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# Nuclear Programs of Eastern Europe

**An Intelligence Assessment**



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*July 1979*

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# Nuclear Programs of Eastern Europe [redacted]

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**An Intelligence Assessment**

*Information available as of 1 March 1979 has been used in the preparation of this report.*

The author of this paper is [redacted] Nuclear Energy Division, Office of Scientific Intelligence. Comments and queries are welcome and should be directed to the author on [redacted] (b)(3)

This paper has been coordinated with OWI, OER, OSR, OPA, DDO, OGCR, and OIA. [redacted] (b)(3)

The supporting references are identified in a list published separately, are available to authorized persons, and may be obtained from the originating office through regular channels [redacted] (b)(3) Requests for the references should include the publication number and date of this report. [redacted] (b)(3)

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*SI 79-10050*
*July 1979*

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**Table 1**

**Summary of East European Nuclear Program Elements and Policies**

| | Albania | Bulgaria | Czechoslovakia | East Germany | Hungary | Poland | Romania | Yugoslavia |
|---|---|---|---|---|---|---|---|---|
| [redacted] (b)(1) | | | | | | | | |
| Number, purpose, and status of reactors (OP, operational; UC, under construction; P, planned) | 1 suspected research reactor | 1 research, 5 power (4 OP, 1 UC) | 4 research, 19 power (2 OP, 6 UC, 10 P, 1 shut down) | 2 research, 13 power (5 OP, 8 UC) | 9 research, (6 zero-power), 6 power (4 UC, 2 P) | 6 research, 3 power (2 UC, 1 P) | 3 research, 5 power (all P) | 3 research, 3 power (1 UC, 2 P) |
| [redacted] (b)(1) | | | | | | | | |

# Nuclear Programs of Eastern Europe [redacted] (b)(3)

## Key Judgments

***Status of Technology***

The elements of nuclear technology in Eastern Europe range from the modest research reactor suspected to be in Albania to the nuclear components manufactured in the other countries. Czechoslovakia has the most highly developed program; by 1980 it will be able to build entire reactors without Soviet assistance and will begin providing technical assistance to other East European countries. (Table 1 summarizes the status of East European nuclear programs.) [redacted] (b)(3)

***Power Generation***

All the East European countries except Albania have received major nuclear technology from the USSR and have nuclear power plants in operation, under construction, or planned. Yugoslavia and Romania also have acquired significant Western technology and appear interested in using more in their current programs. [redacted] (b)(3)

The East European countries have set several goals under agreements signed in 1978 as members of the Council for Mutual Economic Assistance (CEMA). One goal is rapid construction of nuclear power stations. Another is production of specialized reactor components to support development of the new Soviet-designed reactor (the VVER-1000) for the East European countries and possibly for Soviet export. Each signatory will have specified obligations supporting the VVER-1000 program. [redacted] (b)(3)

East Europeans see nuclear energy as the long-term solution to their energy problems—for example, the blackouts caused by infrequent but serious shortages. Unlike some Western areas, Eastern Europe shows no evidence of reexamining or changing its nuclear goals. By the end of 1979, nuclear power will produce 3 to 4 percent of the electricity in Eastern Europe from an installed capacity of 4,470 megawatts (MW). [redacted] (b)(3)

All spent fuel from East European reactors will be sent to the Soviet Union, except for the Yugoslav Krsco fuel (to be stored at Krsco) and the CANDU fuel from Romanian reactors. [redacted] (b)(3)

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| [redacted] | 16 | (b)(1) |
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| [redacted] | 17 | (b)(1) |
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# Nuclear Programs of Eastern Europe [redacted] (b)(3)

## Summary

All of the nuclear energy programs of the East European countries were developed with Soviet assistance. This assistance began in 1949 with the creation of the Council for Mutual and Economic Assistance, which was formed to foster economic development among the member countries (Albania, Bulgaria, Czechoslovakia, East Germany, Hungary, Poland, Romania, and the Soviet Union). Albania subsequently dropped out and has not participated in the work since 1961. Yugoslavia is not a full member of CEMA, but it does belong to the two open organizations, INTERATOMINSTRUMENT and INTERATOMENERGO. In 1955 and 1956 a series of bilateral agreements were signed with the USSR in which the Soviets pledged assistance in nuclear research to Czechoslovakia, Poland, East Germany, Hungary, Romania, and Bulgaria. The principal facilities provided by the Soviets were two light water–moderated research reactors (VVR-S and IRT-1000), the VVER-440 reactor (a 440–megawatt electrical [MWe] pressurized-water reactor [PWR]), and the enriched uranium fuel for these reactors. [redacted]

At its annual meeting in 1978, CEMA indicated that the main goal of its energy programs would be the rapid construction of nuclear power stations and the production of specialized reactor components. There is to be special emphasis on the design and construction of the VVER-1000, a Soviet-designed 1,000-MWe PWR that is to replace the VVER-440 as the standard Soviet reactor for export to the CEMA members about the mid-1980s. [redacted]

In addition to the participation in research on the VVER-1000 reactor, each CEMA member has the responsibility of specializing in the production of certain components and auxiliary equipment for current reactors. Czechoslovakia is responsible for the production of VVER-440 reactors, steam generators, pressurizers, and turbines. Hungary is responsible for the production of water-treatment equipment, pumps, generator armatures, repair and mounting machines, cranes, and Videoton R-10 minicomputers.[1] Bulgaria is responsible for the production of hermetic doors, Poland for the production of steam generators and accumulators, and East Germany for the production of radiation detectors, instruments, and voltage regulators. [redacted] (b)(3)

To coordinate research efforts in the various CEMA countries, three organizations have been formed—INTERATOMINSTRUMENT, INTERATOMENERGO, and the Joint Institute for Nuclear Research (JINR). INTERATOMINSTRUMENT was formed in Warsaw for standardization of measuring equipment and instruments. INTERATOMENERGO was formed in Moscow for coordination of the specialized production of nuclear components; it is the ordering contractor for nuclear power plants to be built in the CEMA countries after 1980. JINR was established in 1955 at Dubna in the USSR to provide advanced training and research facilities for the CEMA countries. [redacted] (b)(3)

All the East European countries except Albania have an interest in nuclear power and have nuclear power stations either in operation, under construction, or planned. Yugoslavia and Romania appear to be interested in developing their nuclear programs using Western technology. The other East European countries (except Albania) appear dedicated to Soviet technology for their nuclear programs. [redacted] (b)(3)

Albania has the least developed nuclear energy program in Eastern Europe. Albania has not decided to develop nuclear power and will continue to depend on petroleum for a large part of its energy requirements. The Albanian nuclear research program emphasizes the use of radioisotopes in support of oil drilling and exploitation. [redacted] (b)(3)

[1] These computers have been used for control at reactor sites, mass spectrography, software development, automated plasma measurements, high-energy research, and isotope analysis. [redacted] (b)(3)

The Bulgarian nuclear program is also very small and is heavily dependent on the Soviets. Bulgaria has only a modest nuclear research program, based on a single Soviet-supplied research reactor. Bulgaria's first nuclear power station, on the Danube River near Kozloduy, will contain four VVER-440 reactors and a VVER-1000 when it is completed in the mid-1980s. The first two reactors began operating in 1974 and 1975. [redacted]

Czechoslovakia has the most highly developed nuclear program in Eastern Europe, including a broad-based research program in reactor and fuel-cycle technology, a large nuclear power program, and a well-developed nuclear industry. Czechoslovakia's first nuclear power reactor—the 150-MWe, heavy water-moderated A-1 at Jaslovske Bohunice—began operating in 1973. It is believed that this reactor has been shut down as a consequence of several nuclear incidents at the reactor between 1975 and 1977. At one time Czechoslovakia planned to base its nuclear power program on such heavy water reactors, but because of significant problems with the A-1, Czechoslovakia currently is basing its nuclear program on Soviet-designed PWRS. The Czechoslovaks plan to have 13 VVER-440 reactors and four VVER-1000 reactors operating by 1990, with the first two VVER-400 reactors coming into operation in 1979. If the reactors now under construction and in the planning stage are completed on schedule, Czechoslovakia will have 6,270 MW of nuclear-electric generating capacity by 1990. [redacted]

By 1980, when new and expanded industrial facilities are completed, Czechoslovakia will be able to build PWRS without Soviet help and will start to supplement the USSR in supplying CEMA countries, and possibly Yugoslavia, with nuclear reactors and other components. Furthermore, Czechoslovakia is developing its own fuel cycle capability [redacted]

East Germany has an impressive nuclear program that is only slightly less developed than Czechoslovakia's. Also, East Germany was the first country in Eastern Europe outside the USSR to operate a nuclear power station. When the Lubmin nuclear power station is completed in about 1985, it will be one of the largest in Eastern Europe, consisting of eight reactors with a total electrical capacity between 3,520 and 4,640 MW. [redacted] (b)(3)

Hungary has a small nuclear research program based on six zero-power reactors and two other small research reactors. The former are used to support research on the VVER-440 and VVER-1000 reactors, and the latter are devoted mainly to the production of radioisotopes for use in research, medicine, and industry. Nuclear power will not become a part of the Hungarian energy program until about 1980, when the first VVER-440 unit at the Paks nuclear power station is expected to become operational. The Paks nuclear power station originally was planned for operation in 1975, but because of economic conditions in the country, the government decided to delay it for five years. [redacted] (b)(3)

Poland has a modest nuclear program that, like Albania's, is devoted mostly to the production of radioisotopes. Because of Poland's abundant cheap fossil fuels, it did not decide to build a nuclear power station until 1974, when it ordered a station from the USSR. Construction of this station has not yet begun. This station ultimately will comprise two VVER-440s and a VVER-1000 reactor. It is doubtful that any of these reactors will be operational before the mid-1980s. Although there is no evidence of a nuclear weapons program, there is evidence of research and development in high explosives. The explosives are used in Polish fusion experiments to generate neutrons. [redacted] (b)(3)

Romania was the first East European country that appeared to be interested in utilizing Western technology for its nuclear energy program. However, because of Soviet pressure, the Romanians reached an agreement in 1970 for the construction of two Soviet VVER-440 reactors near Pitesti to be operational by the early 1980s. Romanian plans subsequently called for the construction of only one Soviet reactor. The Romanians were insisting that the Soviet reactor [redacted]

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More recently, Romania and Canada have come to an agreement. Several years of negotiations were rewarded in March 1978 when the two countries agreed to include both fixed and escalated clauses in a contract for four CANDU reactors. In December 1978, Canadian and Romanian banks agreed on a $1 billion loan to finance the reactors. The Romanians are hoping construction of the first CANDU can start by 1980, with an expected operational date about 1986 for that reactor and about 1988 or 1989 for the second [redacted] (b)(3)

Yugoslavia is the second East European country to be interested in acquiring Western technology for its nuclear power program. Yugoslavia has purchased a 632-MWe Westinghouse pressurized water reactor. This nuclear power station is near Krsko and is expected to become operational in mid-1980. [redacted] (b)(3)

The Yugoslavs have encountered several construction problems at the Krsko nuclear power station and consider the pace of construction to be too slow. As a result, they have indicated that they will give greater consideration to French, Japanese, and West German bids for Yugoslavia's second nuclear power station. The Yugoslavs have attempted to pressure Westinghouse to speed up construction at Krsko by mentioning that they were close to negotiating a deal to purchase nine CANDU reactors. Although this may have been a move only to pressure Westinghouse, Yugoslavia's uranium deposits would make CANDU reactors a logical choice to achieve nuclear independence. [redacted] (b)(3)

 

# Nuclear Programs of Eastern Europe [redacted]

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## Albanian Nuclear Program

Albania's nuclear energy program is the least developed in Eastern Europe and deals solely with basic nuclear research. The Albanian Academy of Sciences is responsible for nuclear research in Albania. [redacted]

In 1970 the Nuclear Radiation Laboratory at Tirana State University was established with the assistance of the People's Republic of China and inaugurated on 1 October 1970. [redacted]

About May 1971 the Nuclear Radiation Laboratory became the Institute of Nuclear Physics (INP). [redacted] The INP is concerned mostly with the application of nuclear technology in medicine, agriculture, hydrology, and industry. The INP supplies radioactive materials to other institutions and is also responsible for monitoring the level of radioactivity in the air, water, and certain foodstuffs. [redacted]

No nuclear power plants are now contemplated, and Albania will continue to depend on petroleum as its major source of energy. Consequently, a large part of the Albanian nuclear research program supports the petroleum industry in such areas as radioactive tracers and activation analysis in the oil-drilling and exploitation industry. [redacted]

Albania has not signed the Non-Proliferation Treaty. Albania has no capability to develop nuclear weapons, however, and has not shown a desire to do so. [redacted]

## Bulgarian Nuclear Program

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### *Power*

The first Bulgarian nuclear power station is on the Danube River near Kozloduy. This station will consist of four VVER-440 reactors and a VVER-1000, for a total installed capacity of 2,760 megawatts electrical, when the station is completed in the mid-1980s. The first two reactors became operational in 1975 and 1976, respectively. The third and fourth reactors are expected to become operational during 1979 and the fifth about 1987-90. [redacted]

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**Table 2**

**Nuclear Reactors in Bulgaria**

| | Location | Type | Power Level | Type of Fuel | Date Criticality Achieved or Scheduled |
|---|---|---|---|---|---|
| **Research reactors** | | | | | |
| IRT-1000 | Nuclear Research and Power Institute | | 2 MWt | 10%-enriched $UO_2$ | 1961 |
| **Power reactors** | | | | | |
| Kozloduy-1 | Kozloduy | PWR | 440 MWe | 3.3%-enriched $UO_2$ | 1975 |
| Kozloduy-2 | Kozloduy | PWR | 440 MWe | 3.3%-enriched $UO_2$ | 1976 |
| Kozloduy-3 | Kozloduy | PWR | 440 MWe | 3.3%-enriched $UO_2$ | 1979 |
| Kozloduy-4 | Kozloduy | PWR | 440 MWe | 3.3%-enriched $UO_2$ | 1979 |
| Kozloduy-5 | Kozloduy | PWR | 1000 MWe | 4.4%-enriched $UO_2$ | 1987-90 |

[redacted] (b)(3)

While this program is small compared with programs of other countries, it is very important to the economy of Bulgaria. The Kozloduy power station is now producing about 20 percent of the total electric power produced in Bulgaria. By 1990, nuclear power is expected to account for half of the country's power output. The fuel for those reactors is being supplied by the USSR. [redacted] (b)(3)

The Bulgarians have indicated that reactors in the future will be built on the Danube River near Ruse and on the Black Sea near Varna. These are the only rivers in Bulgaria with an adequate cooling capacity for the large reactors being built. A summary of research and power reactors in Bulgaria is presented in table 2. [redacted] (b)(3)

At one time the Bulgarians were interested in buying US reactors, but it now appears that they will continue to build reactors based on Soviet technology. [redacted]

[redacted]

[redacted]

**Czechoslovak Nuclear Program**

The Czechoslovak nuclear program was initiated in April 1955 following a bilateral agreement with the Soviets for cooperation in the peaceful uses of nuclear energy. Under this agreement the Soviets provided technical training, personnel, and scientific equipment—consisting mainly of a small research reactor and a cyclotron. Since that time, the Czechoslovaks have established an impressive nuclear energy program. [redacted]

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[redacted]

The direction of the nuclear program is determined by three Czechoslovak ministries and the Atomic Energy Commission [redacted] The Ministry for Fuels and Power is responsible for managing industrial application of nuclear power, developing energy supply programs, and carrying out construction of nuclear power plants. [redacted] The Ministry of Metallurgy and Heavy Engineering directs and supervises production of components and auxiliary equipment for the construction of nuclear plant facilities. [redacted] The Ministry for Technological and Investment Development sets guidelines for investment policy in the scientific sector and directs research and development. [redacted] The Czechoslovak Atomic Energy Commission was established in July 1955 to direct and coordinate nuclear energy developments. Through its "Council for Nuclear Security," the Commission establishes and supervises the location, layout, and operation of nuclear facilities. The actual nuclear program is carried out by a number of scientific, governmental, and industrial organizations. [redacted]

[redacted]

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***Power***

The first nuclear power station to begin operation in Czechoslovakia was the A-1 plant at Jaslovske Bohunice. The A-1 is a 150-MWe, natural-uranium-fueled, heavy-water-moderated, gas-cooled reactor that began operation in 1973. Construction of the A-1 plant began in 1958 but suffered 14 years of delays. The delays were due to inadequate Soviet assistance (apparently an attempt to impede independent Czechoslovak reactor development) and two Czechoslovak rejections of Soviet preliminary designs. The Soviets submitted the preliminary designs for the reactor in 1961. The Czechoslovaks rejected the designs because of problems related to fuel rod stability and carbon dioxide coolant pumps. Revised Soviet designs were rejected again, and eventually the Czechoslovaks had to complete the project almost on their own. [redacted] (b)(3)

The A-1 has also had numerous problems since operation began. It has been reported that nuclear-related accidents occurred at the A-1 plant between 1975 and 1977. [redacted] (b)(1) With the problems the Czechoslovaks have had with the A-1 reactor, they are probably in no hurry to get it operational again. [redacted] (b)(3)

Czechoslovakia had assumed that their A-1 program would be a success and had planned an extensive nuclear power program based on the A-1 type reactor. In 1966 the Czechoslovaks announced plans for 2,000 MWe of nuclear capacity by 1980, to include a 300-MWe A-2 and a 500-MWe A-3, both based upon the A-1 design. The A-2 was designed by the Skoda Works, but plans for construction of the A-2 were canceled some time between 1967 and 1970; the A-3 was never designed. The problems that had arisen finally caused the Czechoslovaks to abandon the A-1 type reactor technology and instead to utilize Soviet PWRs for their nuclear program. [redacted] (b)(3)

**Table 3**

**Nuclear Reactors in Czechoslovakia**

| | Location | Type | Power Level | Type of Fuel | Date Criticality Achieved or Scheduled |
|---|---|---|---|---|---|
| **Research reactors** | | | | | |
| VVR-S | Institute of Nuclear Research (INR) | | 5 MWt | 10%-enriched uranium | 1957 |
| TR-0 | INR | | 0 | Natural uranium, $D_2O$ moderated | 1972 |
| SR-0A | Plzen | | 0 | | 1970 |
| SR-1 | Skoda Works | | 0 | 10%-enriched uranium | |
| **Power reactors** | | | | | |
| A-1 | Jaslovske Bohunice | HWR | 150 MWe | Natural uranium, gas cooled | 1973 |
| V-1 (Unit 1) | Jaslovske Bohunice | PWR | 440 MWe | 3.3%-enriched $UO_2$ | 1978 |
| V-2 (Unit 2) | Jaslovske Bohunice | PWR | 440 MWe | 3.3%-enriched $UO_2$ | 1979 |
| V-2 (Unit 3) | Jaslovske Bohunice | PWR | 440 MWe | 3.3%-enriched $UO_2$ | 1982 |
| V-2 (Unit 4) | Jaslovske Bohunice | PWR | 440 MWe | 3.3%-enriched $UO_2$ | 1983 |
| V-3 (Unit 1) | Dukovany | PWR | 440 MWe | 3.3%-enriched $UO_2$ | 1982 |
| V-3 (Unit 2) | Dukovany | PWR | 440 MWe | 3.3%-enriched $UO_2$ | 1983 |
| V-4 (Unit 3) | Dukovany | PWR | 440 MWe | 3.3%-enriched $UO_2$ | 1983 |
| V-4 (Unit 4) | Dukovany | PWR | 440 MWe | 3.3%-enriched $UO_2$ | 1984 |
| JEOT I (Unit 1) | Prague North | PWR | 440 MWe | 3.3%-enriched $UO_2$ | 1984 |
| JEOT I (Unit 2) | Prague North | PWR | 440 MWe | 3.3%-enriched $UO_2$ | 1985 |
| JEOT II | Brno | PWR | 440 MWe | 3.3%-enriched $UO_2$ | 1985 |
| JEOT III (Unit 1) | Bratislava | PWR | 440 MWe | 3.3%-enriched $UO_2$ | 1986 |
| JEOT III (Unit 2) | Bratislava | PWR | 440 MWe | 3.3%-enriched $UO_2$ | 1987 |
| V-5 (Unit 1) | Slovakia | PWR | 1,000 MWe | 4.4% $UO_2$ | 1986 |
| V-5 (Unit 2) | Slovakia | PWR | 1,000 MWe | 4.4% $UO_2$ | 1987 |
| V-6 (Unit 1) | Bohemia | PWR | 1,000 MWe | 4.4% $UO_2$ | 1988 |
| V-6 (Unit 2) | Bohemia | PWR | 1,000 MWe | 4.4% $UO_2$ | 1989 |
| V-7 | Unknown | LMFBR [1] | 1,000 MWe | | After 1990 |

[1] Liquid metal fast breeder reactor.

[redacted] (b)(3)

In April 1970, an agreement was concluded between Czechoslovakia and the USSR for Soviet assistance in the construction of two nuclear power stations—the V-1 adjacent to the A-1 at Jaslovske Bohunice, and the V-2 at Dukovany. The first reactor at the V-1 site probably underwent startup testing in late 1978, the second reactor will probably become operational in late 1979. [13, 14] The fuel for the entire life of the reactors will be provided by the USSR, and the spent fuel elements will be returned to the USSR. [redacted] (b)(3)

Current Czechoslovak nuclear power plans call for the construction of 10 nuclear reactors between 1980 and 1990, with a cumulative installed electric power capacity of 5,000 to 7,500 MWe by 1985 and 12,000 MWe by 1990. Those ranges depend upon the introduction of a larger pressurized-water reactor after 1980 having an installed electric power capacity of 1,000 MWe. These nuclear power reactors and others that are planned are summarized in table 3. [redacted] (b)(3)

The April 1970 agreement also provided for Czechoslovakia to cooperate in the Soviet fast breeder reactor (FBR) development program, although the Czechoslovaks do not envisage an FBR for themselves until after 1990. They have contributed to the Soviet FBR program, however, by providing a steam generator for the Soviet BN-350 LMFBR at Shevchenko. This steam generator has been tested in the Soviet BOR-60 test reactor [redacted] (b)(3)

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[redacted]

## East German Nuclear Program

The East German nuclear program was initiated in 1955 with the conclusion of a bilateral agreement with the USSR for cooperation in the peaceful uses of atomic energy. The GDR's nuclear energy program is carried out by three ministries (see figure 2). The Ministry for Science and Technology establishes scientific policy and directs applied research and development. [19] The Ministry for Coal and Energy plans the industrial application of nuclear technology, develops programs to build nuclear power plants, and carries out nuclear power plant construction through the VEB (state-owned) power plant construction combine, which is subordinate to it. The Ministry for Construction of Heavy Machinery and Equipment plans and supervises the production of components and auxiliary equipment. [19] The State Office for Atomic Safety and Radiation Protection also exerts great influence on the nuclear program through its function as radiation protection and approval authority [redacted] (b)(3)

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The Central Institute for Isotope and Radiation Research was established in 1969 at Leipzig. This institute conducts basic research in the areas of radioactive decay, the use of isotopes in biology and medicine, and the application of tracer elements. [redacted] (b)(3)

[redacted]

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*Power*

East Germany was the first CEMA country outside the USSR to operate a nuclear power station. This station, located at Rheinsberg, began operating in 1966 with a Soviet-supplied, 70-MWe pressurized water reactor. In 1974 and 1975 two Soviet VVER-440 PWRs at Lubmin, out of a total of eight reactors planned, were started up [redacted] The third VVER-440 reactor began operation some time between late 1977 and mid-1978. [22] The fourth is externally complete and is expected to begin operation during 1979. The remaining four reactors will probably become operational at yearly intervals after 1982. [redacted]

The first six reactors at Lubmin will be VVER-440s, and the final two will possibly be VVER-1000s. When this station is completed, in about 1985, it will have an installed electric power capacity of between 3,520 and 4,640 MWe. The third East German nuclear power station is under construction at Niedlergorne near Magdelburg. Reportedly this station will utilize four VVER-440 reactors. However, it is now in such an early stage of construction that neither the type nor the number of reactors can be confirmed [redacted] (b)(3)

East German plans for construction and operation of future nuclear reactors call for 5,500 MW of installed power by 1985. It appears that installed nuclear capacity will be about 1,830 MW by 1980, or about 8 percent of total generating capacity. The East Germans should have no trouble in meeting their 1985 goal. A summary of East German research and power reactors is presented in table 5. [redacted] (b)(3)

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**Table 5**

**Nuclear Reactors in East Germany**

| | Location | Type | Power Level | Type of Fuel | Date Criticality Achieved or Scheduled |
|---|---|---|---|---|---|
| **Research reactors** | | | | | |
| VVR-S | Central Institute for Nuclear Research | | 5 MWt | 10%-enriched uranium | 1957 |
| SEG | Central Institute for Nuclear Research | Argonaut | 10 kWt | 20%-enriched uranium | 1962 |
| **Power reactors** | | | | | |
| Rheinsberg | Rheinsberg | PWR | 70 MWe | 3.3%-enriched $UO_2$ | 1966 |
| Lubmin-1 | Lubmin | PWR | 440 MWe | 3.3%-enriched $UO_2$ | 1974 |
| Lubmin-2 | Lubmin | PWR | 440 MWe | 3.3%-enriched $UO_2$ | 1975 |
| Lubmin-3 | Lubmin | PWR | 440 MWe | 3.3%-enriched $UO_2$ | 1978 |
| Lubmin-4 | Lubmin | PWR | 440 MWe | 3.3%-enriched $UO_2$ | 1979 |
| Lubmin-5 | Lubmin | PWR | 440 MWe | 3.3%-enriched $UO_2$ | 1982 |
| Lubmin-6 | Lubmin | PWR | 440 MWe | 3.3%-enriched $UO_2$ | 1983 |
| Lubmin-7 | Lubmin | PWR | 440 MWe | 3.3%-enriched $UO_2$ | 1984 |
| Lubmin-8 | Lubmin | PWR | 440 MWe | 3.3%-enriched $UO_2$ | 1985 |
| Niedlergorne-1 | Magdeburg | PWR | 440 MWe | 3.3%-enriched $UO_2$ | 1984 |
| Niedlergorne-2 | Magdeburg | PWR | 440 MWe | 3.3%-enriched $UO_2$ | 1985 |
| Niedlergorne-3 | Magdeburg | PWR | 440 MWe | 3.3%-enriched $UO_2$ | 1986 |
| Niedlergorne-4 | Magdeburg | PWR | 440 MWe | 3.3%-enriched $UO_2$ | 1987 |

[redacted] (b)(3)

produced by radiochemical laboratories and reactors are being stored in an old salt mine near Bartensleden. [23] [redacted]

[redacted]

[redacted] (b)(1) (b)(3) (b)(3) (b)(1) (b)(3)

**Hungarian Nuclear Program**

The Hungarian nuclear program started in 1955 following the conclusion of a bilateral agreement with the USSR for cooperation in the peaceful uses of atomic energy. Since that time, the Hungarian program has concentrated on isotope production for agricultural, medical, and industrial applications. Hungary has a small nuclear research program, directed by the Hungarian Atomic Energy Commis-

[redacted]

sion, with research activities performed, for the most part, under the auspices of the Hungarian Academy of Sciences. Current Hungarian emphasis is on the use of radioactive isotopes for research, medicine, and industry and for research in cooperation with other CEMA members on the VVER-1000 reactor. Hungary will not have a nuclear power plant operational before 1980. [redacted]

[redacted]

[redacted]

(b)(1)
(b)(3)

(b)(1)
(b)(3)

(b)(3)

(b)(1)

***Power***

The first Hungarian nuclear power station is under construction near Paks on the Danube River. Construction was started in 1969, and the station originally was planned to be in operation by 1975. The Hungarians decided, however, that economic conditions in their country did not warrant introducing nuclear power before 1980, and the station was temporarily delayed. This site will contain four VVER-440 reactors

**Table 7**

**Nuclear Reactors in Hungary**

| | Location | Type | Power Level | Type of Fuel | Date Criticality Achieved or Scheduled |
|---|---|---|---|---|---|
| **Research Reactors** | | | | | |
| ZR-1-ZR-6 | Central Physics Research Institute | | Less than 100 kWt | Slightly enriched $UO_2$ | 1959-72 |
| Budapest | Budapest Technical University | | 10 kWt | | 1971 |
| VVR-S | Central Physics Research Institute | | 3.3 MWt | 33%-enriched $UO_2$ | 1959 |
| Debrecen | Debrecen Research Institute | | 1 MWt | | |
| **Power Reactors** | | | | | |
| Paks-1 | Paks | PWR | 440 MWe | 3.3%-enriched $UO_2$ | 1980 |
| Paks-2 | Paks | PWR | 440 MWe | 3.3%-enriched $UO_2$ | 1981 |
| Paks-3 | Paks | PWR | 440 MWe | 3.3%-enriched $UO_2$ | 1982 |
| Paks-4 | Paks | PWR | 440 MWe | 3.3%-enriched $UO_2$ | 1983 |
| Paks-5 | Paks | PWR | 1,000 MWe | 4.4%-enriched $UO_2$ | 1987-90 |
| Paks-6 | Paks | PWR | 1,000 MWe | 4.4%-enriched $UO_2$ | 1987-90 |

[redacted] (b)(3)

and two VVER-1000 reactors for a total capacity of 3,760 MWe. The VVER-440 reactors will come on line at the rate of one per year between 1980 and 1983, and the two VVER-1000 reactors will be constructed after 1985. When the Paks station is complete, in about 1990, it will supply 25 to 30 percent of the country's electric power requirements. [75] A summary of Hungarian research and power reactors is presented in table 7. [redacted]

[redacted]

(b)(1)
(b)(3)

(b)(3)
(b)(1)

[redacted]

(b)(1)
(b)(3)

**Polish Nuclear Program**

The Polish nuclear energy program began on 23 April 1955 with the conclusion of a bilateral agreement with the USSR for Soviet assistance in the construction of a research reactor and a cyclotron and in the training of personnel. In June 1955 the Polish Government established the Institute of Nuclear Research under the auspices of the Polish Academy of Sciences (PAN). The Polish nuclear program is devoted mostly to the application of radioactive isotopes for scientific, industrial, and medical uses. [redacted] (b)(3)

[redacted]

 

[redacted]

(b)(1)
(b)(3)

*Power*

Thus far, because of Poland's heavy reliance on the country's abundant coal resources, there has not been much of a program to develop nuclear power. Because of the rising cost of developing coal sources, however, nuclear energy will play a very important part in the future. Poland's plans are for nuclear to account for 13 percent of installed power by 1990. A VVER-440 reactor is expected to be operational by 1984 on Lake Zarnowiec near Gdansk. Poland now plans to construct another VVER-440 reactor at the site, with operation expected about 1985, and a VVER-1000 is to begin operation about 1987. Fast breeder reactors are expected to be introduced into the program after 1990. A summary of Poland's research and power reactors is presented in table 8. [redacted] (b)(3)

The Polish nuclear power program is controlled by the Soviet Union. The program will utilize Soviet reactors and other Soviet specialized equipment. It is doubtful that Poland could make any significant steps in the nuclear field without Soviet assistance. [redacted] (b)(3)

 

**Table 8**

**Nuclear Reactors in Poland**

| | Location | Type | Power Level | Type of Fuel | Date Criticality Achieved or Scheduled |
|---|---|---|---|---|---|
| **Research reactors** | | | | | |
| EWA | Institute of Nuclear Research (IBJ) | | 10 MWt | 10%-enriched uranium | 1958 |
| Helena | IBJ | | 0 | | |
| Anna | IBJ | | 100 Wt | | |
| Maryla | IBJ | | 10 kWt | | |
| Maria | IBJ | | 60 MWt [1] | 80%-enriched uranium | 1974 |
| UR-100 | Institute of Physics and Nuclear Technology | | 100 kWt | | 1980 |
| **Power reactors** | | | | | |
| ZARNOWIEC-1 | Gdansk | PWR | 440 MWe | 3.3%-enriched $UO_2$ | 1984 |
| ZARNOWIEC-2 | Gdansk | PWR | 440 MWe | 3.3%-enriched $UO_2$ | 1985 |
| ZARNOWIEC-3 | Gdansk | PWR | 1,000 MWe | 4.4%-enriched $UO_2$ | 1987 |

[1] Presently at 40 MWe but being upgraded to 60 MWt.

[redacted] (b)(3)

**Romanian Nuclear Program**

The Romanian nuclear program was initiated in 1955 following the conclusion of the Romanian-Soviet bilateral agreement for cooperation in the peaceful uses of nuclear energy. The State Commission on Nuclear Energy (CSNE) coordinates and directs all aspects of nuclear research, but the actual nuclear program is carried out under the auspices of the Romanian Academy of Science. [redacted] (b)(3)

[redacted] (b)(1) (b)(3)

Nuclear research is being carried out in a wide variety of areas at the IFA. One of the more important areas is laser isotope separation (LIS). [redacted]

[redacted] (b)(1) (b)(3) (b)(1)

***Power***
In the future, Romania is planning to have the capability to build nuclear power reactors. Romania has been considering nuclear power since 1965 and has solicited assistance for a nuclear power program from the United Kingdom, West Germany, France, Sweden, and Canada. Over the years Romania has maintained a strong leaning toward Western rather than Soviet nuclear technology and has continually attempted to acquire Western equipment. Romania has been reluctant to request assistance from the USSR to avoid becoming dependent upon the Soviets for enrichment services. The Romanians also have shown displeasure with Soviet reactors because of the lack of secondary containment and emergency core-cooling systems. [redacted] (b)(3)

In March 1970, however, because of Soviet pressure, it was announced that the USSR and Romania had concluded an agreement for the USSR to build a nuclear power station in Romania. The station was to be located at Pitesti on the Danube River and contain one Soviet VVER-440 reactor, to become operational about 1985. Romania's intention to purchase only one reactor, instead of the customary two or more reacto(b)(1) for a station, is an indication that Romania still is no(b)(3) happy with Soviet safety practice. Since that time, in fact, Romanian officials have indicated that the Soviet agreement was in principle only and that construction of the power station would not start until necessary safety features were incorporated. Soviet reluctance to incorporate the safety features may have led to the reported demise of the deal. [44] Romania held detailed discussions with Westinghouse and with a Finnish firm for the purchase of an ice-condensor containment system for the Soviet reactor. [45] The Romanians seemed very pleased with systems from both vendors and appeared certain to buy from at least one of them. Since the discussions, however, nothing has happened. [redacted] (b)(3)

[redacted] (b)(1) (b)(3)

It now appears that the Romanians have decided on the CANDU for their nuclear program. They have finally concluded an agreement with Canada under which at least four CANDU reactors will be supplied. It had been reported at one time that Romania was interested in as many as 16 CANDUs, but detailed negotiations in March 1978 and an agreement in December 1978 resulted in contracts for only the four reactors with an option to purchase more CANDUs at a later date. [redacted] (b)(3)

The main problem in reaching an agreement had been pricing and warranties. In previous negotiations, Romania had requested a fixed-price contract, but because Canada had lost several million dollars in a similar fixed-price contract with Argentina, Canada wanted an escalated-cost contract. The settlement reached in March was a compromise. The part of the contract pertaining to Romanian input will be conducted on a fixed-price basis, while escalation terms will cover components to be purchased from Canada. [46] A consortium of Canadian banks signed an agreement with the Romanian Bank of Foreign Trade, giving Romania a loan of $1 billion to finance the construction of the reactors. [47] The first reactor will not be operational before 1985. Cernavoda has been decided as the location for the power station. [redacted] (b)(3)

Romania envisages nuclear power supplying 20 percent (6,000 MWe) of installed electric generating capacity by the year 2000. It is very doubtful that the Romanians could reach this long-term goal, even if construction on the CANDU reactors were started in 1979. A summary of Romania's research and power reactors is presented in table 9. [redacted] (b)(3)

[redacted] (b)(1) (b)(3)

**Table 9**

**Nuclear Reactors in Romania**

| | Location | Type | Power Level | Type of Fuel | Date Criticality Achieved or Scheduled |
|---|---|---|---|---|---|
| **Research reactors** | | | | | |
| Triga | Institute for Nuclear Technology | | 14 MWt | 93%-enriched $UO_2$ | 1980 |
| | Institute for Nuclear Technology | | 0 | | |
| VVR-S | Institute of Atomic Physics | | 3.5 MWt | | 1957 |
| | Institute of Atomic Physics | | 0 | | 1962 |
| **Power reactors** | | | | | |
| Pitesti | Pitesti | PWR | 440 MWe | 3.3%-enriched $UO_2$ | 1985 |
| Cernovada | Cernovada | CANDU | 600 MWe | Natural $UO_2$ | 1986 |

[redacted] (b)(3)

nuclear energy agency in research and the development on heavy water reactor technology, but there has been no evidence of such cooperation. [53] [redacted]

[redacted]

[redacted] (b)(1) (b)(3) (b)(3) (b)(1) (b)(3)

## Yugoslav Nuclear Program

The Yugoslav nuclear program began in 1956 following the conclusion of the Soviet-Yugoslav bilateral agreement for cooperation in the peaceful uses of atomic energy on 28 January 1956. The Federal Commission for Nuclear Energy was established to direct and coordinate the Yugoslav program. Under this commission there are five institutes and a center engaged in both fundamental and applied research. [redacted] (b)(3)

[redacted] (b)(1)

[redacted]

(b)(1)
(b)(3)

***Power***

The first Yugoslav nuclear power station is under construction at Krsko on the Slóveno-Croatian border. A 632-MWe PWR is being built there by US Westinghouse and is scheduled to start operating in middle to late 1980. Originally the reactor was to start operating in 1978, but a variety of problems have pushed it several years behind schedule. [redacted] The Yugoslavs have announced plans for two more nuclear power stations. One, with a capacity of 800 to 1,000 MWe, is planned for the island of Vir. This station will begin operating about the mid-1980s. The other is planned for the Zagreb area, with operation planned for 1990. [redacted] (b)(1)

(b)(1)
(b)(3)

The Yugoslavs have encountered several problems trying to complete the Krsko plant and have shown considerable displeasure with US construction. The most difficult problem was obtaining the US reactor export license. This was the only reactor license application to come up under provisions solely for IAEA safeguards. The United States wanted to arrange a bilateral agreement, in addition to the IAEA safeguards, to give the United States more control. The Yugoslavs finally convinced the United States that no US technology or equipment would be transferred without US approval, and the license was issued on 20 May 1977. [redacted]

Other problems have resulted from changes in scope, such as upgrading the seismic design of the facility from 0.2 G [3] to 0.3 G. Also, the Save River was found to be inadequate as a cooling source for the reactor, and a number of cooling towers had to be added. These changes reportedly will cost Yugoslavia about an additional 3 percent of the original contract price. [redacted]

There have been other problems as well. On 11 September 1977 the carrier transporting the second 317-ton steam generator for the reactor tipped over. Damage to the steam generator was reported to be enormous. About the same time, the reactor vessel for the plant was left stranded near the Victor Lenac Shipyard in Rjeka because of a mechanical failure to the transporter carrying it. [redacted] There has also been a constant shortage of housing for project workers [redacted]

In an effort to install nuclear power plants more expeditiously in energy-poor areas, the Yugoslavs have inquired among several other countries (including France, Japan, and West Germany) about building their second and third nuclear power plants. [69] The Soviets have been mentioned, but it is unlikely that the Yugoslavs will turn to the USSR to build either of these power stations. The Yugoslavs are almost completely independent of Soviet influence over their nuclear power programs and would like to retain that independence. Furthermore, the Yugoslavs are concerned about the Soviet failure to incorporate Western-style safety features into their power reactors. A summary of Yugoslavia's research and power reactors is presented in table 10. [redacted]

Uranium for Yugoslav reactors probably will come from the Zirovski Vrh mine in Slovenia. The mine is projected to produce 300,000 tons of uranium ore per year, enough for about 300 tons of uranium oxide. The enrichment of the fuel will be arranged by Westinghouse. [redacted] Yugoslavia's uranium oxide reserves are estimated at about 3,000 tons. The Yugoslavs also are considering a joint venture with a US company to produce uranium, and they are considering the possibility of joint ventures in uranium exploration in Africa. [redacted]

[redacted]

(b)(3) (b)(1) (b)(3) (b)(3) (b)(3) (b)(3) (b)(3) (b)(1) (b)(3) (b)(3) (b)(1)

[3] Acceleration of gravity.

**Table 10**

**Nuclear Reactors in Yugoslavia**

| | Location | Reactor Type | Power Level | Type of Fuel | Date Criticality Achieved or Scheduled |
|---|---|---|---|---|---|
| **Research reactors** | | | | | |
| RB | Boris Kidric Institute | | 0 | Natural uranium $D_2O$ moderated | 1958 |
| RA | Boris Kidric Institute | | 10 MWt | 2%-enriched uranium $D_2O$ moderated | 1959 |
| Triga-II | Josef Stefan Institute | | 250 kWt | | 1966 |
| **Power Reactors** | | | | | |
| Krsko | Krsko | PWR | 632 MWe | | 1980 |
| Zadar | Island of Vir | | 800-1,000 MWe | | Planned |
| Zagreb | Zagreb | | 1,000 MWe | | Planned |

[redacted]

(b)(1)
(b)(3)