The thirtieth anniversary of the People's Republic of Bulgaria is marked by the successful commissioning of its first nuclear power station. This report on its construction and operational programme has been submitted by the Committee on the Peaceful Utilization of Atomic Energy of the People's Republic of Bulgaria.

The Development of Nuclear Power in the People's Republic of Bulgaria

Construction of the first Bulgarian nuclear power station was started on 6 April 1970 near the town of Kozlodui. This day marks the beginning of the development of nuclear power in Bulgaria.

The decision to develop nuclear power in the People's Republic of Bulgaria was preceded by serious and extensive studies and discussions, in order to clarify a number of scientific and technical, internal and international problems associated with the possible construction of a nuclear power station.

The first estimates relating to the introduction of nuclear power were made in 1960. Later, in 1965, the Government called for further studies on the introduction of nuclear power in the country's power system, and preliminary negotiations were started in the same year with the Soviet Union on the possibility of the supply of a complete Soviet nuclear power plant. As in the case of the construction of most of our country's large industrial undertakings, the Soviet Union agreed to provide full assistance in the design, construction and provision of equipment for Bulgarian nuclear power stations. This preliminary stage culminated in the signing of an agreement in 1966 between the Governments of the Soviet Union and the People's Republic of Bulgaria on collaboration in the construction of the first Bulgarian nuclear power station.

The main reasons for the decision to use nuclear power in the country were as follows:

1. Analysis of world experience confirmed the development of nuclear power as one of the most characteristic and promising trends in power production;

2. Analysis of national energy resources showed that Bulgaria's water resources were limited and variable and that coal reserves were not extensive and consisted mostly of low-grade lignite coals, while its oil and natural gas reserves were small. Consequently, the country has to import sources of power, of which nuclear fuel is considered to be the most favourable choice involving a minimum of transport problems and expenditure.

3. Analysis of certain factors associated with public well-being indicated that nuclear power offers considerable advantages from the point of view of environmental and site pollution. This aspect is very important in view of the country's highly developed agriculture.

The programme for nuclear power development comprises the following stages:

a) The commissioning in 1974-75 of the first two units of the Kozlodui nuclear power station, with a total capacity of 880 MW;

b) The supply of an additional 1800 MW of nuclear power between 1976 and 1980. Power production from all nuclear plants in 1980 will amount to 13 000 - 14 000 million kW/h, representing about 25% of the total power generated in the country. During the above-mentioned period, nuclear power stations will account for more than 50% of the growth in power generation.

c) In the period 1981-2000, the growth of power production will be due mainly to nuclear power stations, which from 1990 to 2000, will account for 75-85% of the total growth. By the year 2000, the total nuclear power generating capacity is expected to increase to 13 000 - 15 000 MW(e), constituting 60-65% of the country's total power output.

On 4 September 1974, the first Bulgarian nuclear power plant near Kozlodui was officially inaugurated and the first nuclear reactor with a capacity of 440 MW(e) was handed over for operation.

In consultation with Soviet design institutes, our design organizations have prepared a general plan and the detailed construction plans for the main and auxilliary buildings, the water supply system, a wharf on the Danube, an ancillary wing comprising workshops and laboratories, an open power distribution facility, a chemical water purification plant and other facilities.

In the first stage, use was made of 20 cranes of different types, 18 excavators, 55 bulldozers and scrapers, several hundred dump trucks, automated concrete-making units, concrete pumps, special machines for concrete-lining and filtration-proof walls and other machinery.

The grid plan and the operational sub-programmes are being prepared, checked and correlated with the help of computers.

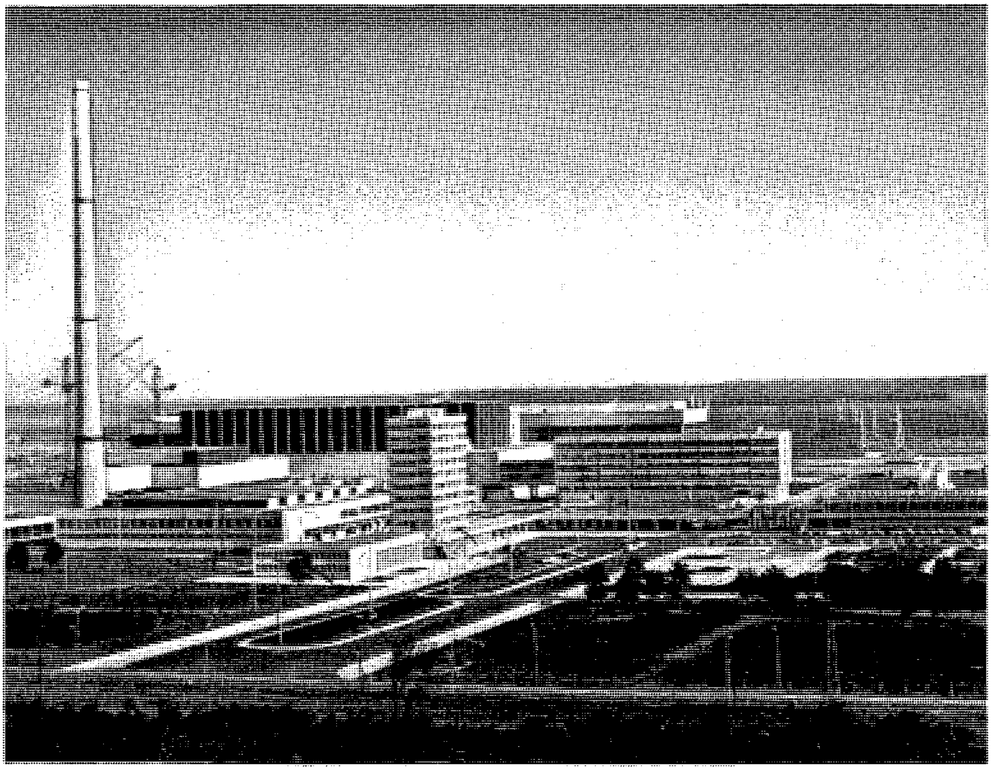
The equipment has been transported from the Soviet Union via the Danube. For this purpose, a new wharf with an artificial channel has been built. It is equipped with two cranes, one with a capacity of 275 tons and the other of 32 tons. The wharf is the biggest in Bulgaria as regards capacity for accommodating heavy loads.

The development of nuclear power in Bulgaria also raises the problem of radiation safety and environmental protection. For this reason, a system of public health surveillance has been established in the country and a group has been formed to monitor the radiation background in the area of the Kozlodui plant and the Danube river. The appropriate health and safety rules and instructions are being prepared. In this work, we are making use of the experience gained in the Soviet Union and of the documentation prepared by the International Atomic Energy Agency and the Standing Commission on the Peaceful Uses of Atomic Energy of the Council for Mutual Economic Assistance.

PLANT CONSTRUCTION

The construction of our plant has certain features which deserve special mention, viz.

1. The soil at the Kozlodui plant site consists of loess of insufficient density, which does not provide the required loadbearing capacity. For this reason, use has been made of the technique of creating a "loess-cement cushion". The procedure is as follows: The



The first nuclear power station in Bulgaria situated at Kozlodui.

foundation pit is dug. The loess is returned to its place in layers 15 cm thick and having a specific moisture content. These layers are covered with cement, which is mixed with loess by means of agricultural rotary ploughs. Each layer is compacted with road rollers to a density of 1.7 tonnes/m^3. The thickness of the loess-cement cushion is 3.2 m under the reactor block, 1 m under the machine room and varies as a function of load-bearing requirements in the case of other structures.

2. A second feature of the construction of the station is the use of the slip-form technique. This technique is well known elsewhere in the world but has been used here on a large scale in the construction of the instrument section and the machine room. Its special feature is that the slipping is performed by raising the roof, which is fully assembled on the ground. Thus, the machine room was built in four and the instrument section in two stages. Each stage took 18-24 days.

Although the slip-form technique calls for detailed organization, very good preparation and a large work force, it reduces the construction time for some items.

3. A specific problem of the Kozlodui power station was the building of a system of water supply to cool the turbine condensers.

The cooling water from the Danube is supplied through a pumping station situated on the river bank, a double channel (for "cold" and "warm" water) 6.5 km in length and a recirculation station on the bank. The channel can supply up to 160 m^3 of water in a second, and thus the nuclear power station can be expanded to a capacity of 2760 MW(e).

One part of the channel lies in a depression and another in the embankment, the soil along its whole length consisting of loess. The channel is lined with reinforced concrete; this was carried out by means of special concrete-placing machines. The total area of the lining is more than 600 000 m^2. In the construction of the channel, some 5 million m^3 of earth were removed.

A hexagonal concrete antifiltration wall was designed for the construction of the pumping station on the River Danube, part of which is lower than the bed of the river. The wall is 0.5 m thick, 450 m long and 23 m high. This height is governed by the depth at which the first geological layer permeable to water occurs. The antifiltration wall was built with special construction machinery.

4. The formula for the preparation of biological concrete with a specific weight of 3.65 t/m^3, which has been adopted and approved by the Soviet design organizations, has proved successful in the construction of our nuclear power station. Waste slag from the hot rolling of steel, the so-called scale, is used as the "heavy" filler. The formula together with the scale has several advantages:

– Simple production technology;

– Much greater homogeneity as a result of the decrease in separation of the heavy constituents;

– Reduction in the cost of the concrete;

– Easy provision of the heavy constituent (scale), which is a waste product from iron and steel rolling processes in the country's plants.

Included in the plans for the future development of the Kozlodui power station is the construction of a further four units, each with a capacity of 440 MW(e) and similar im composition to the first assembly. According to the overall plan, the third and fourth assemblies will be housed in an open-ended machine hall which will be joined to the first stage machine hall, thus forming a complete hall with eight turbogenerators. This has several advantages in the operation of the facility.

The third unit is due to come into operation in 1977 and the fourth in 1978. The construction of the second stage is already nearing completion.

The future development of nuclear power in the People's Republic of Bulgaria raises the question of the selection of sites for subsequent nuclear power stations. The lack of large inland water bodies necessary to provide the required cooling for the turbine condensers is a feature peculiar to our country in this respect. As a result we have to rely on the only suitable sources of water, the River Danube and the Black Sea. The following two sites are the most suitable:

a) Near the town of Ruse on the River Danube. Here it is possible to erect several units with a total capacity of up to 5000-6000 MW(e). In practice this means that almost all future construction in Bulgaria up until 1990 can be carried out on the "Ruse" site;

b) In the "Shabla" region on the Black Sea coast north of the town of Varna. It is similarly possible to concentrate large-scale power generating assemblies on this site, and it will probably be utilized during the period 1990-2000.

The nuclear power development programme until 1980 is based on nuclear power stations with thermal-neutron, water-moderated, water-cooled reactors with pressurized reactor vessels, since from a technological point of view these have now been fully developed and tested under operational conditions. The later development of nuclear power in Bulgaria will be based mainly on fast neutron reactors.

TRAINING SPECIALISTS

The expanded programme raises the question of training the necessary specialists. A special national programme for training personnel takes several forms.

A great many of our primary needs are filled by the further training in nuclear power of specialists with suitable higher education. This training starts with six-month courses in five subjects: nuclear reactor physics, reactor engineering and technology, reactor management, dosimetry and power supply. In addition there is practical training and appropriate exercises at our reasearch reactor. These six-month courses have been running since 1970.

The next stage is a period of training at the Novovoronezh nuclear power station in the Soviet Union.

The direct participation of operating personnel in the construction and assembly of the nuclear power station and in the elaboration of appropriate operating codes is an important stage in their training.

The final stage in the training of specialists are courses run in the power station workshops based on specially prepared programmes which cover specific aspects dealt with by the individual workshops. The courses are given by Bulgarian and Soviet engineers and physicists. There is a final examination which is the qualification for the job.

The operating staff has gained valuable experience in commissioning and shake-down work, hot rolling and physical and power start-up.

At the same time specialists also undergo training in higher educational establishments. New syllabi are being drawn up – in which the student, on the basis of his special field (physics, thermal power engineering, electronics), receives additional training at the end of the normal period of instruction. Moreover, each year a certain number of young people are sent to study abroad (principally to the Soviet Union).

Personnel with secondary technical education undergo a four-year period of training in our technical institutes.

Experience shows that the training of highly skilled personnel for the development of nuclear power is an extremely important question which cannot be resolved in a short period of time and which requires the joint efforts of individual countries.

Particular attention is paid to scientific and research work on problems raised by nuclear power. As a result the Institute for Nuclear Research and Nuclear Power Enginnering was set up in 1972 as a part of the Bulgarian Academy of Sciences. Work is also progressing at the present time on establishing a scientific and industrial section at the Kozlodui nuclear power station and appropriate problem groups at the Directorate of Scientific Research of the "Energoproekt" Institute.

Development in the People's Republic of Bulgaria is inconceivable without the wide-scale introduction of nuclear power. In reporting our first success – the completion of Unit 1 of the Kozlodui nuclear power station – we should recall that it is the highly skilled scientific and technical aid provided by the Soviet Union that has enabled our country to accomplish this great work in 4 years and 3 months.