified railroad. Uralmash is the largest heavy equipment producer in the Urals area and also has a subsidiary steel plant producing an estimated 259,000 tons of steel per year. 177/ Other large installations, such as an electrical equipment plant, a chemical apparatus plant, and a substation supplying the electrified railroad, are located in the immediate area in the middle of the city. In addition to using the 28,000 kw of a power plant located in the vicinity, this industry depends on imports of power from the 285,000-kw plant north of the city. The other two heavy power consumers also are located north of the city and close to the 285,000-kw power station. The Verkhnyaya Pyshma electrolytic refinery is estimated to produce 100,000 tons of refined copper per year, 178/ and probably requires about 5,000 kw.* The other large consumer is the Viza steel works. Although it produces only an estimated 233,000 tons of steel per year, 179/ this steel is high-grade metal used in transformers, turbines, springs, and the aviation industry, and, therefore, much of it must be produced by electric furnaces. If one assumes that 120,000 tons out of the total 233,000 tons of steel are produced by electric furnace methods, then about 13,000 kw would be used by the electric furnaces alone. Total requirements of the steel plant might be 20,000 kw.** This power center also supplies a fairly large region around Sverdlovsk. It is believed that the Pervoural'sk-Revda-Degtyarka and the Severskiy-Polevskoy districts to the west and south, respectively, receive power from the 285,000-kw power station to the north of the city which is called a regional power station by the Soviets. The region to the east is believed to be adequately supplied by the 250,000-kw plant at Kamensk-Ural'skiy and the 69,000-kw plant at Yegorshino (Artemovskiy).

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* Using 315 kwh per ton, 7,000 hours per year per kw of generating capacity, and 10 percent upward adjustment for power station use and losses.
** Using 600 kwh per ton, 6,000 hours per year per kw of generating capacity, and 10 percent upward adjustment for power station use and losses.

27. Ufa-Chernikovsk.

a. Location. [redacted] 50X1

b. Local Population. 1942: 330,000.*

c. Local Industry. Basic: oil (refining). Other: aircraft engines, woodworking, cable, and locomotive repair.

d. Generating Capacity. 162,000 kw. This capacity is installed in four plants: 50,000 kw in a power plant at Chernikovsk 180/; 75,000 kw in a power plant on the southwest corner of the eastern section of the aircraft engine works in Chernikovsk 181/; 36,000 kw in a power plant supplying the oil refinery in Chernikovsk (the estimate for generating capacity represents a poor guess, [redacted] 50X1 and 800 kw in a power 50X1 plant supplying the locomotive repair works. 182/

e. Transmission. There is possibly a 110-kv line to Zlatoust.

f. Consumption. Municipal, domestic, and commercial use is estimated to require 17,000 kw. Except for the locomotive repair plant, all the above industries are located in Chernikovsk, which is the northern suburb of Ufa. The oil refinery and aircraft engine plants have their own electric power plants, and it is possible that the generating capacity of these power plants is equivalent to the requirements of their respective industries. Since they are closely grouped together around Ufa, it is believed that the woodworking industry (veneer, plywood, and matches) as well as the cable works depends on the 50,000-kw power plant and, therefore, must share this generating capacity with minor industry and municipal, domestic, and commercial consumers. The Ufa-Chernikovsk power center is similar to Chkalov, a city with a large population and a relatively small amount of electric power. Both cities were developed as administrative and trade centers for a large, predominantly rural area because of their convenient locations at the intersections of rivers and railroads. Neither has sufficient coal reserves to provide energy for large power stations and basic industry.

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* The population presumably has not increased and may have decreased, since estimates based on figures for voting districts give a population figure of 240,000 for 1939 and 225,000 for 1949. 183/

28. Verkhnyaya Salda-Nizhnyaya Salda.

a. Location. Verkhnyaya Salda: [redacted] 50X1
Nizhnyaya Salda: [redacted] 50X1

b. Local Population. Verkhnyaya Salda: 40,000; Nizhnyaya Salda: no estimate.

c. Local Industry. Basic: ferrous metallurgy. Other: aluminum utensils.

d. Generating Capacity. 17,000 kw (including 2,000 kw hydroelectric) installed in three plants: a 2,000-hydroelectric plant at Verkhnyaya Salda near the rolling mill, a 12,000-kw plant at Verkhnyaya Salda near the rolling mill, 184/ and a 3,000-kw plant at Verkhnyaya Salada near the aluminum utensil plant. 185/

e. Transmission. A 30- to 60-kv line from Nizhniy Tagil runs past Verkhnyaya Salda to Nizhnyaya Salda. 186/

f. Consumption. No estimate is possible for municipal, domestic, and commercial consumption. This is a small ferrous metallurgy center with an estimated output of 310,000 tons of steel per year. 187/ The blast furnaces are located at Nizhnyaya Salda and the rolling mills at Verkhnyaya Salda. The aluminum utensil plant, which appears to be the only other significant industry in the area, is located at the latter locality. One source implies that the power plants in Verkhnyaya Salda supply those factories which are close as well as the adjacent residential and commercial sections of the town. 188/ If this is correct and if the generating capacity estimates are reliable, then, after making a 20-percent allowance for a municipal, domestic, and commercial load, it can be assumed that the rolling mill obtains about 11,000 kw, and the aluminum plant 2,500 kw. Nothing is known concerning the supply of electric power to the blast furnaces, but, in any case, only a small amount would be required, which could be supplied by the high-tension line extending from the main line at Nizhniy Tagil.

29. Yegorshino.*

a. Location. [redacted] (approximate). 50X1

b. Local Population. 1950: 50,000. 189/

* This power center includes Artemovskiy, Bulanash, and Yegorshino.

c. Local Industry. Basic: coal. Other: mining machinery production and repair.

d. Generating Capacity. 69,000 kw. 190/

e. Transmission. There are a single- or double-circuit 110-kv line to Sverdlovsk, a single-circuit 110-kv line to Nizhniy Tagil, a 110-kv line to Alapayevsk, a line to Rezh, and a line to Irbit. 191/

f. Consumption. The population figure for the area is believed to be too unreliable to make an estimate concerning municipal, domestic, and commercial consumption. There is very little industry in this area. The coal mining industry is important because of the quality of the coal, but production represents only about 3 percent of the total output in the Urals area, or about 750,000 tons. The rest of the industry in the area requires a relatively minor amount of electric power, so that probably more than half of the power available is being transmitted to other industrial centers. This power station probably helps to supply Alapayevsk with its machine tool and its metallurgical industry; Irbit with its motorcycle factory and its glass factories; Rezh, which has a mining industry; and Asbest, where asbestos is mined and processed; and also probably contributes some power to the main line running between Nizhniy Tagil and Sverdlovsk.

30. Zlatoust.

a. Location. 50X1

b. Local Population. 1949: 200,000. 192/

c. Local Industry. Basic: ferrous metallurgy. Other: machine tools and armaments.

d. Generating Capacity. 38,000 kw (including 3,000 kw hydroelectric) is installed in three plants, none of which is sufficiently reported for reliable estimates: 15,000 kw in an electric power plant at the Lenin steel plant, 193/ 20,000 kw in an electric power plant at an ammunition plant, 194/ and 3,000 kw in a hydroelectric plant. 195/

e. Transmission. There are a single-circuit 110-kv line to Miass 196/; a single-circuit 110-kv line to Kusa; a single-circuit 110-kv line to Ufa, via Kropachevo; and a single-circuit 110-kv line to Magnitka. 197/

f. Consumption. Municipal, domestic, and commercial use is estimated to require 10,000 kw. A recent estimate gives steel production in Zlatoust as 565,000 tons per year. 198/ Presumably this steel is used in the machine tool and armaments industries located in the city. As these industries would require high-grade steel, it is probable that there is considerable electric furnace capacity both at the steel plant and in the armament and machine tool plants. Information is too scanty, however, to make estimates for electric power requirements. Furthermore, it cannot be assumed that the generating capacity figure represents the total requirements of the city. The capacity estimate is so weak that no reliance can be placed on it, and although it is probable that Zlatoust imports power from Chelyabinsk, the quantity of power imported is not known.

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# APPENDIX D

## ASSUMED CONNECTIONS

There are believed to be some transmission lines [redacted] 50X1 whose existence is indicated by other evidence. 50X1 These lines and the reasons for assuming them are given below.

1. 110-Kv Lines from the Vicinity of Kushva to Krasnotur'insk.*

The electrification of the railroad between Nizhniy Tagil and Krasnotur'insk 245/ indicates this line, as it would be the sensible thing for the USSR to accompany electrified railroad with 110-kv transmission lines.

Also, the recent completion of the Nizhnyaya Tura power plant of 100,000 kw would make such a connection more worth while. A 110-kv line is subject to excessive losses where the distance between two regulating stations is more than 100 miles. Prior to the building of the Nizhnyaya Tura power plant, there was no power plant of sufficient size between Krasnotur'insk and Nizhniy Tagil which could regulate the line. The air-line distances between the Nizhnyaya Tura plant and the electric power centers at Krasnotur'insk and Nizhniy Tagil are about 82 miles and 48 miles, respectively, so that the route length of transmission lines between the regulating stations can be kept below the economic distances for a 110-kv line.

2. 110-Kv Line from the Vicinity of Kushva to Molotov.

According to [redacted] in 1945, the Urals area 50X1 system has one main transmission line from Molotov through Sverdlovsk to Chelyabinsk. 246/

This main line is assumed to run between Sverdlovsk and Goroblagodatskaya, near Kushva, since the region between these two points is heavily industrialized. No important consumers appear to exist between Pervoural'sk, just west of Sverdlovsk and Molotov, and such a line would be justified only where there was industry along the way.

* Goroblagodatskaya is the meeting point near Kushva for transmission lines coming from the west and south. It may, therefore, be the point from which this estimated line extends north.

It is probable that the line follows the Sverdlovsk-Kushva-Chusovoy-Molotov railroad, as it would be economically sensible for the transmission line to supply the same localities as are served by the railroad.

3. 110-Kv Line from Zlatoust to Ufa.

This is a weak estimate and is made only because it is likely that transmission lines connect those cities also connected by electrified railroads. After World War II a power plant with an estimated capacity of 50,000 kw was built at Kropachevo apparently for the sole purpose of electrifying the Zlatoust-Ufa section of the railroad. For continuity of railroad service, it would be highly desirable to have the power stations at Ufa and Zlatoust tied to the Kropachevo power station. It is assumed that the USSR has done this, but there is no supporting evidence.

# APPENDIX E

## METHODOLOGY

A discussion of a high-tension transmission network is useful only when it explains how industry is served by it and to what extent its operation contributes to the economic potential of the region. This requires not only a description of existing transmission facilities but also the relation of generating capacity and industrial requirements of electric power to these facilities. A complete study along these lines would require that an estimate for electric power requirements be made for every industrial installation. This has not been attempted, as it is believed that too many errors would be introduced through lack of adequate information and that estimates on which fair reliability can be placed would suffer by becoming enmeshed with many unreliable estimates.

This report attempts to describe not only the physical layout of the electric power network but also the geographic distribution of the generating capacity and power consumption, as these two subjects must be examined in order to measure the contribution of the network to the economy of the Urals area.

In the course of research, it became clear that the entire story could not be told, because of the quality of the source material available.

[redacted] 50X1

The best estimates seemed to group themselves as follows: the generating capacity of power stations, the production level of certain basic industries which control the production level of most of the industries producing semifinished or finished goods, the location of electrified railroads, the existence of transmission lines between industrial centers, and the existence but not the production level of industries other than the basic industries.

Some system had to be devised of assembling these estimates in order that they might tell as much as possible about the network and its contribution to the economy. It was decided to select the 30 most important industrial centers in the region. The above categories of estimates were set down for each of these industrial centers. Estimates of electric power requirements were then made on the basis of the production levels of the basic industries wherever it appeared that comparison with US practice would be fairly accurate. Conclusions with respect to electric power requirements and the role played by the network were drawn wherever possible.

The appendixes to this report give the substantive information. The principal one is Appendix B, which includes a description of the 30 industrial centers in the Urals area where basic industrial processes of significant proportion are located. In addition to showing how much generating capacity is locally available, these sketches usually give the production rates of basic industries located in each center and a listing of other industries which are significant consumers of electric power.

Originally it was hoped that all the generating capacity known to exist could be allocated to specific users. This task was found to be impossible for the time being. However, it is believed that the appendixes are so organized that additional estimates of electric power requirements and transmission lines can easily be added, so that eventually a more complete report can be written.

[redacted] 50X1

[redacted] 50X1

German documents. A comparison of the two shows that they have a certain basic similarity. Some of the differences between the two can be attributed to the fact that the date of the German information is, on the average, 6 years prior to the average date of the information used for the other map.

Only the non-German transmission information was used in drawing conclusions in the text, but it is possible that Map B may be better in some respects than Map A. Map B is included, therefore, as it makes some contribution to the total body of information and can be of assistance, after checking against new information, in drawing more accurate conclusions as to the status of the transmission network. 50X1

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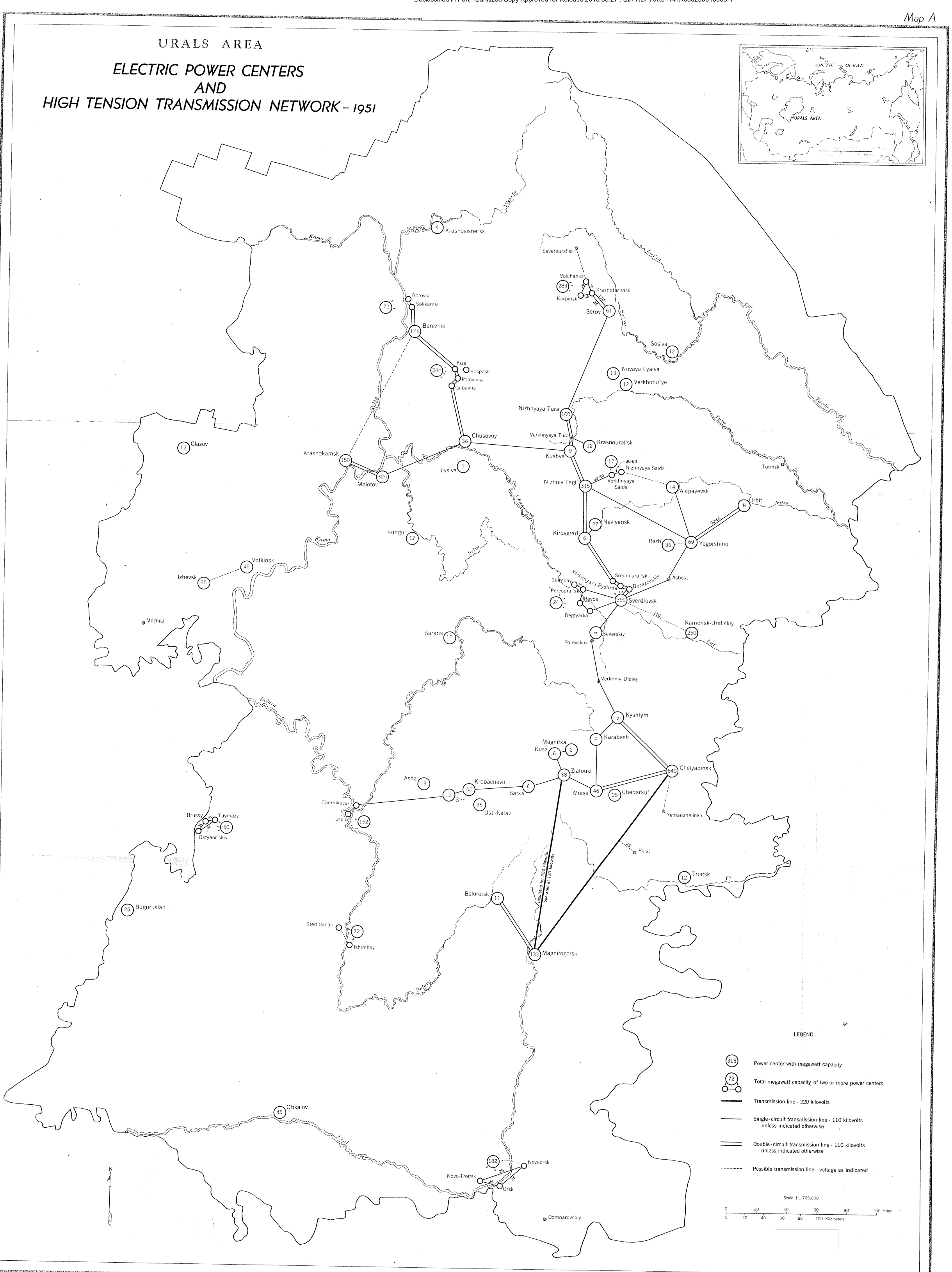
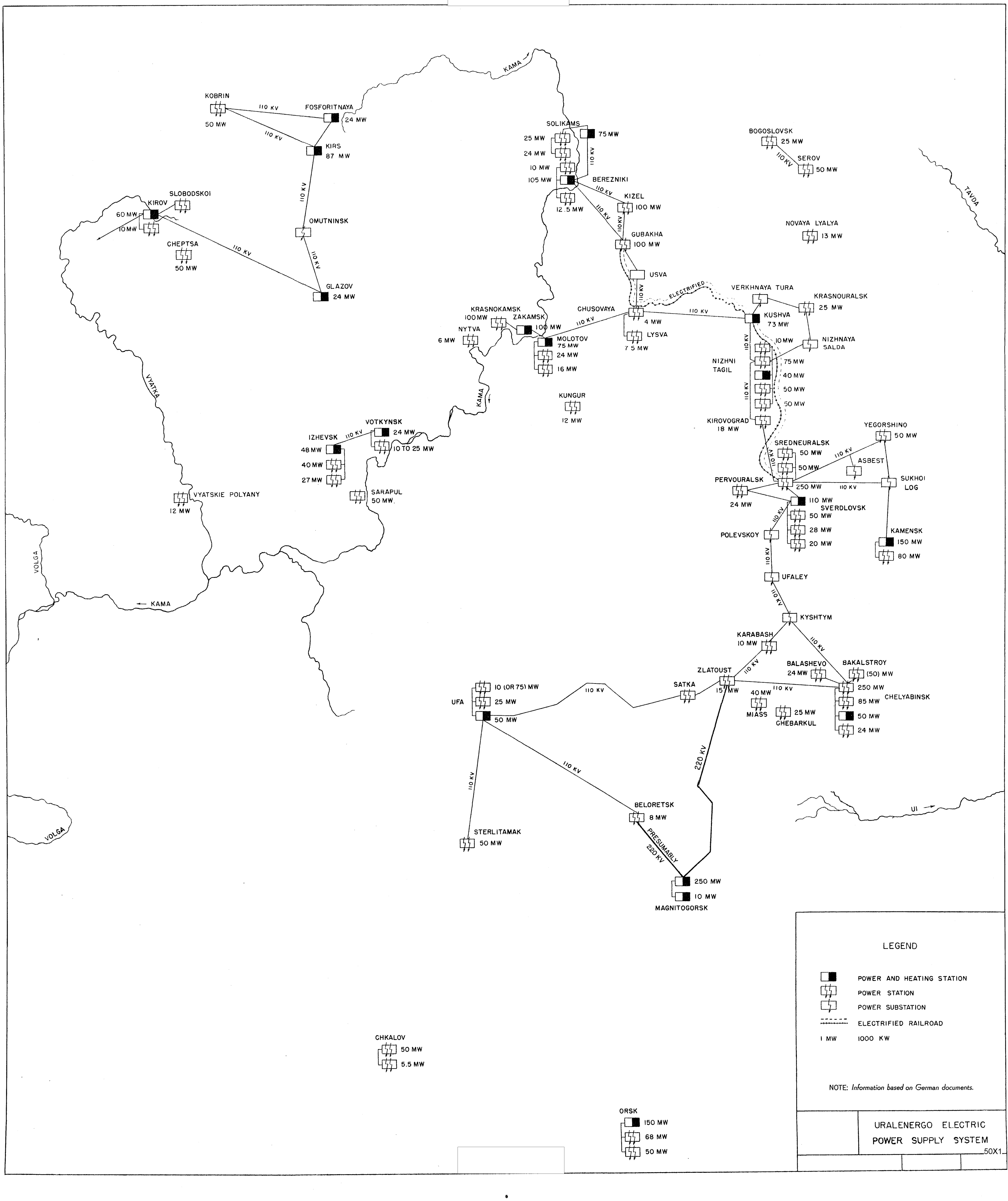
Map A


URALS AREA
ELECTRIC POWER CENTERS AND HIGH TENSION TRANSMISSION NETWORK - 1951
ARCTIC OCEAN
U. S. S. R.
URALS AREA
Krasnovishersk
Severoural'sk
Volchanka
283
Krasnotur'insk
Karpinsk
Serov
61
Sos'va
12
Borovsk
Solikamsk
72
Berezniki
Kizel
Kospash
344
Polovinka
Gubakha
Novaya Lyalya
13
Verkhotur'ye
12
Nizhnyaya Tura
100
Verkhnyaya Tura
Krasnoural'sk
12
Chusovoy
36
Glazov
12
Krasnokamsk
150
Molotov
325
Lys'va
7
Kushva
9
17
30-60
Nizhnyaya Salda
Verkhnyaya Salda
Nizhniy Tagil
315
Alapayevsk
14
Irbit
8
Turinsk
Nev'yansk
27
Kirovgrad
6
Rezh
36
Yegorshino
69
Kungur
12
Votkinsk
45
Izhevsk
55
Sredneural'sk
Berezovskiy
Bilimbay
Pervoural'sk
Verkhnyaya Pyshma
24
Revda
Degtyarka
Sverdlovsk
399
Asbest
Kamensk-Ural'skiy
250
Mozhga
Seversk
6
Polevskoy
Saranа
12
Verkhniy Ufaley
Kyshtym
5
Karabash
6
Magnitka
Kusa
6
2
Zlatoust
38
Chelyabinsk
640
Asha
13
Kropachevo
50
Satka
6
Miass
46
Chebarkul'
25
Chernikovsk
Ufa
162
Sim
Ust'-Katav
36
Yemanzhelinka
Urussy
Tuymazy
50
Oktyabr'skiy
Plast
Troitsk
12
Beloretsk
11
Buguruslan
25
Sterlitamak
72
Ishimbay
Magnitogorsk
133
Chkalov
45
Novoorsk
182
Novo-Troitsk
Orsk
Dombarovskiy
Kama
Vishera
Belaya
Ufa
Ural
Chusovaya
Sylva
Tura
Tavda
Nitsa
Iset'
Sos'va
Lozva
Ui
110
30-60
Installed for 220 kilovolts operated at 110 kilovolts
LEGEND
315 Power center with megawatt capacity
72 Total megawatt capacity of two or more power centers
Transmission line - 220 kilovolts
Single-circuit transmission line - 110 kilovolts unless indicated otherwise
Double-circuit transmission line - 110 kilovolts unless indicated otherwise
Possible transmission line - voltage as indicated
Scale 1:7,760,000
0 20 40 60 80 100 Miles
0 20 40 60 80 100 Kilometers
N
12429 CIA, 10-52

50X1

Map B




50X1

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