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TRENDS IN DEVELOPMENT OF THE USSR ELECTRIFICATION AND NEW TECHNICS OF POWER INDUSTRY OF THE SOVIET UNION

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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 outstart 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 srone in the industrial structure of the new social system.

In I920 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 I0-I5 years. This plan was fulfilled ahead of schedule.

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

I. 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 tecnology must be introduced and power systems developed utilizing steam power and hydroelectric stations effectively.

These basic Lenin's theses have found further development in the decisions of the Central Committee of Communist Party and of the Soviet Government in working out the programm of country electrification for the next periods.

The widespread construction of new thermal and hydro plants and transmission lines has been started in all economical regions.

To the end of I962 the installed capacity at power stations in the USSR amounted to about 85 million Kw.A total of 369 billion kWh were generated in the country in I962, of which 4 billion Kwh came from hydroelectric stations. The power production of the country at present surpasses that of I9I3 by I90 times.

The power consumption balance of I96I could be broken in round figures, as follows; Industrial - 77%, agricultural- 3%, transport - 6%, domestic and public use - I4%.

The rapid growth of power generation and of plant capacities of the Country for years of Soviet Power has developed conditions to turn the beggar and miser Russia into a mighty Socialist State with well developed industry and agriculture.

All the World could be convinced of that, at the time when soviet people became the First to start the Cosmic Era, put to cirle the first satellites, target the Penart on the moon and constructed the first cosmic ship "Vostok I", by which the First cosmonavte, Hero of Soviet Union, Uri Gagarin accomplished his Legendary tour arond the globe.

The first nuclear power plant was arrected in this country and the first nuclear powered Icebreaker "Lenin" was launched there too.

The longest on the planet electrified rail-way embrassed 5500 kilometers from Moscow to Irkutsk.

Electricity in our country had changed unrecognizably the appearance of Cities and Towns. It had deeply penetrated into life and culture of soviet people, with power, light, electric utensiles, radio, television, etc.

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 I2%.

Only Twelve Thousand kw were put into operation in our

country during the first two years of GOELRO programm, I92I & I922.

Twelve million Kw were switched on for the same first, two year of seven-year plan, I959 and I960. The rate of power growth had been rised thousand times.

For the annual power generation the USSR has much over-passed many advanced capitalistic countries: England, France, Canada, Japan, Italy and others.

By I947 the Soviet Union became the second in the world for annual generation of power, the USA being the only one ahead.

The new CPSU programm calls, That "The Plan of country electrification provides: the three times increase of electro-powering the labour for the nearest ten year period; the widening of electroconsuming industries on the basis of cheap electrical power; accomplishement of mass-electrification of city and town population mode of life.

In the second decade the electrification over the country is to be basicaly accomplished.

The annual generation of electricity should reach to 900-I000 billion kw by the end of first decade, and to 2700-3000 billion kw by the end of second. Jt will require hundredsthousand kilometers of main and distributing transmission lines to be built in all parts of the country.

Consolidated power System of the USSR will be created, being adequatly reserved by capacity, permiting energy exchange from East to Europenian part of country and interconnected with power systemes of other socialist states. As nuclear power production became cheaper the nuclear power plants are to be built, especially for regions laking of other resourses of power".

In conformity with decisions of CPSU XXI Congress of I959 the priority will be given to thermal power plants for the period of I959-I965.

The Hydrostations will produce only one fifth of total country power generation.

The same congress had outlined the basic transformation of country fuel balance structure by means of wide use of more-

economical kind of fuels _

natural gas, oil and cheap coals of open exploitations. Till I965 and furtheron the increased firing of this kind of fuels on power stations is provided. In new CPSU programm has written down, that "In order to gain time the natural resourses available for prompt mastering and giving the most national-economic effect are to be utilized at first".

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

The fuel balance of power stations in I96I was broken down as follows: 65,5% coal, I7% gas, 8,5% fuel oil, 9% 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 I928 the equipment at the power stations of the Soviet Union was rated for an initial steam pressure of I3 - I6 atm. abs. and temperature of 325 - 350°C. At present large units are installed for I30 - I70 atm. abs. and a superheat temperature of 565°C. Tens of turbine generators with these steam parameters having ratings of I00, I50 and 200 MW are already running in the power systems of the country.

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 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.

For instance, the Pre-Dnieper power plant capacity equals to I200 MW, the Lugansk plant capacity - I300 MW; these are the most powerful thermal stations in Europe. In I965 the capacity of Pre-Dnieper plant will reach 2400 MW in I4 units of I00-I50 and 300 MW.

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 separats 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. Thermification plants up to 600 MW are being constructed.

The construction of several large hydro-electric stations in the Soviet Union enabled us to utilize a great deal of our water potential. About I9% of the total generation in the country in I962 came from hydro-electric stations.

The power systems in Kolsk, Georgia and Armenia are almost enterely supplied by hydro-electric stations. The systems of Leningrad, Kuibishev, Volgograd, 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 35 million tons of coal annually.

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 Party XXII Congress'Volga -river Hydro-station of 2 563 near the City of Volgograd.

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 Midle 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. At the same time a possibility arises for shorter water way communication from Baltic to Black Sea, eLiminating the long way around Europe through Giblartar.

The enormous storage basins created at these hydro-electric stations unfold mahy 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 (over 85%) 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, creating the Consolidated Power system of 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 Volgograd hydroelectric station to Moscow and are operating at 500 Kv. The majority of the transmission lines have two circuits running in parallel for up to I 000 km and transferring 750 and more MW per circuit.

A d. c. transmission Line of 800 (± 400) Kv is constructed in this system from the Volgograd hydro-electric

station to the Donbas, and can transmit in both directions 750-900 MW. This line, erected as an experimental-industrial set-up, is very important for designing perspective of extra long-distance (2 000-3 000 km) trans-Siberian lines transmitting extra-large blocks of power (6 000- 7 000 MW) by d.c. at a voltage of I 400 (± 700) Kv.

Sueh D.C. transmission lines are to be sceleton in astablishing the Consolidated Power System over the USSR. It should be noted, that for D.C. transition of large capacities of over one million KW and for distances over I500 kilometers the capital investments and needs for line-wire and other materials decrease as much as two times of compared with A.C. transition.

An experimental-industrial A.C. transmission line of 750 kilovolts will be put into operation from Konakovo to Moscow in I965.

The 750 Kv lines are to play an important step toward forming transsibirien power systems and for interconnection of Khazach SSR system with Consolidated power system of USSR Europenian part.

The rapid growth of capacity at the power stations and system 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 hundreds of automatically controlled and tele-supervised medium-sized unattended hydro-electric stations (up to I00 MW capacity) 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 programm of active and reactive power.

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 capability 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 fel oil, and also the fuelhandling are entirely automatic.

Labourous 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 station and in networks: automatic reclosure of transmission lines with or without checking of synchronous operation prior to reclosure; automatic devices for connecting stand-by equipment; automatic devices for emergency load shedding in case of system frequency drops 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 I959-I965 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 I965,The capacity of turbine stations is to rise by 60 million Kw or by 2.2 times during this period, and to amount to more than II3 million Kw. The total length of 35/II0/I50/220/330 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 I965.

This means that during these seven years more capacity will be put into service that in the preceding 4I years of the Soviet State existence.

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 I 200-I 400 MW are to be built. At these stations, which mostly are located in coal mining areas, turbine generators of I50, 200, 300 and more MW are to be installed in a block arrangement with a single boiler of adequate steam acapacity.

This enables power stations to be constructed less expensively and more quickly with a smaller specific fuel consumption and a cheaper power generation. Equipment rated for steam of I30-I70 atm.abs. and 565°C and of 240 atm.abs and 580°C is used for the turbine and boiler units.

A turbine unit will be put into service rated for steam of 300 atm. abs. and of superheat 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 realised by nearly complete 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 Volgograd hydro-electric station is completed and the Saratov Hydel on the Volga river is progressing toward a finish.

On the Kama river, the Votkinsk hydro-electric station is being completing, and works are getting under way at the Nizhne-Kama station. The water potential of the lower Dnieper will be completely harnessed when the stations at Dnieperdzerjinsk, Kanev and Kiev are put in to service.

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

The main tendency of the seven-year 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 allocated.

Factors such as rivers with bulky flows, narrow canyons and sound rock, embankments for high dams and favourable conditions for flow regulation enable very powerful and highly efficient hydro-electric stations to be constructed here. The Angara and Enisey rivers are specially favourable in this respect. On the Angara revir, a cascade of hydro-electric stations (Bratsk, Ust-Ilim, Boguchan) can be built having a capacity of more than 14 million Kw and an annual generation of about 70 billion Kwh. In 1961 the second station in the

Angara cascade was 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 enourmous storage basin. Twelve units, each 225 MW, are already operated there.

Still larger hydro-electric stations can be built on the Enisey river, with total capacity amounting to 27000 MW and generation of more than 130 billion Kwh annually. One of them, the Krasnoyarsk station having a capacity of 5 000 - 6 000 MW is being built. The first units of this station, rated at 500 MW each, will be put into operation in 1965. Construction of Sayan Hydrostation of 6000 MW Power is also started.

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

The construction of great hydro-electric station on the abundant flow rivers of Siberia and of powerful thermal thermal plants utilizing the richest Siberian cheap coal deposits, to be mined in the open, affords of great stimulus for creating a consolidated powerful system in the central Siberia already in the present seven-year period. Transmission lines of 220, 330 and 500 Kv will interconnect the hydro-stations on the Irtish, the Angara and the Enisey with thermal power stations in the Kusbas, Irkutsk-Cheremkhov, Itatsk, Kansk-Achinsk and in other regions.

In the future, plans are made for creating the Consolidated power pool system of Midle Asia on the basis of the Nurek hydro-electric station of 2 700 MW in Tadjikistan, Toktogul Hydro of 1200 MW in Kirghizia and other hydro and steam power plants which are being constucted in this seven-year period in Uzbekistan, Kirghizia and in southern Kazakhstan.

Problem of nuclear power industry deserves special attention. 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. Two more power stations are nearing completion, with their total capacity of about 1 000 MW.

It is to be noted that there will not be many nuclear power stations built in the Siviet Union during the current seven-year period, since nuclear 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 production of cheap power. The enormous water potential of the USSR, amounting to 1,100 billion Kwh annually, less than 7% of what, is utilised 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 techology, 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 computers are being used more and more alongside with telemechanical and radio-relay equipment for supervising and regulating the operation of power systems.

About 13 billion rubles[1)] 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 MW 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 (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.

1) One Soviet ruble equals 1.11 American dollar; one kopek equals 1.11 cent.

At large up-to-date hydro-electric stations of I000 to 6000 MW, the cost per kilowatt installed ranges from 75 to 250 rubles and up, depending on the size and type of the station and on the other functions the development serves. These specific costs correspond to utilization factor of the installed capacity to at least of 4000 hours per annum.

The prime cost per kilowatt-hour generated at large hydro-electric station 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.

The new program of CPSU says that "Tremendous scale of capital construction requires speedy development and Technical refining of building industry, considerable expansion of production volume, improvement in quality and reduction in cost of construction works by consistent industrialisation of them and introduction of prefabricated members".

Proceeding from these instructions implementation of a vast program of power development implies typification of designs of power plants and electrical networks, vast application of unified prefabricated reinforced concrete structures both for construction of thermal and hydro-power stations and for substations and transmission lines of any voltage.

Reinforced concrete members are now fabricates at plants and casting grounds of building industry. Sites of power plants and substations are turned into assembly grounds with highly developed mechanization of work execution.

For mass concrete construction nowadays a method of continuous concreting is applied. This method giving a considerable gain in time mechanizing manual jobs, cuts down costs and increases quality of work. If Dnieper hydro-electric station was constructed by efforts of the whole country and with help of american specialists and in took seven-years to complete the station, the total power of electric stations to be commissioned during the current seven years shall be equal to that of I00 Dnieper stations.

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To ensure the level of power development set by XXII Party Congress for I980, during the forthcoming years we are to put into operation, on an average, power equal to that of Dnieper station for 7 days but not for 7 years, as it was before.

Such a breake through in the rate of power development can be brought about only basing upon highly organised building industry with mass production of future power generating schemes.

Soviet power specialists have pledged to cut terms of commissioning thermal stations down to 3-4 years and of large hydro-power plants down to 4-5 years.

Successful implementation of the tremendous program of power development during the current seven years, till I9$5, has decisive importance for our country. It will serve as a fast footing for carrying out the 20 years-long-term plan and for realisation of all-round electrification of the USSR.

Looking into the future development of the national economy of the country, the design institutes of The State Industrial Committee for Power and Electrification of the USSR together with other industry-wide bureaus and in accord with Decisen of the CPSU XXII Congress have made their first drafts of the perspective plan on the development of the Soviet power industry for the coming 20 years-till to I980.

According to the figures of XxII Congress of CPSU the annual energy production is to be increased 9-I0 times, to 2 700 - 3000 billion Kwn by I980, what correspond to 540-600 million KW of installed capacity. About 20% of the power generation will to come from hydro-electric stations, as at the present time level.

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 consuming coal, gas and fuel oil with those working on nuclear fuel.

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 domestic and public needs of the population.

To achieve these ends in electrification of the country it is necessary, along with speedy construction of power plants, to carry on with heightened speed and on a wide scale construction, of power systems all over the developed territory of the USSR (totalling 7 million km.2)

If in I960 the length of electric power systems inclusive of 0.4 Kv, in our country totaled about one million of kilometres to bring into effect a complete electrification of the country the length of electric power systems is to be increased ten times as great by I980.

Speaking about importance of the long term plan for electrification of the country N.S. Khruschev said " The main economic task of the Party and the Soviet people is to create the material and technical basis of communism within two decades. This means complete electrification of the country and perfection on this basis of the techniques, technologies, and organisation of social production in all the fields of the national economy; comprehensive mechanisation of production operations and a growing degree of their automation.

As a result, the USSR will possess productive forces of unparalelled might; it will surpass the technical level of the most developed countries and occupy first place in the world in per capita production.

In this conjuction we should touch some scientific problems relating to power engineering, settlement of which may result in considerable speeding-up and reduction in cost of power plant construction and simplification of technology of power generation.

Development of an economic qualitatively new small sized boiler unit for a block of about I million capacity, application of direct current for transmitting big power over super range distances, rank among the vital scientific problems.

Highly actual sientific problemes are also industrial use of magnetic hydrodynamic and thermoelectric effect for direct generation of electric power from heat and atomic energy, omitting the complicated and out of date method of converting thermal and atomic energy firstly into steam and then through mechanical rotation into electric power.

A problem of controlled thermonuclear reaction able to provide unlimited source of electric power is of particular interest.

Problems of using wind energy, sun energy and geodetic thermal energy, tide energy for generating electric power present some interest. However all these new resources of electric power will be of relatively small importance as compared with the conventional sources in the future. Power stations running on these sorts of energy will have relatively high value of capital investments per Kwatt of installed capacity.

The possibily of setting up a power pool system on the state's scale is a great advantage of socialist organization and form of public production.

Development and pooling of power systens setting up in conformity with decisions of XXII Party Congress, of a power pool system will enable us to put rapidly into operation new large thermal and hydro-electric stations, provide with electric power briskly growing demands of the national eco - nomy, increase reliability of power supply for consumers as well as increase economy of power system operation by harmonious combination of operation of thermal and hydro-electric stations.

As said above the pooling together of the Ural, Central and, South power systems by 500 Kv transmission lines has resulted in setting up the power pool system of Europe part of the USSR. This power system has unired 30 local power systems with power output coming up to half the total output of USSR.

Later the power pool system of the Europe part of the USSR will be coupled to the power pool systems of 4 republic i.e. Estonia, Latvia, Lithuania and Bellorussia, Leningrad power system and Karelia system. On the South it will be coupled to Caucasus system.

During I970-I975 the power pool system of the Europe part is to be connected by transmission lines of direct and alternative current to the power systems of Central Siberia and North Kasakhstan thus forming the power pool system of the USSR. Then power systems of Central Asia Far East and South Yakutia are to join it. And somewhere after I980 the power pool of the USSR is to take power from. Lower Lena hydropower station, the biggest power station in the USSR. In not distant future the power pool system will be connected with power systems of other countries.

The power pool systems of the USSR is being set up as the most powerful and biggest with respect to an area to be covered by it, and the most advanced one from the point of outfit.

This giant system will generate and distribute over 3,000 billions of kwh!

In the conclusion we should stress that the main problem to be solved by our people in the field of power engineering during the coming 20 years is to carry out behests of Lenin about a complete electrification of the Country.

"Hydroproject" Ord.64