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SURVEY OF THE STATUS AND DEVELOPMENT OF THE

ELECTRIC POWER INDUSTRY IN THE USSR

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The Soviet Union is making rapid advances in carrying out far reaching plans concerning the development of its power industry and the all-out electrification of all branches in its national economy.

The power industry in pre-revolutionary Russia was greatly undeveloped, its total installed capacity comprising one million Kw. and its generation about 2 billion Kwh annually.

From the outset the Soviet Government paid serious attention to this industry, maintaining that electrification is a vital factor in the reconstruction of the national economy and the corner stone in the industrial structure of the new social system.

In 1920 on Lenin's initiative a plan was worked out on the electrification of Russia (this plan is called GOELRO in Russian for short). It was the first plan for the development of our national economy, calling for the construction of 30 power stations having a total installed capacity of 1 750 MW in the course of 10-15 years. This plan was fulfilled ahead of schedule.

The following basic premises were set forth for the first time in the plan GOELRO:

1. All-round development of the power industry in the different regions of the country is the base on which the productive forces of that region grow.
2. Local power resources have to be uncovered; local fuels and water potential have to be utilized as much as possible in the power balance of the country through the construction of large plants each servicing an entire district.
3. Modern technology must be introduced and power systems developed utilizing steam power and hydroelectric stations effectively.

These premises were elaborated in subsequent plans covering later periods. The construction of new steam power and hydro-electric stations as well as networks was carried out in all the districts of the country on a large scale.

/To the end

To the end of 1960 the installed capacity at power stations in the USSR amounted to more than 65 million Kw. A total of 292 billion Kwh were generated in the country in 1960, of which 50 billion Kwh came from hydro-electric stations. The power production of the country at present surpasses that of 1913 by 150 times.

In spite of the enormous damage caused by World War II, the power industry grew by leaps and bounds. The average annual growth in power generation over the post-war period amounts to 12%.

Large steam power stations are erected in the USSR for the most part near sources of fuel and are linked to the load centers by means of high-voltage transmission lines. This enables local and low-grade fuels, including cheap coals mined in the open, to be utilized on a large scale. The consumption of coal transported over long distances was sharply curtailed.

After having solved several complicated problems, Soviet engineers achieved the highly efficient combustion of brown coals, dust anthracite, peat, shales and coal enrichment by-products at the power stations of the country. Of late natural gas and fuel oil are being more and more used at power stations.

The fuel balance of power stations in 1959 was broken down as follows: 73% coal, 13% gas, 7% fuel oil, 7% peat and shales.

Power production in the country developed making use of the latest advances in technology.

The main progressive trend at steam power stations is the use of steam at higher and higher pressures and temperatures in units of very high rating. For example, prior to 1928 the equipment at the power stations of the Soviet Union was rated for an initial steam pressure of 13 - 16 atm.abs. and temperature of 325 - 350° C. At present large units are installed for 130 - 170 atm.abs. and a superheat temperature of 565° C. Tens of turbine generators with these steam parameters having ratings of 100, 150 and 200 MW are already running in the power systems of the country.

/Steam generators

Steam generators and turbines are in the process of production at present for coupling in "boiler-turbine" units having a capacity of 300 MW with the steam at 240 atm.abs., 580/565° C. Construction work has begun on super turbine generator units, 500 to 800 MW and over.

The progress achieved in our power industry can also be gathered from the fact that the installed capacity at the majority of power stations, which have been built or are under construction during the past few years, amounts to hundreds of MW with the capacity of some soon surpassing one million Kw. To name a few of them we should mention the Cherepet, Yuzhno-Ural, Staro-Beshevsk, Tom-Usinsk, Lugansk, Prebaltic, Slavyansk, Schekin, Novocherkassk, Ali-Bairamlinsk, Tashkent, Tbilisi and many other stations.

An important progressive trend in the power industry is the development of thermification making use of the joint production of electric power and heat at heat-and-power stations. Thermification results in large fuel savings (about 20%) as compared with the separate supply of consumers with electric power and heat. As a result, the thermification has been greatly developed in the cities and industrial centers of the Soviet Union.

The construction of several large hidro-electric stations in the Soviet Union enabled us to utilize a great deal of our water potential. About 20% of the total generation in the country in 1960 belonged to hydro-electric stations.

The power systems in Kolsk, Georgia and Armenia are almost entirely supplied by hydro-electric stations. The systems of Leningrad, Kuibishev, Stalingrad, Uzbekistan, Tadjikistan and elsewhere have a large percent of hydro-electric stations.

Hydro-electric stations now result in substantial fuel savings, amounting to more than 25 million tons of coal annually.

Recently, the large hydro-electric stations at Irkutsk and Kremenchug, each developing more than 500 MW were put into operation at their ultimate capacity. Tens of billions of Kwh of cheap power have already been produced at the largest hydro-electric stations in the world - the Lenin Volga Station developing 2 300 MW and the Stalingrad Station developing 2 563 MW.

/One should

One should bear in mind that the economic effect of hydro-electric stations is not only obtained from the cheap power it produces, but also to a large degree from their utilization in solving important problems connected with irrigation, navigation, fisheries, flood control, etc. For example, the hydro-electric stations in Central Asia alongside with power generation are used for irrigating hundreds of thousands of hectares of dry and fallow lands. After the Volga and Dnieper cascades of hydro-electric stations will have been completely constructed, the Volga and Dnieper rivers will turn into deep water-ways forming the arteries of the river navigation system in the European part of the Soviet Union.

The enormous storage basins created at these hydro-electric stations unfold many prospects for carrying out extensive irrigation in the dry and prairie agricultural districts along the Volga and in the southern Ukraine.

Steam and hydro-electric stations in the Soviet Union are interconnected in large power systems providing the bulk of the power in the country. Power systems are being perpetually developed and consolidated, participating in more powerful pools.

Today the three largest power pool systems -- the Central, Southern and Ural systems -- have been interconnected, thereby creating the consolidated power pool system in the European part of the Soviet Union.

The main electrical tie lines forming this system run from the Volga hydro-electric station to Moscow and to the Urals, and also from the Stalingrad hydroelectric station to Moscow. All these lines are operating at 400 - 500 Kv. The majority of the transmission lines have two circuits running in parallel for up to 1 000 km and transferring 750 and more MW per circuit.

A d.c. transmission line of 800 ( $\pm 400$ ) Kv is being constructed in this system from the Stalingrad hydro-electric station to the Donbas, which can transmit in both directions 750 900 MW. This line, being erected now as an experimental-industrial set-up, is very important for designing perspective extra long-distance (2 000-3 000 km) trans-Siberian lines transmitting extra-large blocks of power (4 000-5 000 MW) by d.c. at a voltage of 1 400 ( $\pm 700$ ) Kv.

/The rapid

The rapid growth of capacity at the power stations and systems of the Soviet Union has always occurred hand in hand with deep-rooted qualitative transformations in power technology.

Automation and telemechanics have been developed extensively. It is sufficient to say that many years ago already all the large district hydro-electric stations in the Soviet Union were completely automatized. More than half of them (on the basis of capacity) are controlled or supervised from dispatchers' offices by means of telemechanical apparatus.

There are tens of automatically controlled and tele-supervised medium-sized unattended hydro-electric stations in the country with their machine room kept under lock and key.

The high extent of automation at hydro-electric stations is characterized by the fact that large water-wheel units of 100 MW and over are automatically brought up to normal speed after the command for starting them up has been given; thereafter they are connected to the line by the method of self-synchronization, and full load is taken on in the short time of 50-60 seconds. At several hydro-electric stations an automatic operator is used for regulating their operation according to a preset real and imaginary power schedule.

Water-wheel generators connected to long-distance transmission lines are provided with special quick-response automatic field regulators (so called "strong action" regulators) in order to increase the transfer capacity of these lines. In the boiler rooms of steam power stations the process of fuel combustion is largely automatized using electronic regulators, as is the production of pulverized fuel and the water supply to boiler. Moreover, the operation of pump houses for the cooling water and fuel oil, and also the fuelhandling are entirely automatic.

Labourious processes are becoming mechanized more and more. For example, car dumpers are installed for unloading coal, which have a productivity of more than 1 000 tons per hour.

The following devices have found extensive use at power stations and in networks: automatic reclosure of transmission lines with or without checking

/of synchronous

of synchronous operation prior to reclosure; automatic devices for connecting stand-by equipment; automatic devices for emergency load shedding with a drop in the system frequency below 49 cps; automats for quickly starting up stand-by water-wheel units at hydro-electric stations when the system frequency drops below 49.5 cps, etc.

The seven-year plan for the development of the power industry in the Soviet Union covering the years 1959-1965 calls for a considerable growth in the power base and for the electrification of industry, transportation, agriculture and the household. Power generation over the seven-year period is to increase by 2.25 times comprising 520 billion Kwh by 1965. The capacity of turbine stations is to rise by 60 million Kw or by 2.2 times during this period, and in seven years will amount to more than 113 million Kw. The total length of 35/110/150/220/330 and 500 Kv transmission lines will increase during the 7-year period by 200,000 Km, i.e. by more than three times, and will amount to about 300,000 Km in 1965.

This means that during these seven years more capacity will be put into service than in all the preceding 41 years that the Soviet government has existed.

A specific feature of this seven-year plan for the development of the power industry in the Soviet Union is that it calls for the erection of very large power stations. During this period steam power stations of up to 1 200-1 400 MW are to be built. At these stations, which mostly are located in coal mining areas, turbine generators of 150, 200, 300 and more MW are to be installed in a unit arrangement with a single boiler of adequate steam capacity.

This enables power stations to be constructed less expensively and more quickly with a smaller specific fuel consumption and a cheaper power generation. Equipment designed for steam at 135 atm.abs., 565°C and 240 atm.abs., 580°C will be used for the turbine and boiler units.

/A turbine

A turbine unit will be put into service designed for steam at a pressure of 300 atm.abs. and a superheat temperature of 650°C.

Hydro-electric stations will continue to be erected alongside with the prevalent construction of steam power stations in the current seven-year period.

In the European part of the country this development is realized by near completely harnessing the water potential of the Volga, Kama, Dnieper, Dniester, Western Dwina, Neman and other rivers. For example, in the course of the seven-year period the Stalingrad and Saratov hydro-electric stations will be finished on the Volga river, and construction work will get under way at the Cheboxari hydro-electric station.

On the Kama river, the Votkinsk hydro-electric station will be erected, and work will get under way at the Nizhne-Kama station. The water potential of the lower Dnieper will be completely harnessed when the stations at Dnieper-dzerjinsk, Kanev and Kiev are put in service.

In 1960, with the end of construction work at several hydro-electric developments in the Caucasus --in Azerbaijan, Georgia and Armenia--, the power systems of these republics were interconnected into the consolidated transcaucasian power system.

The main tendency in the seven-year plan for hydrodevelopment work is the marked intensification of construction work at power stations in the Eastern regions of the country, such as Siberia, Central Asia and Kazakhstan, where over 80% of the Soviet Union's water potential is concentrated.

Factors such as rivers with large flow, narrow canyons and rocky embankments for erecting high dams and favourable conditions for regulation the flow enable very large highly efficient hydro-electric stations to be constructed here. The Angara and Enisey rivers are specially favourable in this respect. On the Angara river, a cascade of hydro-electric stations can be built having a capacity of more than 10 million Kw and an annual generation of about 70 billion Kwh. In 1961 the second station in the Angara cascade will be put into operation the first being the Irkutsk station. This exceptional large station at Bratsk has a design capacity of 4 500 MW. The dam of this station raises the water level in the river by about 100 meters forming an enormous storage basin.

/Still larger

Still larger hydro-electric stations can be erected on the Enisey river, with their total capacity comprising 20 000 MW and generation more than 130 billion Kwh annually. One of them, the Krasnoyarsk station, having a capacity of 5 000-6 000 MW is already under construction. The first four units at this station rated at 500 MW each will be put into operation in 1965.

The largest hydro-electric station in the Soviet Union can be erected on the lower Lena. This gigantic hydro-electric station is designed to have a capacity up to 20 000 MW with possible generation of about 100 billion Kwh annually.

The construction of great hydro-electric stations on the large rivers of Siberia and of powerful thermal plants working on the richest of Siberian cheap coal deposits, which can be mined in the open, affords of great stimulus for creating a consolidated powerful system in the central Siberia already in this seven-year period. Transmission lines of 220, 330 and 500 Kv will interconnect the hydro-stations on the Irtysh, the Angara and the Enisey with distinct power stations in the Kuzbas, at Irkutsk Cheronkhov, at Kansk - Achinsk, and elsewhere.

In the future, plans are made for creating the consolidated power pool system of Central Asia on the basis of the Nurek hydro-electric station of 2 700 MW in Tadjikistan and other hydro and steam power stations which are being constructed in this seven-year period in Uzbekistan, Kirghizia and in southern Kazakhstan.

The problem of nuclear power industry deserves special attention. As is known, the first nuclear power station in the world of 5 MW was put in service in the Soviet Union on June 27, 1954, while in 1959 the first 100 MW unit was put into operation at large power station running on nuclear fuel. At present two more power stations are being constructed, which will have a total design capacity of about 1 000 MW.

It is to be noted that there will not be many nuclear power stations built in the Soviet Union during the current seven-year period, since nuclear

/fuel is

fuel is rather expensive as compared with other kinds of fuel and water potential.

The matter is that the Soviet Union has the most abundant natural resources for the production of cheap power. For example, the enormous water potential of the USSR, amounting to 1,700 billion Kwh annually is greater than that of the USA, Canada, England, France, Italy, Germany and Japan taken together. On the basis of far from complete data of our organic fuel deposits (coal, gas, oil and others) the Soviet Union has no equal in the world.

The introduction of modern technology, the mechanization and automation of processes at power stations and in networks will be continued during the current seven-year period on a full-fledged scale.

Electronic digital computers are being used all the more alongside with telemechanical and radio-relay equipment for supervising and regulating the operation of power systems.

About 13 billion rubles <sup>1</sup>/<sub>1</sub> will be invested for the development of the power industry in the Soviet Union during the period 1959-1965, of which approximately 25% is designated for the construction of networks.

As was already mentioned, in the current seven-year period priority is given to the construction of large steam power condensing stations of 1200-2400 MW with 200-300 units. The cost per kilowatt installed at these stations amounts to 50 - 65 rubles, depending on the capacity of the station and the kind of fuel used (coal, gas, fuel oil). The prime cost per kilowatt-hour generated at these stations varies from 0.12 to 0.35 kopeks depending on the price of the fuel used.

At large up-to-date hydroelectric stations of 1000 to 6000 MW, the cost per kilowatt installed ranges from 75 to 250 and more rubles depending on the size and type of the station.

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<sup>1</sup>/<sub>1</sub> One Soviet ruble equals 1.11 American dollar;  
one kopek equals 1.11 cent

/and the

and the other functions the development serves. These specific costs are for utilizing the installed capacity at the station at least for 4000 hours annually.

The prime cost per kilowatt-hour generated at large hydroelectric stations varies from 0.025 to 0.09 kopeks, i.e. it will be 4 to 6 times cheaper than the power obtained from large steam power stations.

Looking into the future development of the national economy of the country, the design institutes of the USSR Ministry of Power Station Construction together with other industry-wide bureaus are already making their first drafts of the perspective plan on the development of the Soviet power industry for the coming 20 years.

It is planned to increase the generation of electric power in the country during this period by 8 - 10 times. In doing so about 20% of the generation will continue to come from hydroelectric stations.

The specific weight of nuclear power stations will increase in the power generation balance of thermal plants beginning with the second half of this period. The amount of nuclear power generation will be determined by comparing the technical and economic characteristics of stations working on coal, gas and fuel oil with those working on nuclear fuel. Most likely, in the future, thermal plants will be constructed having a high efficiency of up to 55-60%. They will utilize the possibility of obtaining electric power directly from heat and atomic energy bypassing the mechanical stage of converting the energy in prime movers and rotating machines.

In the coming 20 year period it is planned to greatly increase the consumption of electric power in industry and even more so in agriculture, transportation and for satisfying the domestic and public needs of the population.

/We set

We set our goal to reach and then overtake the United States of America during the second half of the above period (that is, in 1970-1980) at first with respect to the consumption of electric power in industry, then with respect to total power generation and finally with respect to the power generated per capita.

In the coming 15 - 20 years the largest (as to total length of lines) and most powerful consolidated system in the world will be formed on the entire vast territory of the Soviet Union which surpasses the territory of all countries in Latin America by 1.1 times.

The fundamental problem, solved by this perspective plan for the development of our power industry in the coming 15 - 20 years, is the realization of Lenin's idea concerning the all-out electrification of the entire country and the creation of the material and industrial base for communism in the Soviet Union.

