Special reports

30th anniversary

A pioneer of nuclear power

by A.M. Petros'yants

Thirty years ago, on 27 June 1954, the world's first nuclear power station at Obninsk was connected to the Moscow grid and humanity became aware of the appearance of a new source of energy for electricity production. For the first time ever, the fission energy from uranium nuclei was being used to benefit mankind for peaceful and constructive purposes. The commissioning of the world's first nuclear power station was to become a milestone – an epoch-making event in the peaceful uses of nuclear energy in the service of humanity.

Today our knowledge, ideas, and technology where nuclear power is concerned have advanced so far that the world's first nuclear power station, with its electrical output of 5 megawatts (MWe) and the design of its primary and secondary circuit systems, seem to many of us to be anachronistic.

This is not surprising, since present-day science and technology have made such enormous leaps forward and the whole of life is changing continually and radically as a result of technological developments. One need only think of electronics, space technology, biology, microbiology, medicine, and so on. But this does not cause the significance of the world's first nuclear power station to be diminished; in fact, the reverse is true. It was a pioneer – a kind of Christopher Columbus – which showed humanity the way and the opportunities for using nuclear energy as an unprecedented new energy source never applied before. In fact, it was only by the middle of the century that people had managed to accumulate sufficient knowledge and experience to release the nuclear energy of heavy atoms.

Worldwide development fuelled

The creation and operation of the Obninsk nuclear power station gave rise to unheard of enthusiasm among many people throughout the world: an energy source had appeared which did not need the transportation by rail or sea of vast loads in the form of coal or oil. Many politicians and officials from various countries and distinguished scientists and experts visited Obninsk to see the world's first nuclear power station in operation. The Obninsk power station served as a demonstration to the world that the new energy source could be used for industrial power production.

The main capitalist countries immediately embarked on the development of nuclear power and started to construct nuclear power stations. In September 1956 in Marcoule, France, a power station with a gas-graphite reactor using natural uranium as fuel, carbon-dioxide gas as coolant and graphite as moderator was taken up to a power of 5 MWe. In October 1956 the first unit of the Calder Hall power station in Great Britain, using a natural uranium reactor, reached its full-rated power of 55MWe. The first nuclear power station in the United States, using a water-cooled, water-moderated pressurized-water reactor with a capacity of 90 MWe, was put into operation at Shippingport in 1957.

In Great Britain very intensive efforts were initially put into nuclear power station construction, and it became the leading country as regards the amount of operating nuclear capacity; in 1969 the total installed nuclear power generating capacity of Great Britain was 4205 MW; France had at the time 1528 MW and the United States 3077 MW.

However, the United States took the lead after a few years, and in 1972 there was an operating nuclear capacity in that country of 10 040 MW, whereas that of Great Britain was only 6980 MW. By mid-1984 just over 300 nuclear power stations with a total electrical capacity of some 200 000 MW had been put into operation in 25 countries.

But is that a lot or a little?' For purposes of comparison, let us say that it is equal to the installed electrical generating capacity of power stations of all types and purposes in countries such as Great Britain, France, and Italy taken together. So it can't be all that little!

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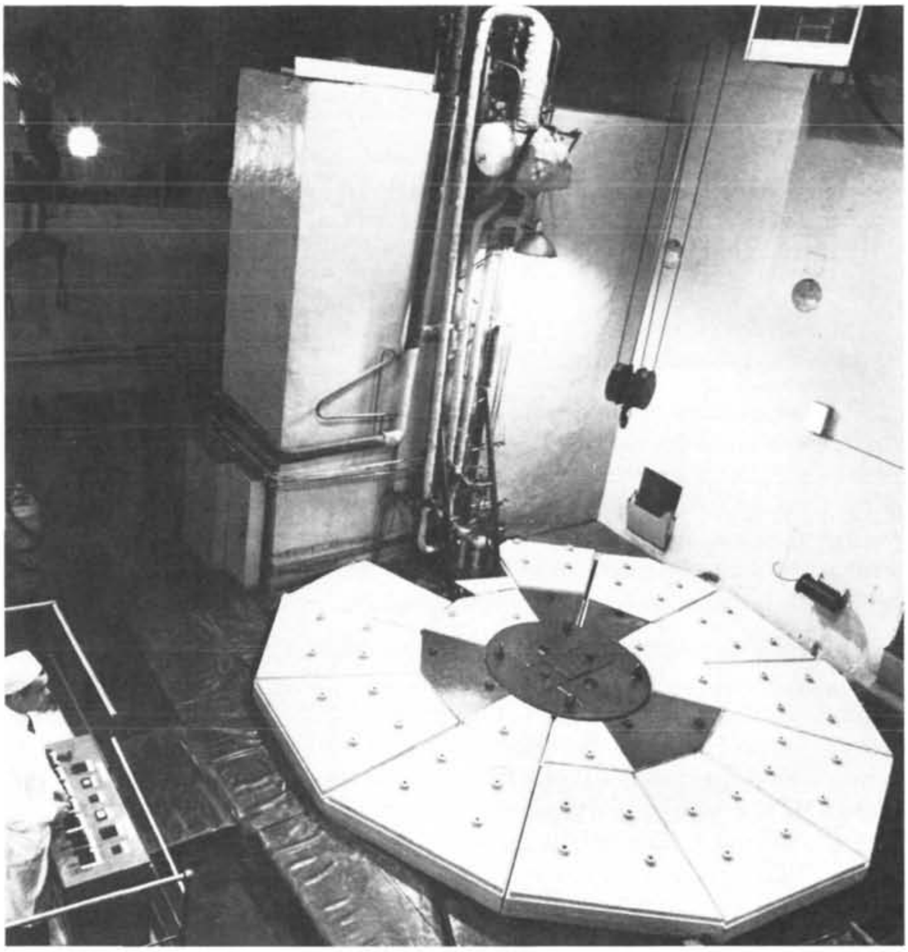


The reactor of the Obninsk nuclear power station, first connected to the Moscow grid 30 years ago in 1954.

In USSR: rapid capacity growth

The Obninsk nuclear power station honourably fulfilled the role entrusted to it of providing a basis for the development of nuclear power in the USSR. It enabled a group of experimenters and operators to carry out a large number of studies needed for the design and construction in the Urals of the Beloyarsk pilot industrial nuclear power station.

In the Soviet Union, the development of nuclear power is proceeding apace despite the country's rich natural resources in coal, oil, and gas and its still unexploited hydropower resources. However, all these organic fuel resources as well as hydropower resources are found predominantly in the eastern part of the country, in which a little over 25% of the population lives. In the European part of the USSR, on the other hand, in which the bulk of the population lives, the lack of fuel resources is keenly felt. For this reason the XXVI Congress of the Communist Party of the Soviet Union (CPSU) decided to develop nuclear power extensively in the European part of the USSR.

At the June 1983 Plenum of the CPSU's Central Committee, emphasis was laid on the special importance of nuclear power development: "... The future of our power production will lie first of all in the use of the most advanced atomic reactors and later also in a practical solution to the problem of controlled nuclear fusion..."

In 1983 the following new nuclear power capacity was put into operation: The fourth reactor unit of the Chernobyl' nuclear power station with a capacity of 1000 MW; the third unit of the Kursk power station with 1000 MW; and the first unit of the Ignalino power station with 1500 MW.

The commissioning of the first unit of the Ignalino nuclear power station represents another great triumph for the power engineers. In terms of unit capacity this high-power channel-type RBMK-1500 reactor is the largest, not only in the USSR and in Europe, but in the whole world. Such a powerful electricity producing system in a single unit with a single nuclear reactor has hitherto been unknown.

The Ignalino power station, which began operation in late 1983, has already passed its first hundreds of million of kilowatt-hours of electricity into the USSR's grid in the first few months of 1984. Following a specially developed schedule, the first unit is now gradually being taken up to full power.

Scientists, engineers, and workers have something to be proud of and something to record in the annals of the Soviet people's achievements. In thirty years the capacity of power reactors has increased 300-fold.

By early 1984 over 40 reactor units with a total installed capacity of more than 21 000 MWe were in operation in the USSR. In 1983, 115 thousand million kilowatt-hours of electricity were generated, 15% more than in 1982.

Broad building campaign

At present, nuclear power stations are being constructed on a broad front at over 20 sites in the USSR. In the Soviet Union and the European member countries of the Council for Mutual Economic Assistance (CMEA), nuclear power has taken a firm hold. Nuclear power stations have shown themselves to be a cheap, profitable, and reliable source of energy in Eastern Europe, too.

With a view to effective utilization of the opportunities for socialist countries arising out of the present-day scientific and technical revolution, to even greater economic expansion and to the solution of large economic, scientific, and technical problems in the context of the CMEA, a multi-faceted programme for further consolidation and development of economic integration among CMEA member countries has been drawn up and is under way. A contribution to this is being made by the construction near the western borders of the Soviet Union, by the joint efforts of CMEA member countries, of an enormous nuclear power station which is to have an installed capacity of some millions of kilowatts. Construction work is proceeding at a rapid rate.

With technical assistance from the Soviet Union, nuclear power stations have been constructed in Bulgaria, Czechoslovakia, the German Democratic Republic, and Hungary and are generating electricity continuously, reliably and cheaply. In Bulgaria the Kozloduj nuclear power station with a number of water-cooled, water-moderated reactors has been in operation for ten years. In the German Democratic Republic the Bruno Leuschner nuclear power station is operating with reactors of the same type.

Since 1972 the A-1 experimental nuclear power station in Bohunice, Czechoslovakia, has been operating with a heavy-water gas-cooled reactor. In 1978–80 the B-1 nuclear power station with water-cooled, water-moderated reactors also was put into operation in Bohunice. In 1982 the first unit of the Paks nuclear power station in Hungary was put into operation. The construction of additional units for Paks and of further nuclear power stations in Bulgaria, the German Democratic Republic, and Czechoslovakia continues on schedule. Construction of nuclear power stations have begun in Poland and Romania.

The wave of nuclear power, which originated in the Obninsk power station, has now reached many other countries. There are now 25 such countries, and in the near future there will be many more. Nuclear power has now become the most dynamic energy sector in the industrialized world and is a serious competitor with oil, which is expensive and will be in short supply in the very near future. And, as already pointed out, despite considerable and persistent opposition, nuclear power is expanding rapidly and is taking on considerable significance as a new energy source in Europe, Japan, and North America.

Impressive oil savings, cost edge

Irrespective of their social systems, nuclear power is a strategic energy source of the highest importance in various countries for their economic policies. As mentioned earlier, during the past decade electricity generation at nuclear power stations has been growing at a constant annual rate of 15 to 20%, which is faster than any other energy source. This is particularly true of capitalist countries. The influence of nuclear power station operation on the oil-producing OPEC countries is enormous. Nuclear power stations constructed and commissioned between 1972 and 1982 have reduced the demand for oil produced in Middle Eastern countries by 550 000 tonnes per day, accounting for one quarter of the total reduction in oil production by OPEC countries.*

By early 1984, total electricity power generation at nuclear power stations throughout the world exceeded one trillion kilowatt-hours, which is equivalent to over 700 000 tonnes of oil per day. According to IAEA data, by 1990 nuclear electricity generation will have doubled and will have attained the equivalent of over 1.5 million tonnes of oil per day, which is equal to the record oil production figure of Saudi Arabia.

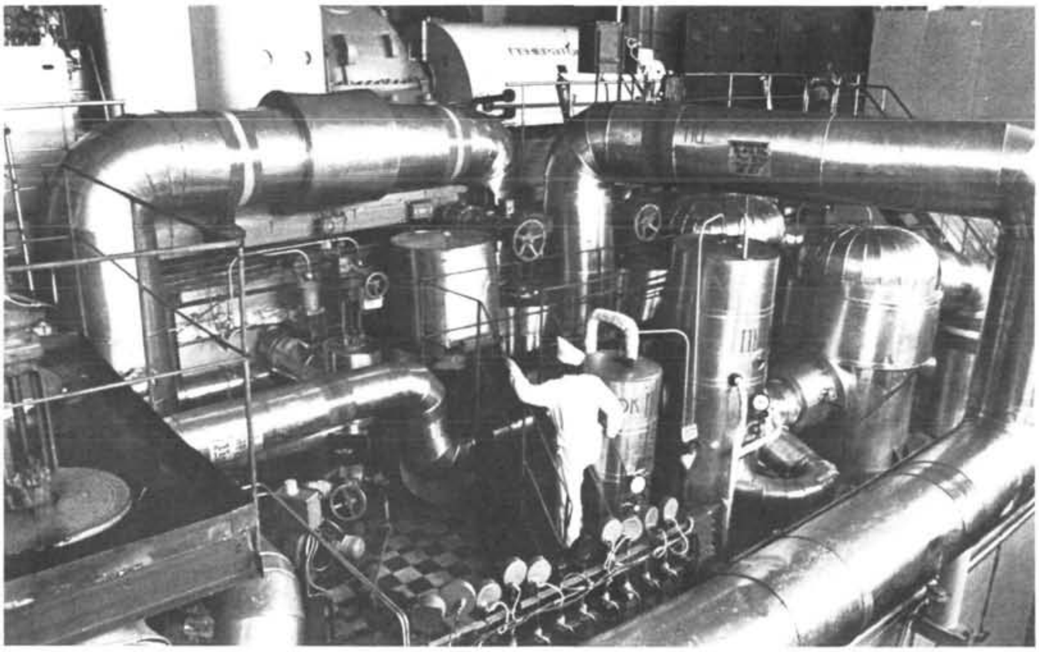
Electricity produced at European nuclear power stations is, on average, 30 to 40% cheaper than that from coal-fired thermal power stations. In France this difference is even more impressive. The French company EDF has published comparative data on the production costs of electricity at nuclear and fossil-fuel thermal power stations: for base-load operation, electricity production at nuclear power stations, coal-fired thermal stations, and oil-fired thermal stations costs 19.2, 33.5 and 66.9 centimes per kilowatt-hour respectively.**

An interesting point is that, following a referendum, Sweden has imposed a moratorium on the expansion in nuclear power production. As a result of the referendum, the number of nuclear power stations approved for construction was limited to twelve. The decommissioning of all the country's nuclear power stations is foreseen for the period 2010–30.

However, it will not be so simple to renounce nuclear power, since nuclear power stations already account for

* Reported in *International Herald Tribune*, Paris, 8 December 1983.

** *Atomwirtschaft*, 1983, Bd. 28, No. 5, p. 225.



Inside the turbine hall of the Bilibino nuclear power plant, which since 1973 has been supplying both electricity and heat to a diamond-mining town in the Chukotka region in the far northeast of the USSR.

a considerable proportion of power production. In 1981, for example, the share of nuclear electricity production out of total power production was 35%, in 1982 it was 38.6% and during the first nine months of 1983 it was 39%. These data show that Sweden's renunciation of nuclear power poses considerable problems.

Nuclear power for heat supplies

Mention should be made of the significance of nuclear power not only for electricity generation but also for the production of low-temperature heat for heating dwellings and other buildings and, in the future, of high-temperature heat for industrial processes.

Centralized heat production accounts for up to 30% of organic fuel, consisting mainly of gas and oil which are in shortest supply. In optimization of the fuel and energy balance an important part could be played by nuclear fuel in heat supply. (See related article in this issue.)

In the Soviet Union work is under way on the development of special nuclear district-heating plants which generate low-temperature thermal energy for heating dwellings. The construction of such plants will make it possible to use nuclear fuel for supplying heat to large towns and will represent an important part of the Soviet long-term energy programme.*

For centralized heat supply, use may be made of nuclear heat production plants, dual-purpose electricity and heat production plants and also condensation nuclear power stations in which steam from unregulated turbine extraction is used.

Since 1973 the Bilibino dual-purpose plant, which is of considerable economic and social significance for development of productive potential in the Chukotka region in the Soviet Union, has been in operation. Operating experience has shown that in the far north dual-purpose nuclear plants are technically and economically superior to thermal electricity-generating stations of the same capacity using organic fuel. The cost of electrical and thermal energy generated at dual-purpose nuclear plants is much lower than at thermal plants situated in the same area. The commissioning of a nuclear power source has resulted in economies of millions of tonnes of organic fuel and has obviated the need to use extensive transport facilities for supplying it.

When plant components were being selected, it was decided that it would be best to use water-cooled, water-moderated reactors for dual-purpose nuclear plants until other reactor types had been developed and fully mastered. The turbine system was redeveloped, resulting in the T-500-60 and TK-500-60 turbines.

The first dual-purpose nuclear plants are designed to be as safe as nuclear power stations. They are sited not less than 25 to 30 kilometres from large towns, which ensures the safety of the public but means that large amounts of piping for the thermal mains are required. Work is being done on the development of new safety barriers which will enable these plants to be sited nearer the heat consumers. Consideration is being given to different types of multiple-layer and reinforced concrete reactor buildings, sub-pressure protective containments and also "double" containments.

It should be noted that dual-purpose nuclear plants use medium-pressure steam, which renders them less economic than high-pressure dual-purpose plants using organic fuel.

* *Pravda*, 11 June 1983.

Heat for towns, industries

In recent years, extensive development work has been done on nuclear plants for generating low-temperature thermal energy for heating purposes. The undemanding parameters of the coolant in all circuits make it easy to solve the safety problems of such plants and to bring them nearer to consumers. The safety of nuclear heat production plants is also assured by the use of integrated layouts and natural convection in the primary circuit, by the presence of a secondary containment, and by a triple-circuit hot water supply system in which the water pressure in the heat supply network is higher than in the water heating circuit.

In the USSR the advisability of building nuclear heat production plants with two 500-MW, water-cooled, water-moderated reactors has been recognized. A plant of this type, together with peak load systems, will meet heat requirements of approximately 6300 to 8400 Gigajoules per hour (GJ/h). Calculations show that nuclear heat production plants are competitive at thermal loads of 4200 to 6300 GJ/h.

With a view to supplying industrial enterprises and settlements in outlying areas of the north and northeast with low-temperature heat, a design has been developed for a nuclear heating plant with a thermal capacity of 30 MW called the ATV-15 X 2. The water temperature in the heating network would be 150°C.

At the Beloyarsk, Leningrad, Kursk, Chernobyl' and certain other nuclear power stations, heat supply systems use unregulated condensing-turbine extraction steam to meet the heat requirements of the power stations themselves and of nearby residential areas.

The intention is to use large quantities of unregulated extraction steam from K-1000/60-1500 turbines. Each turbine of this type can provide up to 840 GJ/h of thermal energy for heating nearby towns of medium size.

The extensive nuclear power station construction programme which is planned also provides for the installation of pilot high-power dual-purpose units for supplying Odessa and Minsk with heat and electricity. The Odessa dual-purpose plant is being built 25 kilometres from the town. Phase 1 will consist of two units with WWER-1000 reactors. The intention is to provide two TK-500 turbines for each power unit. Pilot nuclear heat production plants are being built immediately outside the boundaries of the towns of Gorky and Voronezh.

On the 30th anniversary of the Obninsk power station, nuclear power has taken on considerable significance both in the Soviet Union and in many other countries. The USSR is the only country in the world with three operating nuclear power stations using fast reactors. It also has developed the world's only programme for the construction of nuclear heat production plants for large industrial towns.

Nuclear power owes a great deal to the team who worked on the Obninsk nuclear power station. At this time of jubilee celebrations, we pay a respectful tribute to those scientists, engineers, and workers who did so much to bring about what has led to a triumph of power engineering throughout the world.