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USE OF NEW AND RENEWABLE SOURCES OF ENERGY IN THE PEOPLE'S REPUBLIC OF BULGARIA

The high rates of development in the energy sector of the People's Republic of Bulgaria in the years of socialist construction which began after World War 2 created the necessary prerequisites for the overall growth of the national economy and resulted in raising the standard of living of the people.

Back in 1944 total energy consumption was estimated at some 400 kg coal equivalent per capita (1 kg of coal equivalent is the fuel with combustion heat 29.3 MJ/kg) the main energy source being wood (51%) and coal (46%). Only 1% of this amount was electric energy.

By 1980, or 36 years later, total energy consumption in this country stood at 4700 kg c.e. per capita. The relative share of the different energy sources underwent considerable changes. Thus, wood's share is presently only about 1%. Besides hydro energy, solid and liquid fuels, the energy balance covers also natural gas and nuclear energy. This multi-component structure, consisting of local and imported sources, meets the needs of all consumers in the country.

The main part of the fuels (about 50%) is converted into electric and heat energy supplied by thermal power stations. As a result, the electric energy share in the energy balance rose considerably, ie. 150 kWh/t.c.e. in 1944, 418 kWh/t.c.e. in 1960, 900 kWh/t.c.e. in 1980. The development of the electricity generating capacities in recent years made possible the considerable growth rates of the total electric energy consumption, viz. 311 million kWh in 1944, 4685 million kWh in 1960 and 38.7 thousand million kWh in 1980. The average annual growth rate in the period 1944-1960 was 18.5%, and in the last 20 years it was 11.2%.

The increase of total energy consumption, Fig. 1, became possible due to the higher output of energy resources (coal, oil, natural gas) and the development of hydro and nuclear energy. In 1961 the burning of 1.6 t.c.e. per capita was enough to reach world"s average consumption per capita while in 1980 it exceeded it by more than two times.

The electric energy industry developed more rapidly as seen in Table 1. After World War 2 electricity consumption per capita in Bulgaria was 5 times less than the average world level and 9 times less than Europe"s average level. In 1963 with 900 kWh/capita consumption Bulgaria reached the average world level while in 1980 with 4360 kWh/capita it exceeded by a factor of 2.2 this figure and came closer to Europe's average level, Fig. 2.

In future, total energy demand in Bulgaria will increase by 3-4% annually on the average and will be accompanied by considerable structural changes such as increase of the share of nuclear energy, decrease of the share of liquid fuels and general increase of the share of local resources. Of particular interest in the last case are the low-calorie coals with characteristics which until recently qualified them as unusable.

Simultaneously with the use of the traditional sources a program was started for the use of new and renewable energy sources such as solar, wind, geothermal and other energies.

1. <u>NEW AND RENEWABLE SOURCES OF ENERGY</u>

a) Solar Energy

Bulgaria lies within a very narror band of geographic latitudes, ie. 41-43^{o} northern latitude. For this reason the differences in the radiation conditions in the various regions are small and depend mainly on the differences in cloudiness. According to average statistical data for a period of 20-30 years the number of cloudy days for almost the whole country is 60-80 annually. In the southern regions this figure drops considerably. Thus, Bulgaria is located in the so-called sun belt. Annual duration of sun radiation reaches 2000-2300 hours. Average total radiation for the most part of the country is about 1.5 MWh/m^2 per year. Climatic conditions in Bulgaria favor the use of solar installations for a long period of the year - 7 to 8 months.

From economic point of view it is advisable to use in Bulgaria solar collector systems for hot water supply to households, hot-houses, dry houses for fruits, tobacco, lumber etc well as for developing the "solar architecture". Very promising is the developing and use of self-contained stationary or mobile sets of photoelectric cells for local power supply. Solar power stations of small and medium capacity based on photoelements and thermodynamic cycle are expected to be built somewhere around the year 2000. Bulgaria possesses the necessary raw materials and industrial potential to proceed in these directions. The necessary specialists are also at hand.

Bulgaria has certain technological experience in the following fields:

- Development of photoelectric converters with silicon and cadmium sulfide and experimenting solar modules and cells of them;
- Development of technology for producing effective thermoelectrical materials designed for thermoelectrical generators;
- Development of technology of selective optical coating to raise the effectiveness of the various types of solar devices;
- Development and study of photoelectrochemical cells to produce hydrogen through water photolysis with a semi-conductor photosensitive anode;
- Development of solar air collectors and systems for industrial and agricultural dry houses;
- Development of elements of solar tracking systems.

Bulgarian manufacturers offer solar tube water collectors for hot water supply to one- and two-family houses, restaurants, hotels, campings, swimming pools and industries. They also produce solar shower boxes for campings, rest homes, beaches, construction sites etc. Also manufactured are mobile solar shower boxes to be used by farm workers and construction workers.

According to plans, by 1985 the energy produced will be equivalent to primary fuel 12×10^3 t.c.e./year, and by 1990 this figure will be 50×10^3 t.c.e./year.

b) Geothermal Energy

On the territory of the country there are no active vulcanoes or steam-hydrothermal phenomena but there exist extensive geothermal systems and geothermal (mainly convective) anomalies with higher temperatures and natural heat flux. The insignificant density of the conductive heat flux hinders the direct use of the geothermal energy. The thermal waters are the most effective source for practical utilization of the underground heat.

Bulgaria is rich on hydrothermal resources with low thermodynamic parameters and varied composition and properties. Predominant are the weakly mineralized nitrogen thermal waters with soluble salts content below 1 g/dm^3.

All total, there are more than 1000 hot springs and artesian wells in Bulgaria. The temperature of their waters varies between 20° and 100°C. The hydrogeological test borings also revealed the presence of hot and superhot waters (up to 130°C). On their part, the deep-lying aquifers contain mineralized waters with temperatures even exceeding 150°C.

The discharge of the various sources varies in a wide range reaching tens of cubic meters per second.

The gross dynamic reserves of all types of thermal waters established by the investigations carried out so far exceed 5 m^3/s. The prognosticated hydrothermal reserves which could be found at depths up to 2-3 km are estimated at about 5-6 m^3/s. The thermal waters bring to the surface each year about 1.3×10^{12} kJ of heat.

The hydrogeothermal resources find wide application mainly in public health establishments and rest homes, households, tourism etc. Their significance as a new and renewable energy resource is growing of late. Part of the water sources' heat capacity is used for heating purposes. 18 hydrothermal sources with temperatures between 45° and 100°C are used for the heating of greenhouses for vegetables and flowers, buildings, hatcheries etc.

A heating and air conditioning plant with heat pumps using waters up to 55°C hot has already been built. Thermal waters are also used for technological purposes in the industries.

In the overall heat energy balance of Bulgaria the hydrothermal sources have a limited local or regional significance in district heating, industry and farming.

Forecasts, conceptions, concrete programs and designs to investigate and step up the use of geothermal resources have already been worked out. According to plans, the annual output of the plants with geothermal waters will reach 40×10^3 t.c.e. in 1985 and 150×10^3 t.c.e. in 1990.

The more important forthcoming tasks ot the complex utilization of geothermal energy in Bulgaria can be summarized as follows:

- Expansion of geothermal investigations;
- Development of heat pump sets, heat exchangers, heating and air conditioning installations etc for low-temperature heat carriers.

c) Wind Energy

The investigations of the eventual utilization of this type of energy in Bulgaria are aimed mainly at establishing the potential resources and the solving of many technological problems.

- Many regions have already been investigated and the basic statistical characteristics of wind speed and direction such as density of speed distribution in different directions as well as correlation and spectral functions have been established.

These investigations take place at standard meteorological heights. The results obtained are entered in the mathemathical models. This is necessary for the technical and economic optimization of runner type, unit rating etc as well as a number of aerodynamic, technological and other parameters of plant.

In many areas wind's average speed is of the order of 4.5 to 6 m/s throughout the year at 5 to 10 m above ground. In some regions considerably higher wind speeds have been measured.

Very favorable is the fact that wind energy correlates to a high degree with demand in terms of time and increase of its intensity. The latter fact favors strongly the solving of the problems of its accumulation.

- The second group of problems are those connected with the technology of wind energy conversion.

Statistical estimates of speed characteristics in terms of direction and study of world experience gave preferance to the rotor-type runner Savonius. In this connection a number of theoretical problems with the dimensioning of similar runners have been solved. Their performance and efficiency were studied experimentally. Steps are taken now to develop the first 1 kW pilot plants.

Concerning the remaining elements of the plant, ie. synchronous electric generator and accumulator, the designers have adapted existing technologies in this country.

The development of such plants with capacities up to 10 kW is deemed advisable for a number of individual consumers now.

2. <u>NEW NON-CONVENTIONAL SOURCES OF ENERGY</u>

a) Use of Wood Wastes as Boiler Fuel

In Bulgaria the use of wood as fuel has been reduced to the minimum the trend being to eliminate it altogether. However, wastes from the processing of wood could be used for various purposes. In a number of cases these are technologically unusable raw materials whose burning cuts down mainly liquid fuel consumption in some industries. Examples in this respect are the following technological developments.

System for individual burning of hydrolyzed lignin in pulverized form in box furnaces. The lignin is the waste product from the production of feed grade yeast. Its heating value is

7000 kJ/kg and moisture content is around 60%.

It is burnt in the fire-tube boilers in special pre-arranged furnaces. These are a hybrid between the grate furnace and the cyclone furnace and combine the advantages of both methods of combustion.

The effect from the burning of lignin is three-pronged:

- Development of a wasteless technology;
- Saving of considerable amounts of fuels which are in short supply;
- Environment protection.

A furnace specially designed for buring of barks was developed. It is used by the wood-processing and paper industries which release annually no less than 200 000 t of wastes. Their chemical composition is the same as that of the wood material.

By 1983 some 25 boilers with steam output 4-6 t/h will be already in operation.

b) Low-Grade Fossil Solid Fuels

It looks that solid fuels are going to play a major part again in covering world energy demand. However, the deposits of solid fuels and mainly coal are distributed, as in the case of oil, quite unevenly by continents and countries. Besides, their mining and transportation are considerably more difficult than those of oil. This creates prerequisites, as in the case of oil, to change their prices on the international market in disproportion to their prime cost. For that reason it is necessary, within the framework of individual countries or regional groupings, to search for the best methods of their utilization. There exist considerable reserves of conventional fossil fuels such as peat, shales, tar sands low on combustibles, slightly carbonized coal etc which are still regarded as technically and economically unsuitable for use. Many nations do not even include them in their fuel balance. However, some countries as Greece, Turkey, Roumania, Bulgaria and others have already built power stations to produce electric and heat energy from very low-calorie fuels. Quite indicative is the case of Bulgaria where one third of the electric energy is produced from fossil fuel with heat value 4200-6500 kJ per kg and sulfur content 4% in the dry mass. That type of fuel provides over 1500 kWh/capita. The energy crisis affected Bulgaria only slightly because of the developed technologies for the utilization of these coals, the broad application of nuclear energy and the help of the Soviet Union which made up the defficiency of energy resources. We plan to use extensively in future the local low-grade fossil fuels with calorific value 2.6-2.8 MJ/kg as well as fuels with calorific value 4.6-6.0 MJ/kg but with a very high sulfur content, somewhere around 10 g/MJ.

Usually, the specialists refrain from using such fuel because of its specific features resulting from the high content of moisture, sulfur and mineral matter . Its utilization poses a number of problems in connection with its effective and reliable combustion, flawless behavior of the heating surfaces and environment protection.

Such a fuel cannot be regarded as a conventional source of energy. For example, coal in the Maritsa-East coal field in Bulgaria are located in deposits where some coal beds and seams contain between 20 and 60% ash in the dry mass and moisture content varies between 50 and 60%. Calorific value depending on admixtures is between 2.6 and 6.5 MJ/kg. With the present technology, fuels with calorific value less than 4.2 MJ/kg are utilized only partially by adding them to the fuel supplied to the power stations. In order to utilize it more completely we are developing now a technology for independent combustion. Thus far, for environmental reasons no coal with high sulfur content have been burnt. A technology is being developed now for the burning of coal with sulfur content exceeding 8 g/MJ.

The developed technologies are being gradually realized in practice. Thus, we are on the verge of commissioning the last unit of a power station designed to burn fuel with calorific value 4.2-4.9 MJ/kg containing 50-62% moisture, 30-55% ash as per dry mass and 2-4% sulfur. In the power station burning this fuel are installed 4 units of 210 MW each. From technological point of view the design of the power station covers several basic elements which guarantee its operation according to the highest modern standards despite the high admixtures percentage, low calorific value and very wide range of changing of fuel qualities. The following technological problems have been successfully solved:

- Averaging of fuel qualities. The high clay content of the fuel makes it difficult to transport. Averaging is achieved by mixing it several times. The first mixing takes place during the mining process. On the basis of the mine surveying data the coal-winning machines are placed at faces with different ash content and extract from layers with one or another thickness. The coal are then loaded on a common conveyer belt where they intermix to a considerable degree. At storage site the coal are spread by the sandwich method. They are removed from the storage by means of a rotary bucket excavator operating along the height of the layer. Thus, the boiler units receive coal differing only slightly from the design quality.

- Inner-station transport and delivery to the pulverization systems. The presence of clays in the mineral matter of the fuel does not permit the use of the conventional transportation means for the other fuels. On the basis of the complex study of the physical properties a method was developed for calculating bins, feeding equipment and transfer chutes. It is used to determine the slope and shape of bins' walls. Its outlet is made not less than 1.5 x 3.0 m and coal is removed by a scraper batcher in the direction of the narrow side.

The plant dimensioned by these methods have never caused any operating difficulties despite the very unfavorable physical properties of the fuel which are affected among other things by the meteorological conditions in the cases of open cast mining and open storages.

- Drying and pulverization. On the basis of laboratory tests and bench trials was developed a method for dimensioning of mills. This method was used to calculate and construct some of the largest mill fans in the world, those operated with success in the above-mentioned power station. Because of the quite variable fuel qualities specially designed systems are used in order to regulate the output capacity of the coal pulverizing systems thus guaranteeing unit's rated capacity in cases of different fuel qualities. This permitted a fully automatic regime when optimizing the operation of the power station.

- Stabilizing of firing and securing of complete burn-out of fuel. High admixtures content in fuel and particularly so moisture hinder the firing and the control of the combustion process. In order to overcome these difficulties a system to stabilize the combustion process, consisting of a pulverized coal concentrator and a primary burner, was developed. Depending on fuel quality the concentrator produces fuel mixtures of different degrees of dressing. The amount of pulverized coal fed into the primary burner and guaranteeing a stable firing ranges between 70 and 90% of the total amount while the amount of the drying agent transporting it varies between 50 and 30%. The system guarantees the stable firing of fuel with moisture content up to 62% and calorific value about 5.2 MJ/kg.

The use of this technology allows the stable and economic operation of the power station. It is of great importance to the present day state of the energy sector in Bulgaria. The construction of a power station with 500 MW units burning similar fuels is to begin in the near future.

3. WATER POWER

The natural conditions forming the nation's hydroelectric potential are the continental climate with partial Mediterranean influence in the southern river valleys, the average annual precipitations of 670 mm and the comparatively low run-off coefficient. Out of a total of 74×10^9 m^3 precipitations entering the rivers the surface run-off amounts to only 18.6×10^9 cu m, or 2100 m^3/capita annual river run-off. Bulgaria is not rich on water resources and occupies a middle place in Europe, Fig. 3.

A characteristic feature of Bulgaria's water resources is their uneven distribution both on the territory of the country and in the various years and seasons of the year. The sources of the five largest rivers in this country are located in its south-western part which is predominantly mountainous. This region covers 31% of the territory of the country and contains over 90% of its hydroelectric potential. About 50% of the run-off occurs in the spring months; in the summer this figure is only 7%. Quite significant is the variation of the run-off in the years of different humidity - between 50% and 150% compared to the average annual figure. The greater part of the inland rivers are short and with comparatively low run-off.

Until the end of World War 2 some rivers and sections were investigated only without a sufficient hydrological clarification. A total of 47 small water power stations with an overall installed capacity of 47 MW were built; they were of the run-of-river type with or without daily ponds.

The year 1945 saw the beginning of the planned, all-round investigation by river valleys and regions of the possibilities, the economic and technical advisability to develop the hydro-electric sources and the working out of construction schedule. Detailed geological, hydrogeological, agrarian, topographic and other investigations were carried out. By 1960 were practically completed the schemes for the development of almost all river valleys and the overall technical hydro-electric potential was calculated at 12×10^9 kWh including that of the Danube river. When completely developed the hydro-electric potential will provide an annual production of electric energy of 1380 kWh/capita which is less than world's average hydro-electric potential - 1800 kWh/capita, Fig. 4.

At this stage the economically favorable hydro-electric potential comes close to the technical one in view of the tendency for the maximum utilization of the national energy resources and particularly so the renewable resources such as water power as the result of the rising fuel prices.

The schemes for river water utilization, realized in their majority, take into consideration the specific features of the natural conditions for each river and river valley. The optimum design of each project has been sought. The river heads in the mountainous regions are utilized by means of long systems of collecting tunnels and canals and many water intake structures.

The river developments include seasonal and multi-seasonal water storages necessary to equilize the uneven run-off throughout the seasons and years. The larger part of the power stations have daily ponds which guarantee the peak operation of the water plants within the 24-hour period.

Another feature of the schemes for water utilization is the transfer of waters from one river valley into another. Thus, conditions are created to use concentrated heads to create water storages and meet water consumption needs.

All schemes for the utilization of the hydro-electric potential meet the requirements for the complex utilization of the waters and environment protection.

For three decades of intensive hydro-electric development work were utilized 51% of the inland rivers potential and 36% of the total potential, the Bulgarian share of the Danube included.

In 1980 the power system of Bulgaria included water power stations with a total installed capacity 1870 MW. The concentration of capacities was improved considerably.

Nine power stations operate at heads exceeding 500 m but they provide 40% of the capacity. The same percentage falls to another 29 power stations operating under meadium heads from 100 to 500 m. The remaining water power stations operate under heads less than 100 m.

Scores of dams of various heights, the highest among them being 144 m, impoumd the rivers and create the necessary water storages. Dams of various types have been built, e.g. concrete-gravity, arch, overflown rockfill, earthfill, hollow-gravity etc.

The total impounded volume of all 28 water storages within the energy complex amounts to 3870×10^6 cu m. The waters are collected and transferred to the storages and the power stations through a system of supply and power canals and tunnels with a total length of 616 km and 420 water intake structures.

Besides water for electricity generation the multi-purpose storages provide water for the irrigation of 120×10^3 ha of arrable lands and 500×10^6 cu m annually for drinking and industrial purposes.

Electric energy generated by the water power stations rose from 170×10^6 kWh in 1945 to 1884×10^6 kWh in 1960 and 3700×10^6 kWh in 1980.

Particular attention in the development of the hydro-electric projects is being devoted to the problems of environmental protection. To begin with, the requirements toward the selection of the routes of the supply conduits became stricter. Apart of being run through the best geological and topographic conditions they should be least damaging to nature. This task is being achieved by increasing the length of the tunnels. For example, the present designs envisage that about 70% of the supply conduits be tunnels.

For ecological reasons, during the dry summer months the rivers are left to flow freely in their valleys and this results in the decrease of impounded waters by about 10%.

Very interesting proposals have been made aiming at the sizeable increase of the hydro-electric potential as compared to the conventional methods.

An example in this connection is the Belmeken-Sestrimo development, Fig. 5.

Kriva river, flowing in south-western Bulgaria, with a run-off of 18 x 10^6 cu m has a denivellation of 1550 m on a stretch of 10 km. Geological conditions in the area are exceptionally favorable for the building of hydraulic structures while topographic data revealed the possibility to create high-altitude storages of large volume. A chain of power stations located here would have an installed capacity of 15-20 MW and an annual generation of 70 x 10^6 kWh. The specialists decided to catch the waters of all neighboring streams and rivers at the respective elevations thus increasing the water mass in the upper storage to 230 x 10^6 cu m, and that discharged by the lower-most power plant to 330 x 10^6 cu m. The water catchment area of the development covered 311 sq km of the slopes of Bulgaria's highest mountain Rila (2925 m). The development comprises a dam, three power stations, two belts of supply canals with a total length of 205 km and 225 water intake structures, and two daily ponds. Two main and four auxiliary supply conduits running along the northern and the southern parts of the divide collect some 215 x 10^6 cu m. Their total length is 143 km, mostly of them being tunnels; there are also 147 water intake structures. The canals discharge the waters into the reservoir which impounds the waters from the water catchment area of the development. Thus, the waters are regulated in conformity with the energy schedule of demand.

A 3 km long pressure tunnel and a 2.2 km long pressure gallery take the waters from the storage to the first power plant with installed capacity 375 MW at a gross head of 725 m. In the plant are installed 5 sets, 2 of them being of the three-component type (turbine, pump, generator) and can be operated as reversible sets. Thereafter the discharged water enters a pond created by a 39 m high dam. This pond receives the waters from the second belt which is 62 km long and has 78 water intake structures. This belt provides an inflow of 92×10^6 cu m. The water discharged from the pond is carried by a tunnel and a pressure gallery with a total length of 5 km to the second power plant with a total head of 540 m and two trubines with a total installed capacity of 240 MW. After the second stage a 3 km long combination of a free-level tunnel & canal takes the water to the second daily pond of 200×10^3 cu m capacity. Then, a 1285 m long pressure gallery delivers the water to the two turbines of the third power plant with an installed capacity of 120 MW.

Thus, the total capacity of the development is 735 MW when generating and 110 MW when pumping. The design electric energy production is 1160×10^6 kWh out of which 1×10^9 kWh are produced in the generating mode and 160×10^6 kWh in the pumping mode of operation.

The design and construction took 10 years and commissioning was done in stages. It is used to cover the peak daily and seasonal loads in the power system. Presently, 8% of the installed capacities in the power system and 39% of the capacity of all hydro plants are concentrated in this development. Besides being used for electricity generation part of the waters are also used for irrigation and water supply to a number of settlements and industrial projects.

4. ORGANIZATION OF RESEARCH, DESIGN AND DEVELOPMENT WORK IN THE FIELD OF THE NEW AND RENEWABLE ENERGY SOURCES

In Bulgaria all research organizations are state-owned and their activities are subject to coordinated plans.

The top governmental body that coordinates, plans, finances and controls all new developments in the field of science and technical progress is the State Committee for Science and Technical Progress. It performs super-departamental functions with basic activities focused on the following more important fields:

- Development of short- and long-term forecasts and programs to promote technical progress;
- Development on this basis of the state plans and policy in the particular fields;
- Coordination of the plans for the technical progress in the different branches of the national economy, research institutes and administrations;
- Financing and control of perspective research works;
- Organization and provision of the necessary technologies for the realization of the tasks developed;
- Specialists-related policy etc.

The concrete works at all stages take place basically in the research and design institutes of the Ministry of Energy, the Bulgarian Academy of Sciences and the universities.

The most important institute within the framework of the Ministry of Energy is the institute for research and design of power projects Energoproekt. It employs well over 1000 highly qualified specialists, over 200 of them being scientists, who develop the forecasts, models and programs for the development of the energy sector, carry out research work in the fields of fuels and energy-producing equipment and systems, water power, automation, environment protection, management organization and labor protection, geological, topographic, hydrological and other investigations needed for the energy development and design all elements of the power system as a whole - thermal and water power stations, partially nuclear power stations, heating stations, transmission lines, substations and town networks, district heating systems, dams, hydraulic structures etc.

Almost all power projects in Bulgaria have been built in the last 30 years. They have been designed by Energoproekt, or with its participation. The engineers of Energoproekt have also designed many water power projects, district heating systems, transmission lines, substations etc in Egypt, Syria, Morocco, Iraq, Iran, Vietnam, Cuba, the German Democratic Republic and other countries.

In order to fulfil all those tasks Energoproekt has set up a modern laboratory and experimental center, computing center etc.

For a comparatively short time in Bulgaria were organized two centers which share among themselves the activities in some of the basic fields of utilization of solar energy.

At the Bulgarian Academy of Sciences was formed the Central Laboratory for Solar Energy and New Energy Sources which focuses on research and practical activities. Its sections work on such problems as photoelectric converters and sollar cells, thermoelectric materials, some particular problems in connection with the solar concentrators and air flat collectors, optical coatings for the needs of solar energy, hydrogen generation and utilization.

At the Ministry of Energy was established the Scientific and Production Economic Complex 'New Energy Sources' whose main functions (introducing of engineering solutions, development and production) are concentrated in:

- Scientific and production laboratory with the following sections: research, experimental, design, systems for automatic regulation and workshop;

- Assembly and erection factories in 5 towns in the country;

- Plant for thermal technical equipment.

This complex carries out the basic work in connection with the introducing of solar and geothermal energy in the households and industries.

Besides them, some of the other institutes participate in the solving of some problems of the introducing of the new energy sources such as NIPKI Industrial Energy, NPP Techenergo etc.

Considerable research work is also being carried out in the universities. Thus, the Thermal energy department at the Lenin Higher Institute of Mechanical and Electrical Engineering works on the utilization of low-grade fuels, wind energy etc.

5. PROPOSALS FOR INTERNATIONAL COOPERATION

Bulgaria's achievements in solving its heat energy problems and particularly so in the field of the new and renewable energy sources are due to a large extent to the cooperation among the member-nations of the Council for Mutual Economic Assistance (CMEA). Particularly valuable is the help of the USSR which has wide experience in the field of energy. We intend to continue and expand this fruitful cooperation in future too. Within the framework of CMEA we plan to participate in a number of works. The idea is being studied to establish in Bulgaria an International Testing Grounds for new energy sources to meet the needs of CMEA member-nations.

At this stage, Bulgaria can render assistance to all interested countries in the utilization of low-grade solid fuels. We have the potentialities to conduct all necessary preliminary studies, research works and give recommendations on their most effective utilization. It is also possible to design the required structures and installations for the setting up of plants and institutes for their utilization. We could offer complete plants for the construction of thermal power stations. Bulgarian specialists are always ready to render complete engineering services, the training of specialists in the utilization of low-grade fuels included.

The same refers to our readiness to carry out all necessary preliminary investigations, design and construction of all types of hydraulic structures.

In the near future Bulgaria will be able to propose its experience in the development, testing and erection of solar heating installations based on flat collectors as well as on the problems of photoelectric conversion, selective optical covers etc.

In the field of solar energy Bulgaria has already established international contacts and has assumed the respective obligations.

In the field of geothermal investigations Bulgaria is cooperating actively with the socialist countries. It is also cooperating with Italy and Greece.

The People's Republic of Bulgaria is cooperating with other countries in the international organizations within the United Nations Organization. Thus, within the framework of UNDP we are presently rendering assistance in the investigation and utilization of the hydro-thermal resources of neighboring Greece.

Table N° 1

Total consumption of electrical energy
and maximum loading of the energy systems of the People's
Republic of Bulgaria

Year	Total consumption of elecrical energy			Maximum loading MW
	million kWh	average year increase for 5 years %	kWh per capita	
1944	311		45	
1945	401		58	
1950	819	15,4	113	
1955	2106	20,8	281	346
1960	4685	17,3	596	808
1965	10232	16,9	1246	1591
1970	19407	13,7	2286	3295
1975	28860	8,3	3320	5000
1980	38700	6,1	4360	6922

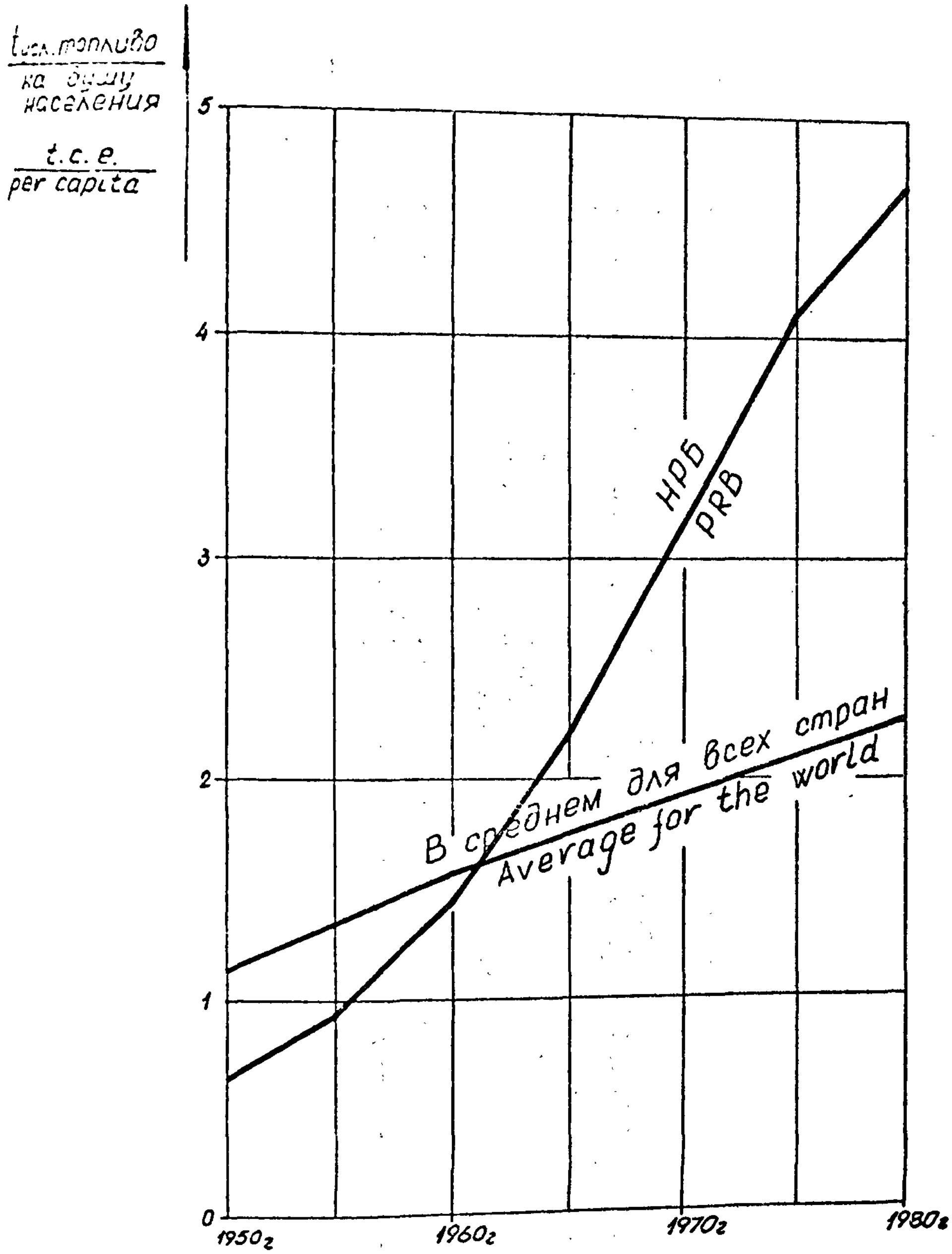

t усл. топливо / на душу населения
t.c.e. / per capita
5
4
3
2
1
0
НРБ
PRB
В среднем для всех стран
Average for the world
1950г
1960г
1970г
1980г

Fig. 1

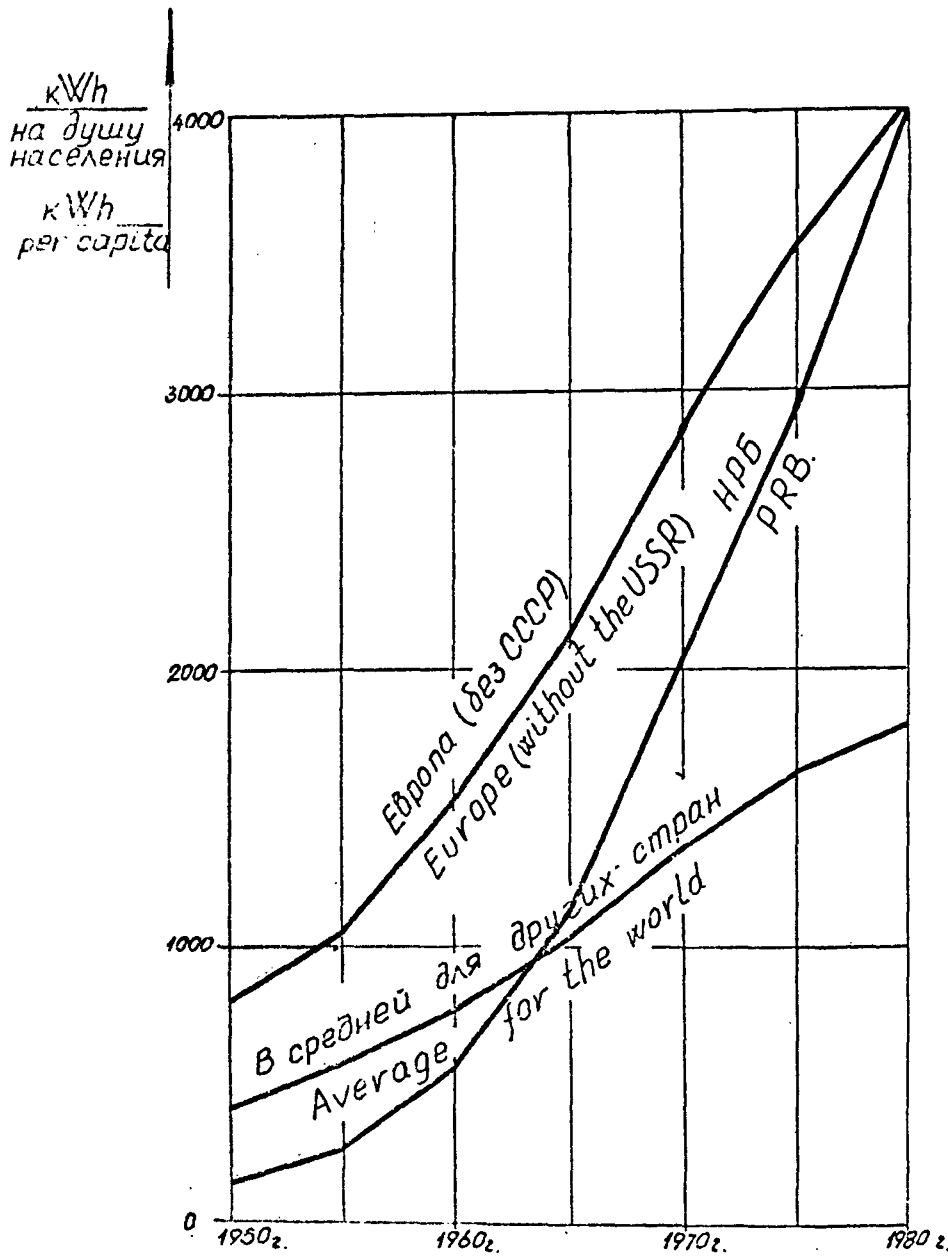

kWh
на душу населения
kWh
per capita
4000
3000
2000
1000
0
1950г.
1960г.
1970г.
1980 г.
Европа (без СССР)
Europe (without the USSR)
НРБ
PRB.
В средней для других стран
Average for the world

Fig. 2

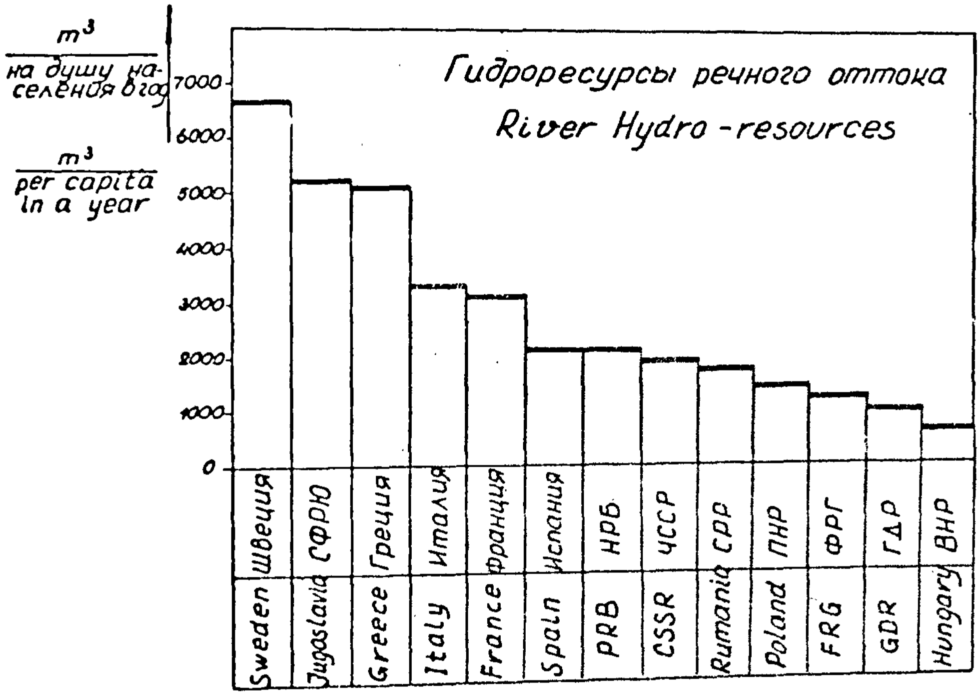

Гидроресурсы речного оттока
River Hydro-resources
m³
на душу населения в год
m³
per capita
in a year
7000
6000
5000
4000
3000
2000
1000
0
Швеция
СФРЮ
Греция
Италия
Франция
Испания
НРБ
ЧССР
СРР
ПНР
ФРГ
ГДР
ВНР
Sweden
Jugoslavia
Greece
Italy
France
Spain
PRB
CSSR
Rumania
Poland
FRG
GDR
Hungary

Fig. 3

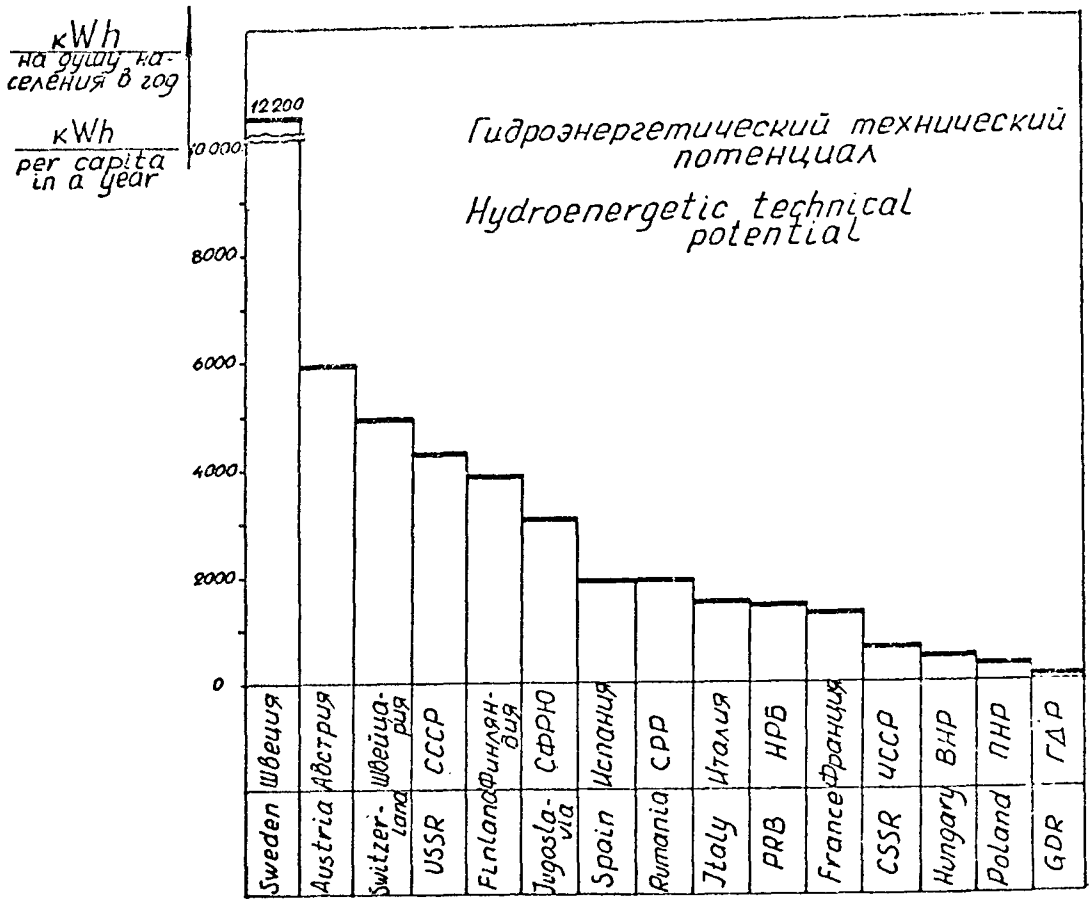
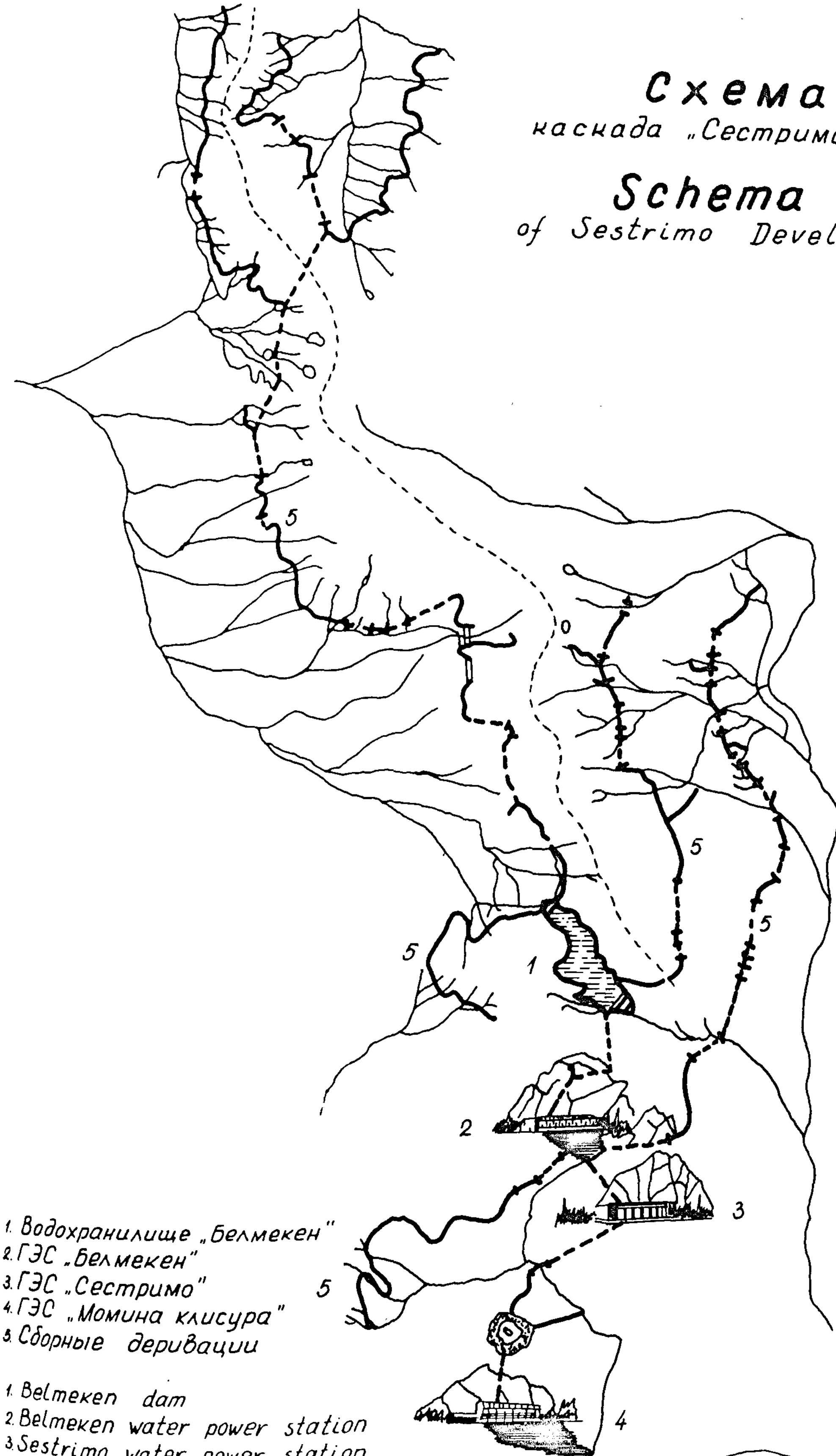

kWh
на душу населения в год
kWh
per capita in a year
12200
10000
8000
6000
4000
2000
0
Гидроэнергетический технический потенциал
Hydroenergetic technical potential
Швеция
Австрия
Швейцария
СССР
Финляндия
СФРЮ
Испания
СРР
Италия
НРБ
Франция
ЧССР
ВНР
ПНР
ГДР
Sweden
Austria
Switzerland
USSR
Finland
Jugoslavia
Spain
Rumania
Italy
PRB
France
CSSR
Hungary
Poland
GDR

Fig. 4

Схема
каскада „Сестримо"

Schema
of Sestrimo Development



1. Водохранилище „Белмекен"
2. ГЭС „Белмекен"
3. ГЭС „Сестримо"
4. ГЭС „Момина клисура"
5. Сборные деривации

1. Belmeken dam
2. Belmeken water power station
3. Sestrimo water power station
4. Momina Klisura water power station
5. Supply conduits