NUCLEAR ENERGY IN THE FORMER SOVIET UNION

The nuclear energy program built by the former Soviet Union remains a major source of electricity for the now independent states of the region:

	Total nuclear units	**Nuclear percentage of total electricity production**
The Russian Federation	29	13.1
Ukraine	15*	43.8
Lithuania	2	85.8
Armenia	1	37

*Fifteen units were operating in Ukraine until Nov. 30, 1996, when Chernobyl 1 was shut down.

The Soviet Nuclear Energy Legacy

The governments of the Russian Federation, Ukraine, Lithuania and Armenia inherited responsibility for the nuclear energy program of the former Soviet Union. When the region's nuclear energy program was consolidated under the old regime, the Soviets maintained total control over plant operations, safety, upgrades, backfitting, power distribution, planning and all other aspects of nuclear energy. Today, these functions fall under new oversight organizations, new utility organizations and inter-republic agreements.

Chernobyl Gives Rise to New Era

The 1986 accident at Chernobyl 4 propelled the Soviet program into a new era as it drove home the need for major improvements in the Soviet nuclear energy program.

Before its collapse at the end of 1991, the Soviet Union saw a flurry of international exchange activities, contracts, consortia, plant upgrades and backfits.

A Growing Wave of International Assistance

The Creation of WANO. A major initiative to improve Soviet nuclear power safety and operations was the establishment of the World Association of Nuclear Operators (WANO). Chartered in May 1989, WANO involves all electric utility organizations with nuclear power plants around the world.

WANO's objectives are to foster open communication, the exchange of operational information, and the emulation of excellence in operations. Its objectives mirror those of the U.S. Institute of Nuclear Power Operations, which has guided the improvement of U.S. plant operations since 1979.

Under WANO's programs, managers or chief engineers from every plant in the former Soviet Union have visited Western plants to observe operating approaches. To date, more than 100 formal technical exchange visits have taken place involving U.S. and Soviet-designed plants.

U.S./Soviet Working Groups. Soviet nuclear energy experts joined their U.S. counterparts from the Nuclear Regulatory Commission (NRC) in 1988 to set up subject-specific working groups to exchange personnel, technology and ideas. These groups, created under the auspices of the U.S./Soviet Joint Coordinating Committee on Civilian Nuclear Reactor Safety (JCCCNRS), addressed the repair of weakened reactor vessels, fire protection, plant backfitting, accident analysis, the health and environmental effects of radiation, the exchange of operating experience, the diagnosis of plant conditions, plant life extension and the development of symptom-based emergency operating instructions.

IAEA Missions. In 1988, the Soviet government made its first request to the International Atomic Energy Agency (IAEA) to review a Soviet nuclear power plant. Since then, more than a dozen IAEA missions have visited plants in the former Soviet Union.

U.S. Assistance Program. The U.S. government's nuclear safety assistance program, one product of the Lisbon Coordinating Conference on Assistance to the Newly Independent States of the Former Soviet Union, was launched in 1992. It is a three-part program covering operational safety improvements, risk reduction and regulatory assistance for Russian, Ukrainian and East European nuclear power plants. The Department of Energy is responsible for the first two elements of the program, and the Nuclear Regulatory Commission for the third. See **NRC Programs**, **DOE Programs** for details.

Bilateral Agreements. Soviet leaders also established bilateral nuclear cooperation agreements with a number of countries, including Finland, Sweden, Italy, Germany, the United States, Canada and France.

Early Soviet Initiatives to Reform Safety Practices

Following the 1986 Chernobyl accident, Soviet leaders initiated programs to upgrade safety measures for all operating VVER and Chernobyl-type RBMK plants.

Initial Safety Precautions. Immediately after the Chernobyl accident, the Soviets ordered new measures designed to reduce the time required to shut down RBMK reactors in response to an emergency. These measures included operating RBMK units at reduced power levels and with control rods partially inserted, and installing new fast-shutdown systems. It is not certain whether plant operators fully implemented these measures. The Soviets also announced plans to:

- increase the enrichment of the uranium fuel from 2 percent to 2.4 percent
- reduce the amount of graphite in the fuel channels
- install systems to prevent accidental changes in coolant flow rate in each core channel, accidental changes in neutron flux, and depressurization of piping and
- re-size pressure-suppression pools to handle simultaneous rupture of 10 to 14 fuel channels.

Measures apparently yet to be fully implemented include backfits of rod-type control and protection system actuators and installation of planned diagnostic systems for equipment, pipes and reactor internals.

A New Regulatory Agency. In response to Chernobyl, the Soviet government created a new regulatory agency, Gospromatomnadzor, to complement the work of its Ministry of Atomic Power and Industry.

Programs to Improve All Reactor Types

Within a year of the Chernobyl accident, a number of projects were under way to improve each of the Soviet-designed reactor types.

RBMK Reactors. Seven countries formed an international consortium to focus on improvements; a contract was signed with General Physics International Engineering & Simulation Inc. (GP International) for installation of the first Western-style training simulator for the RBMK units. Soviet leaders also requested IAEA reviews of all RBMK units.

Since the collapse of the Soviet Union, a number of projects have focused on RBMKs. The IAEA established a program to assist in evaluating and improving the safety at these plants. Under the program, the agency

convened an expert consultants' group to review the findings of IAEA missions to RBMK plants and determine any applicable generic insights. In addition, the Russian Institute for Nuclear Power Plant Operations issued a paper on the status of RBMK-1000 safety that identified tasks to be undertaken for improved operational safety.

Following the 10th anniversary of the Chernobyl accident, GRS—Germany's nuclear safety agency—published a report on the RBMK reactor family, describing its inherent characteristics, the differences between various models and the extent to which improvements have been and can be made. A four-year study by the International Electrotechnical Commission suggested several upgrades to improve generic RBMK safety: backfitting with instrumentation and control systems, installation of hydrogen monitoring systems and installation of at least three separate leak detection systems.

For a summary of other activities aimed at RBMK safety, see *Barselina Project* and *RBMK Review* in the **International Assistance** section.

VVER Reactors. Soviet leaders entered into contracts worldwide—with Germany's Siemens/KWU to supply reactor parts, with the U.S. company Singer-Link to develop training simulators, with Electricité de France to provide software, and with Finland's IVO International Ltd. to verify VVER-1000 safety. Soviet officials also launched a series of technical improvements to their VVER designs, including plans for steam generator replacement and generic safety system backfits, along with plans to extend the VVER operating lives. Work to upgrade the older VVER-440 Model V230s began involving WANO, Westinghouse and two German companies. Another seven-country consortium was formed to target these older reactors.

The IAEA launched a program in 1990 to evaluate the VVER-440 Model V230 reactors. The program's aim was to help countries operating these reactors to identify design and operational weaknesses, and to prioritize safety improvements. The program was expanded in 1992 to cover VVER-440 Model V213 reactors and VVER-1000 reactors as well as RBMKs.

Old Soviet Problems for New Governments

The Soviet Union's energy problems did not end with the country's collapse in December 1991. Many of the difficulties—electricity shortages, ethnic conflicts, public opposition to new nuclear plants—were inherited by the newly independent republics.

Power Shortages. According to Soviet forecasts in 1990, every regional power system in the U.S.S.R, except Siberia, was expected to face major electricity shortages by 1995. Reports before the Soviet collapse told of power rationing in areas such as Chelyabinsk Oblast in southern Russia. Planners foresaw problems with aging power resources, including 510 hydroelectric plants (out of 1,164) that were more than 30 years old. Approximately 60 nuclear, fossil and other plants were closed due to environmental protests, strikes and ethnic struggles. And local authorities wishing to distance themselves from Moscow began closing power and heating plants.

Electricity supply problems continued, but by the mid-1990s they were often the result of the failure of consumers to pay for the electricity they used. Many nuclear plants suffered from a shortage of money to pay their staff or to buy needed fuel and spare parts, leading to extended outages for refueling and maintenance.

Soviet Plans for More Megawatts. As far back as 1985, the Soviet government had set a goal of increasing nuclear energy production to 20 percent of all electricity generated. In September 1991, Soviet authorities announced plans for additional nuclear capacity—as much as 7,000 megawatts by 1995, and another 12,600 megawatts by 2000. After the collapse of the Soviet Union, Russian Prime Minister Viktor Chernomyrdin announced a 20-year nuclear plant construction plan for Russia Dec. 28, 1992. The objective was to add approximately 16,500 megawatts of nuclear capacity by 2015, of which 2,000 megawatts were for heating only. But in November 1993, Russia's Supreme Soviet—the parliamentary upper house—canceled the 20-year plan announced in late 1992.

In May 1994, the Ministry of Atomic Energy issued a draft strategy for nuclear energy through the year 2010 that sought to carry out the original 1992 plan. But in December 1995, officials at the Ministry of Atomic Energy reportedly said that financial difficulties and licensing requirements under the country's new nuclear energy law would lead to a scaling back of the original plan (for details, see the **Russian Federation** section.)

The Chernobyl Dilemma. In Chernobyl's wake, Soviet authorities moved to cancel new nuclear plants under construction and on the drawing board—both VVERs and RBMKs. In all, about 100,000 megawatts in planned capacity were lost.

In 1990, the Ukrainian Parliament approved a moratorium on nuclear plant construction until 1995 and voted to shut down all of Chernobyl's nuclear units by 1995. After a 1991 fire on the non-nuclear side of Unit 2, the Parliament accelerated Chernobyl's shutdown date to 1993.

In 1992, however, Ukrainian government officials began questioning whether closing Chernobyl on schedule would be possible, given the shortage of alternative power sources. A government commission held hearings in May 1993 on the issue of lifting the moratorium on plant construction, which would permit the completion of some partly built VVER-1000 units that could replace Chernobyl's production, and of extending operation at Chernobyl. In October 1993, the Ukrainian Parliament voted to continue operating the Chernobyl plant and to lift the moratorium on new plant construction.

The Transition from Soviet Oversight to Republic Control

In most cases, the independent countries of the former Soviet Union have set up their own nuclear agencies since the country's breakup. The Russian Federation, however, assumed the programs, personnel and assets of former Soviet agencies.

In Ukraine, remnants of Soviet administrative functions remained, but new organizations lack the personnel and assets of the former Soviet agencies.

In Lithuania and Armenia, new government agencies were formed to oversee nuclear energy issues.

Minatom—Russia's Ministry. In the former Soviet Union, siting, constructing and operating nuclear power plants were the responsibility of the centralized Ministry of Atomic Power and Industry (MAPI) in Moscow. In January 1992, the Russian Federation created the Russian Federation Ministry of Atomic Energy—Minatom—which absorbed all MAPI functions, staff and assets located in Russia. Minatom oversees nuclear safety, research and design, the modernization of the industry, and the conversion of military facilities to civilian purposes.

Retaining Key Research Institutes. The premier research institute of the old Soviet Union, the I.V. Kurchatov Institute of Atomic Energy, became the Russian Research Center at Kurchatov in December 1991. The old Soviet Academy of Sciences became the Russian Academy of Sciences, and the All-Union Scientific Research Institute of Nuclear Plant Operations remained operational in Russia. This institute—now called the Russian Institute for Nuclear Power Operations—is responsible for improving plant operations as well as providing basic supportive research.

GPAN Splits Into Two Organizations. Since the Chernobyl accident, the Soviet agency GPAN had been gaining strength in directing the upgrades in plant operations that followed the accident. This agency ceased operations and was replaced by two new nuclear regulatory organizations, one in Russia (GAN) and the other in Ukraine (GANU). In December 1994, GANU was abolished, and its functions were assumed by the newly created Ministry for Environmental Protection and Nuclear Safety.

Agreement Among CIS Countries. In June 1992, the countries of the Commonwealth of Independent States signed an accord in Minsk addressing how these countries would cooperate regarding commercial nuclear power. Countries involved include Russia, Ukraine, Belarus, Kazakhstan and Moldova. Among initial issues addressed: 1) the adoption of IAEA standards and 2) the exchange of information and payment for damages in the event of an accident.

In May 1996, delegates and experts from six CIS countries drew up a plan for cooperation in the peaceful use of nuclear energy. The plan covered nuclear energy development, spent fuel and nuclear waste management, the fuel cycle and safety assurance. In February 1997, prime ministers from 11 members of the CIS agreed to the plan, aimed at developing cooperation in the nuclear energy field and improving reactor safety.

Nuclear Plans, Small-Scale Programs

Belarus Considers Nuclear Energy. Belarus must import most of its energy—fuel supplies and electricity. Three nuclear power plants—Ignalina in Lithuania, Smolensk in Russia and Chernobyl in Ukraine—supply about half of the country's electricity. However, rising costs and disruptions in natural gas supplies prompted the Belarus government to consider building its own nuclear plant. In 1992, the country's national power program called for the construction of 1,000 megawatts of nuclear capacity to come on line between 2005 and 2010.

Although Ministry of Energy officials discussed reactor supply with Atomic Energy of Canada Ltd. and Electricité de France, government leaders reportedly favor Russia's VVER technology. Ministry officials continued talks with Western companies, however, including Westinghouse Electric, Siemens, Asea Brown Boveri and General Atomics. As of October 1994, no decision had been made on what type of reactor to pursue. A month later, however, Belarus' minister of energy said in an interview that the country had no alternative—at present—to nuclear energy.

In February 1996, members of the country's nuclear community formed the Belarus Nuclear Society. A month later, Energy Minister Valentin Gerasimov and other senior officials told a news conference that Belarus planned to build a nuclear power plant as part of the country's strategy to develop new energy sources. The head of the Belarusian energy institute said that of 15 possible sites for a nuclear plant, six had been selected as most suitable. Gerasimov said that the energy plan—which runs to the year 2010—calls for energy conservation, the use of home-produced energy sources and the use of a broader range of Russian oil companies. He said Belarus imported 85 percent of the fuel it used from Russia, and 25 percent of its electricity from Russia and Lithuania.

In May, the government ordered three ministries and the Academy of Sciences to explore the development of nuclear energy as part of the country's energy policy.

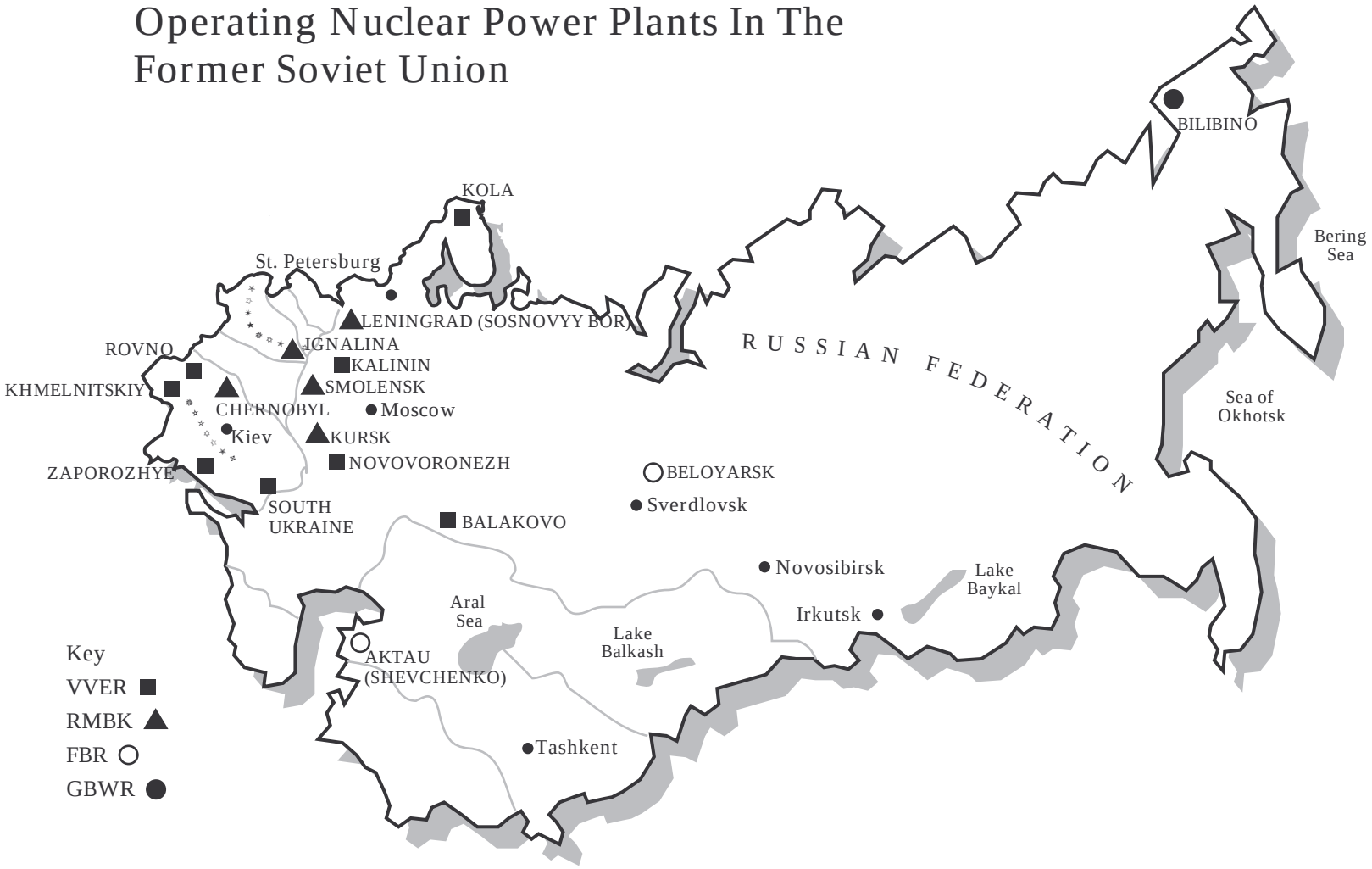
In December, Energy Minister Gerasimov said that construction of the country's first nuclear plant would begin at the end of the decade, with the plant expected to come on line by 2005. He put the cost of the 2,000-megawatt plant at $3.5-4 billion. The minister added that experts had identified three possible sites, all in the eastern part of the country.

In March 1997, the Belarus Nuclear Society reported that parliament planned to conduct a series of hearings on nuclear energy, beginning in May.

Kazakhstan's Fast Breeder Reactor. Kazakhstan has one reactor, the BN-350, a fast breeder. The 135-megawatt reactor, located at Aktau (formerly Shevchenko), is used both to generate electricity and for desalinization. It began operating in 1973.

In June 1994, however, the reactor was shut down because there was no money to buy fuel. As in other countries of the former Soviet Union, many of the BN-350's customers were not paying for the electricity they used. In

Operating Nuclear Power Plants In The Former Soviet Union



addition, a plant official reportedly said there was no money to pay wages, and one-quarter of the plant's employees had left in the past four months.

The plant was shut down for a major refurbishment program in April 1995, and came back on line in January 1996. It now participates in the International Atomic Energy Agency's International Nuclear Event Scale Information System, and is expected to join the World Association of Nuclear Operators.

Russia's Ministry of Atomic Energy has proposed a joint project to the Kazakh Atomic Energy Agency for extending operation of the BN-350 by up to 10 years, decommissioning it and providing replacement power. The ministry has told the Kazakh agency that Russia has completed design work on the BNM-170, a new module breeder reactor.

Nuclear Plans. According to another report, the Kazakh State Corporation for Atomic Energy plans to build a second 135-megawatt fast breeder reactor to replace the BN-350. It has also announced plans to build one 1,000-megawatt reactor or two medium-sized reactors near Semipalatinsk, and the corporation's long-term plans call for the construction of at least 8,000 megawatts of nuclear capacity at four sites.

The Kazakh government adopted a resolution in October 1995 on developing nuclear energy in the country. The resolution called for, among other steps, the formulation of a law on nuclear energy, the development of a nuclear energy strategy to the year 2030, and the preparation by three government ministries of an economic and technical analysis of potential nuclear power plant sites. Separately, the government reportedly adopted a proposal to build a latest-generation nuclear plant at Semipalatinsk, the former nuclear test site for the Soviet Union.

In April 1996, government authorities said they would organize an international tender for the design and construction of a nuclear power plant—either one 1,000 megawatt unit or two smaller units. According to another report, Kazakhstan was reportedly considering the construction of smaller units—500-600 megawatts—to best meet local grid conditions.

In August, Russia cut off electricity supplies to northern Kazakhstan, saying that it was owed more than $420 million for electricity already used. Russia continued to supply electricity to western Kazakhstan, where customers have been paying their bills regularly.

In September, Kazakh and Indian officials agreed to hold joint consultations and exchange specialists for the development of nuclear energy for peaceful purposes. In December, Kazakhstan and India agreed to cooperate in nuclear energy research and reactor designs.

In January 1997, two Kazakh officials said that the country plans to build several nuclear power plants with a total capacity of 4,000-6,000 megawatts over the next four to six years.