AN OVERVIEW

International Assistance to Upgrade the Safety of Soviet-designed Nuclear Power Plants

SELECTED ACTIVITIES IN EASTERN AND CENTRAL EUROPE AND THE COUNTRIES OF THE FORMER SOVIET UNION

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Introduction

The changing political and economic landscape in Eastern Europe and the countries of the former Soviet Union has heightened existing concerns about the safety of nuclear power plants designed and constructed more than two decades ago in a closed society. National and international efforts have been aimed at providing technical and financial assistance for safety programmes and great progress has been made. However, experts agree that the problems associated with the nuclear power plants operating in these countries run deep, and cannot be fixed easily, quickly, or cheaply.

The largest barrier to solving these problems and addressing the concerns of the world community is economically based. The political and economic changes in Europe and the former Soviet Union have brought increasing demand and dependence on energy, particularly electricity. Were it not for the significant dependence of these countries on nuclear power, many existing plants may have been taken out of operation. However, nuclear power is not something that can be easily turned off in these newly developing economies. Here, energy and electricity can make the difference between success and failure of the newly independent states.

Another real concern is that the universe of safety concerns keeps growing. It keeps growing not just in terms of how the plants were designed, built and operated for the past 20 years in a centralized, highly secretive environment, but also in terms of how complete the information about them may be. It has become evident that not only do these plants suffer deficiencies in design and operation, they also, perhaps more importantly, suffer deficiencies in the quality of manufacture and construction. Also apparent to some extent is a hardening of resistance among some plant owners and governments to recommendations about decommissioning — or closing down — those plants that pose the greatest safety risk. Some governments have decided to shut down operating units, but in view of extraordinary energy shortages, the remainder will likely continue to be operated for some years. Upgrades are currently underway and plans exist for major reconstructions; but, further assistance will be required.

The International Atomic Energy Agency (IAEA) has for two decades provided safety assistance to Eastern and Central European and former Soviet Union countries. Such assistance has included technical advice on siting, design and operational matters, along with training and assistance in the use of advanced computer codes. Historically, such assistance has been provided at the request of individual governments. Following the Chernobyl accident in 1986, the Agency's safety assistance to these countries intensified, and today, following the political and economic changes in the region, it has intensified even more.

The heightened assistance has produced numerous on-site plant visits that countries in the region began to request in the late 1980s. As the result of an on-site safety review team visit to Kozloduy in June 1991, for example, the Agency informed the Bulgarian Government that it was imprudent to operate their model 230 reactors under the observed conditions. Findings from that mission triggered global interest in improving nuclear site safety in Eastern Europe, in general, and spurred a momentum that continues today.

The Agency currently operates several programmes focused on each of the various types of "Soviet-designed" reactors—WWERs and RBMKs. The Agency also provides significant assistance to regulatory bodies and international efforts. One task given to the IAEA by its General Conference two years ago was to continue efforts to assess the safety of particular WWER plants. It was also tasked to develop a common basis on which the acceptable level of safety of all operating nuclear power plants built to earlier standards can be judged.

Today, there are 57 nuclear power reactors in operation in Eastern Europe and the countries of the former Soviet Union. Of Soviet origin, they were predominantly designed in the 1960s and 1970s. Many plants group several reactors at a single site.

Collectively, these operating nuclear plants make up a substantial portion of electricity production in the region: nearly 60% in Lithuania, 51% in Hungary, 36% in Bulgaria, 29% in the Czech and Slovak Republics, 25% in the Ukraine, 12% in Russia, and 10% in Kazakhstan. Another two reactors in Armenia could account for 25% of that country's total electricity supply if a pending decision were made to restart them to overcome critical shortages, although they are located near Yerevan in an active seismic zone which was the reason for their being shut down in 1989.

Projects from around the world and from a wide number of sources, far more than can be chronicled in a single publication, are being scheduled or currently underway to enhance the safety of these reactors. Extensive investments of time and money from various international, as well as national, sources have resulted in significant progress in upgrading the safety of many of these reactors, particularly the oldest ones. However, there is still a need for additional involvement and assistance to ensure the future safety of these nuclear power plants.

The following is merely a snapshot of nuclear safety activities to assist the countries of Eastern and Central Europe and the former Soviet Union. While many other activities are planned or ongoing, this publication is meant to provide a general overview of the world community's commitment to improving the safety of Soviet-designed nuclear reactors.

IAEA Safety-Related Services

OSART (Operational Safety Review Team) enhances the operational safety of nuclear power plants worldwide through reviews and exchanges of technical experience. OSART missions are conducted at nuclear power plants and are intended to identify strengths that should be emulated by other power plants and weaknesses that should be corrected. Recommendations for improvement are then given. A technical document on good practices has been published and a regular programme of follow-up visits continues.

ASSET (Assessment of Safety Significant Events Team) carries out missions in various countries that operate nuclear power plants. It reviews operational safety experience from the standpoint of events that have occurred. This includes investigating and identifying the immediate, as well as the root, causes of incidents or accidents, generic safety lessons learned and the appropriateness of corrective actions. An underlying premise is that sound plant design, although widely recognized as a prerequisite for safe operation, is not sufficient; an active management is also a key factor for safe operation.

IRS (Incident Reporting System) is based on the principle that each participating Member State provides information whenever its national analysis of an event in a nuclear power plant identifies a lesson to be learned that might prevent a recurrence elsewhere. The system now has data on more than 1200 events that have occurred at nuclear power plants around the world.

The Reactor Types

The nuclear plants are of four basic designs, generally known by their Russian acronyms and model numbers: the WWER-440/230, the WWER-440/213, the WWER-1000, and the RBMK. The WWER is a pressurized-water reactor with the acronym standing for water-cooled, water-moderated energy reactor. The RBMK is a light-water cooled, graphite-moderated, channel-type reactor that is often called the "Chernobyl-type reactor" that is unique to the former Soviet Union.

Of these plant types, two designs are regarded as creating the most safety concern — the WWER-440/230 and the RBMK. The RBMK, experts agree, represents the most serious potential safety problem as the design lacks a containment structure to prevent a radioactive release in the event of an accident. Many experts believe that the RBMK has other design and construction flaws and recent events such as the incident at Sosnovy Bor (Leningrad-3) in early 1992 have punctuated these flaws.

WWER-440/230—The First Generation

The first generation of WWERs—the 440/230 model—were developed in the 1960s. All ten of the WWER-440/230 plants are located in Bulgaria, the Slovak Republic, and Russia. Six others have been shutdown—two in Armenia for seismic reasons and four at Greifswald by West German safety authorities shortly after German reunification in 1990.

The design has many problems including:

- no containment;
- limited emergency core cooling capability;
- almost no redundancy and separation of safety equipment;
- deficient instrumentation and control systems; and
- serious deficiencies in fire protection.

In response to a growing number of requests from Member States operating these models, a comprehensive international project was initiated by the IAEA in late 1990. During 1991, the Agency conducted a safety assessment of the ten operating WWER-440/230 plants and identified 100 safety issues related to plant design and operation. Some 60 percent of these issues were judged to be of high safety concern requiring immediate attention.

Work under the programme was supervised by a steering committee in which countries with operating units and those providing assistance through extrabudgetary contributions were represented.

Observers from the CEC, OECD/NEA, the World Association of Nuclear Operators (WANO) and the World Bank participated. In addition to the safety review missions to all 10 plants, work included a broad review of the design concept by a panel of international experts and the identification of generic safety issues.

The second phase of the Agency programme, currently in progress, focuses on assisting individual countries to plan and evaluate modifications and to verify that proposed modifications respond to concerns identified during the first phase. The Agency consolidated the recommendations made by regulatory authorities and plant operators on safety issues identified through the programme and information on the status of implementation of backfitting programmes in Bulgaria, the Slovak Republic, and Russia.

Follow-up missions to assess the status of the implementation of recommendations are being conducted and have included ASSET missions and seismic safety missions. Agency staff visited Kozloduy to observe the functioning of safety review mechanisms established by the Bulgarian regulatory authority for the commissioning of Kozloduy unit 2, and a formal follow-up safety review mission to Kozloduy took place in April 1993. The results of the missions indicate significant improvements and appropriate response to recommendations.

Status reports on generic safety issues are continuing to provide an overview of options available to resolve safety concerns. In this context, a methodological study on fire hazards is being completed and a report on the technical basis to improve the confinement function is under review. The Agency also has completed technical work on guidelines to apply the "leak-before-break" concept, and a status report on its applicability was produced. A technical document also was prepared on measures being taken at various nuclear power plants to assess the safety of reactor pressure vessels with regard to embrittlement.

According to the G-24 Database on Nuclear Safety Activities, a total of 55 registered projects are exclusively devoted to the WWER-440/230 model reactor, with donor contributions totaling 68 million ECU.

Additionally, a series of workshops and expert missions sponsored by several donor countries are being conducted on topics such as safety inspections during nuclear power plant (NPP) operation, risk-based prioritization of operational tasks, probabilistic safety assessment (PSA), emergency planning, maintenance optimization, and accident management.

WWER-440/213—The Second Generation

The second generation of WWERs—the WWER-440/213 models—were designed between 1970 and 1980 and improved upon the first generation models. The development of the second generation coincided with the first uniform safety requirements drawn up by Soviet designers. There are some 14 second generation WWERs in operation today in the Russian Federation, two in the Ukraine, four in Hungary, two in the Czech Republic, four in the Slovak Republic, and two in Finland (that have been modernized with Western technology and equipment). Construction of four units was stopped at Greifswald in the former East Germany.

The design deficiencies of the 230s were addressed in the second generation 213s: the containment was upgraded and improved and emergency core-cooling systems were enhanced. However, plant instrumentation and controls still do not meet international standards.

The most improved reactors of this type are operating outside of Eastern Europe, in Finland. The Finnish plants have improved containment and include substantial Western technology and equipment, particularly in areas of instrumentation and control, and the emergency core cooling system.

The IAEA is providing assistance in the area of design basis and beyond design basis accidents through a regional technical co-operation programme. The work is carried out by task groups in Bulgaria, the Czech Republic, the Slovak Republic, Hungary, Poland, and the Ukraine. The programme aims at providing training and facilitating the exchange of information among experts. The programme includes:

- broad-scope accident analyses, including analyses of containment response to beyond design basis accidents;
- evaluation and extension of emergency operating procedures; and
- development of accident management plans.

The project's objective is to develop and apply a common safety assessment methodology, which covers both beyond-design-basis and severe accidents. Regional working groups have been organized, and the Agency has provided advanced safety methodology (including computer hardware and software) and training of specialists at Agency Headquarters and at research centres in Western Europe.

Additionally, computer software is being developed for use with advanced personal computers in performing accident analyses (including analyses of accidents involving core damage and vessel and containment failure). These will be tested at Bohunice.

Considering the need for a broader international evaluation of WWER-440/213 safety, the IAEA began a broader programme in 1993 similar to the WWER-1000 programme. Specifically, the programme aims to identify main safety issues and priority actions. Resolution of topical safety issues, plant specific safety reviews including OSARTs and ASSETs, and training also are included in the programme.

A compilation of backfitting measures implemented at all WWER-440/213 plants has been prepared based on information obtained from the owners group. The document specifies safety improvements, proposed and/or implemented, their technical basis, and the organization requesting the action (e.g. vendor, utility, regulatory authority). It will be the basis for a major design review evaluation that the IAEA will conduct in 1994.

A topical meeting is scheduled for November 1993 to review performance of the bubble tower condenser system as a confinement engineered safeguard system. Topical meetings on instrumentation and control and accident analysis methodology are scheduled for 1994. A consolidated list of safety issues and priorities is to be prepared by the second half of 1994.

G-24 assistance efforts for the WWER-440/213 model reactor include some 41 projects with 18 million ECU in donor contributions.

WWER-1000 plants—The Third Generation

The largest of the WWERs is the 1000 model, 19 units operate in Russia, the Ukraine, and Bulgaria. They were developed between 1975 and 1985 based on the requirements of a new Soviet nuclear standard which incorporated some international practices, particularly in the area of plant safety.

The WWER-1000 model has been viewed as one that could replace the old WWERs and RBMKs as many of the design deficiencies have been addressed in this newer model. Overall, the safety concept of this model is similar to that of the pressurized-water reactor in Western-designed plants and it contains a containment structure. Among the major improvements in this generation, WWER-1000s are equipped with steel-lined and pre-stressed concrete containment structures that conform with Western counterparts. Steel design has improved safety standards over the previous generations.

The IAEA convened a consultants' meeting in 1992 to collect and review the available information and to prepare the technical basis for the formulation of a programme dedicated to WWER-1000 plants. The meeting identified important safety issues including core power stability, instrumentation and control, and the integrity of steam generators. In addition to identifying high-priority areas, the consultants suggested various ways to take full advantage of the expertise of the organizations which designed the plants as well as plant operators and institutions in various West European and other countries.

Following the meeting, and in response to requests from Bulgaria, the Czech Republic, and the Ukraine, a WWER-1000 Safety Programme was established within the framework of the Agency's extrabudgetary activities. The overall objective is to identify design and operational problems that can threaten plant safety and to help countries with operating WWER-1000 plants to establish programmes to resolve such issues.

The programme includes a review of studies being conducted under national and other international programmes, safety review missions to selected plant sites to examine design and operational features of the plants, meetings on safety issues, and the provision of assistance with safety reviews (particularly accident analysis) and training. The programme's reference plant is the Zaporozhye NPP in Ukraine.

A meeting on steam generator integrity was held in mid-1993. A safety review mission to Zaporozhye is planned for later in 1994 and a seismic benchmark study has been initiated for this type of nuclear power plant as well.

A major Russian reconstruction programme for WWER-1000 plants has been submitted for review by the Agency. Insights from this programme are likely to have a major impact on the Agency's WWER-1000 programme. A major meeting to discuss the programme is scheduled for December 1993.

Additionally, the Agency has begun a peer review of the probabilistic safety assessment (PSA) underway for Kozloduy unit 5. The Agency also has been requested by the government of the Czech Republic to assist with the safety review underway at Temelin, particularly with regard to nuclear fuel, instrumentation and control, and the applicability of leak-before-break.

Assistance efforts from the G-24 specifically for the WWER-1000 model reactors are in the form of 40 projects with 42 million ECU in donor contributions, concentrating on management, operating experience feedback, training, fire protection and accident monitoring instrumentation.

RBMKs — The "Chernobyl-type Reactor"

The three generations of Chernobyl-type graphite moderated reactors — or RBMKs — were designed primarily in the 1960s. There are 15 reactors in operation in the countries of the former Soviet Union with four under construction. Two 1500 MW units, the world's largest nuclear power plants, are operated in Lithuania, eleven 1000 MW units are in Russia, and two are at Chernobyl in the Ukraine.

Experts generally agree that these reactors, together with the WWER-440/230s, are the ones requiring the most urgent attention. These RBMKs have no Western-style containment structure and their safety has been a matter of continuous international concern since the Chernobyl accident. Other concerns are focused on areas such as fire protection. While some modifications in design and operation have been made, there is a strong conviction among many international experts that all of these units are still not safe.

The Agency convened an international technical committee meeting in Spring 1992 which resulted in recommendations to urgently establish an international programme directed at the implementation of timely and practical improvements at RBMK plants. The first priority task was determined to be a comprehensive safety review. In parallel, vital safety systems (such as core monitoring and power control systems) were to be evaluated for rapid implementation of improvements.

In response to agreed international urgency to address the problems at these plants, the IAEA launched a new International Programme on Safety Assessment of RBMK Reactors. The objective of the programme is to establish an international consensus on required safety improvements. Implementation is proceeding with a safety review of proposed modifications, specialist meetings on specific topics and missions to assess plant-specific design features, operational practices, safety-significant events, and seismic safety. The results of the programme should also provide a technical basis for decisions on measures to improve safety and on financial matters relating to the implementation of such measures. The RBMK plants at Smolensk and Ignalina are serving as reference plants for the programme.

A consultants group met in the Fall of 1992 to review the results of safety evaluations that already had been performed and the technical basis for safety improvements implemented and planned for RBMK plants. The evaluations were on core monitoring and control; pressure boundary integrity; accident mitigation (including mitigation through safety systems and confinement); and electric power supply (including the supply of emergency power).

Safety modifications proposed for the three generations of RBMK plants in those areas have been analyzed, and significant differences between the 15 operational RBMK units — even between units belonging to the same generation — have been noted. In general, it is considered that modifications already implemented or being proposed will lead to an increase in the safety level of RBMK plants. The Agency has issued a technical document on the subject, IAEA-TECDOC-694.

ASSET (or Assessment of Safety Significance Event Team) missions have been carried out at Chernobyl, Kursk, Ignalina, Leningrad and Smolensk.

Following a review carried out by the Agency in 1992, a progress review meeting was held at Smolensk in mid-1993. It was by far the most detailed on-site examination of an RBMK reactor

The International Nuclear Event Scale (INES)

INES is an important communications tool used by the Agency and its Member States to categorize radiological events and create a common understanding of nuclear events. It is widely used within the nuclear community and among the 48 Member States participating in the system to describe the magnitude of an incident. It is also used to inform the media and the public promptly and consistently of the safety significance and implication of events reported at nuclear installations.

The scale ranges from level zero, for an incident having no safety significance, to level seven for a major accident with widespread health and environmental consequences. On INES, for example, Chernobyl, which had extensive off-site effects, would have rated at the top of the scale, as a level seven.

INES was designed by the IAEA and the Nuclear Energy Agency of the Organization for Economic Co-operation and Development (NEA/OECD). An example of its effectiveness is its international use during the nuclear accident at the Sosnovy Bor (Leningrad 1) nuclear power plant in the Russian Federation in Spring 1992. Partly because the incident occurred at a Chernobyl-type reactor, media interest was high. The Agency received many inquiries from the media, its Member States, and the public when news reports of the event started coming in. The Russian authorities used the scale in their prompt reporting of the incident to the Agency and INES became a commonly understood point of reference.

to date. The 1000 MWe unit 3 at Smolensk is the latest RBMK placed in operation and contains significant improvements over earlier generation plants. The safety upgrades are based on the lessons learned from the Chernobyl accident and the numerous national, as well as international studies, undertaken in recent years.

The focus was plant-specific safety issues at Smolensk unit 3 including, in addition to issues covered in 1992, fire protection, support and safety systems, instrumentation and control, seismic safety and operational safety. The experts were given access to extensive documentation which helped in the preparation of an extensive report which includes design information, engineering drawings and the results of lengthy walkdowns through the various plant buildings. It also includes the reviewers' findings and recommendations.

The meeting participants found that Smolensk unit 3 already incorporated a number of the improvements identified as being necessary on the basis of analyses of the Chernobyl accident and other safety studies. In a comprehensive report prepared based on the meeting, additional safety concerns are identified along with a number of recommendations which are published as an IAEA technical document (TECDOC-722).

Safety assistance efforts

It is clear that the world community faces significant obstacles in attempts to upgrade the safety of these plants. With the pressures of newly formed free market economies, the countries of the former Soviet Union and Eastern Europe are already looking to Western countries for economic help. That assistance must include guidance on meeting energy demands. Finding a safe, viable approach to meeting those demands is the basis for international, as well as national, assistance programmes in this regard.

In July 1992, the leaders of the seven major industrialized nations (G-7) collaborated at an economic summit and decided to provide financial support and technical assistance to upgrade the safety of nuclear power plants in Eastern Europe and the countries of the former Soviet Union.

The G-7 action programme focuses generally on the following items: operational safety improvement; near-term technical improvements to plants based on safety assessments; enhancing regulatory regimes; examination of the scope for replacing less safe plants by the development of alternative energy sources and the more efficient use of energy; and examination of the potential for upgrading plants of more recent design. Significant bilateral and multilateral assistance activities also have been initiated by Western countries.

The Commission of the European Communities (CEC) is playing an active role, and assistance is being coordinated by a Group of 24 countries. The World Bank and its regional arm, the International Bank for Reconstruction and Development, and the European Bank for Research and Development (EBRD) have offered assistance. Expert teams from the IAEA and the World Association of Nuclear Operators have visited the plants.

All of these efforts have generated safety assessments and recommended steps. They range from governmental reorganization and the enhancement of a "safety culture," to regulatory reform and technical projects to fix plant hardware and correct operational problems.

Many bilateral efforts have also been started, particularly by countries bordering the troubled plant sites. Safety authorities in Finland and Sweden, for example, are working directly with local counterparts to improve plant safety at RBMKs in St. Petersburg and Lithuania.

Multilateral Initiatives

The Group of 24 (the member states of the OECD, plus Turkey), the OECD's Nuclear Energy Agency (NEA), the Commission of the European Communities (CEC) and the IAEA met in 1991 and set up a Working Group on Nuclear Safety giving the CEC the charge to set up meetings and collect information, and to serve as the Secretariat. Two technical working groups came out of the Group of 7 meeting in 1992. One to coordinate training assistance to improve operational safety and the other to focus on coordinating aid to the Kozloduy plant in Bulgaria.

In January 1993, the G-7 endorsed the idea to create a multilateral fund to generate immediate assistance for short-term improvements at older RBMKs and WWER-440 model 230s. A total of $70 million (60 million ECU) the amount needed to legally establish the fund, was promised by Germany, France, the United Kingdom, and the EC to supplement bilateral efforts. Japan and the United States have pledged contributions. The fund's activities will include help to improve operational safety through the development of accident procedures and the organization of operations hierarchy and to enhance safety-related hardware such as safety systems monitoring equipment, leak detection devices, fire detection, and emergency diesels.

The fund will be administered by the European Bank for Reconstruction and Development (EBRD). In support of efforts, the G-24 Nuclear Safety Assistance Coordination Centre maintains a database which now holds information on nearly 300 nuclear safety projects totaling more than $ 3.5 million (3 million ECU) and a combined total of over 400 projects with over 380 million ECU in pledged donor contributions. The G-24 Database is due to begin providing on-line access to all participants early in 1994.

The World Association of Nuclear Operators

The World Association of Nuclear Operators (WANO) is an international organization created to further enhance the safety and performance of nuclear power plants worldwide. WANO's programme of international exchange visits between nuclear professionals has resulted in teams from nuclear power plants in Eastern Europe and the former Soviet Union having visited Western nuclear plants to initiate reciprocal operator-to-operator information visits.

WANO, along with the OECD's NEA, the CEC and the IAEA, is involved in assistance projects, including one initiated by the Moscow and Paris WANO centres to recommend improvements to WWER-440/230 model units in Eastern Europe and the former Soviet Union.

WANO is a non-governmental organization that organizes training programmes, assists in making policies to cope with ageing nuclear power plants, and helps operators in affected countries in areas including promotion of bilateral and multilateral assistance to help modernize, upgrade or repair equipment.

The Commission of European Communities (CEC)

The CEC has made available funds to upgrade nuclear power reactors within the framework of its programmes of assistance to Eastern Europe. In line with the economic declaration of the G-7 summit in Munich, a co-ordination mechanism has been established in the CEC by the G-24 industrialized countries since 1991. The European Community has set aside US $518 million over 1991-1993 for nuclear safety in Eastern Europe and the former Soviet Union and works through other international assistance organizations. Additionally, the European Parliament is due to approve a loan worth US $ 1.32 billion to help modernize older nuclear plants.

For 1993, the PHARE and TACIS programmes in the field of Nuclear Safety amount to 100-125 million ECU (US $110-135 million) mainly divided between on site assistance and assistance to the regulatory authorities.

The PHARE programme

The European Community provides technical assistance, training, and feasibility studies through the PHARE programme. It also conducts activities to improve the regulatory framework, build the institutional framework and launch small pilot projects for Bulgaria, the Czech and Slovak Republics, the former Yugoslavia, Poland, Hungary and Romania.

Under the programme, the EC allocated 20 million ECU for 1990-91, and 28.3 million ECU for the 1992 PHARE programme.

PHARE's objective is to improve operational safety and operator training in the nuclear energy area. In Bulgaria, a crash project was launched in 1991 involving a "twinning" programme in which the staffs of the Kozloduy plant and Western European nuclear plants exchanged experience. Activities in the Czech and Slovak Republics have included a probabilistic safety assessment (PSA) for the Bohunice nuclear power plant and instruction and control studies for the WWER-440/230 and the WWER-1000 models. Other activities included a "housekeeping" programme for Kozloduy and a special WANO-organized, six-month safety analysis. In Hungary, a project is underway to transfer Western know-how on regulatory methods and practices to the Hungarian Atomic Energy Commission.

TACIS programme

Under a separate technical assistance programme, the EC allocated 54 million ECU (US $63 million) for nuclear safety measures to the former Soviet Union in 1991. This assistance was meant to cover operational safety measures, particularly for the WWER-440/230 model, training and management centres, and support of safety authorities. With the breakup of the Soviet Union, however, funding had been delayed while allocations for independent republics were determined. Some 22 projects involving safety systems upgrade work, waste management, emergency procedures, measurement technology and training at WWER plants in Russia and the Ukraine are being evaluated by the EC.

Under 1992 TACIS funds, the EC earmarked 60 million ECU (US $70 million) for upgrades at four Russian plants — Kola (WWER), Kalinin (WWER), Beloyarsk (fast breeder) and Smolensk (RBMK) plants. The total budget for safety of nuclear installations was 80 million ECU (US $90 million).

World Bank - International Bank for Reconstruction and Development

The IBRD supports programmes to increase efficiency and safety of all types of electricity producing systems (including fossil, hydro and nuclear) and reducing their environmental impact. The Bank has sponsored a study on safety backfitting in Kozloduy units 1-4 in Bulgaria to demonstrate the risk impact of modifications to the plant. It also has extended a loan to the Czech Republic to be used partially for the Temelin plant which is under construction.

The European Bank for Reconstruction and Development (EBRD)

The EBRD assists by financing nuclear projects, with priority to improve the safety of existing power plants when these can be brought into operation in line with internationally accepted safety standards.

The European Investment Bank (EIB)

The EIB is currently considering the adoption of policies that would allow funding of nuclear safety projects in Eastern Europe and would require consistent expert technical input on safety matters. The financing of longer term safety projects for WWER-440/213 and WWER-1000 model reactors is being considered by the EIB. Comprehensive safety evaluations, environmental impact studies and public acceptance of proposed safety enhancement measures would be necessary as the basis for a long term loan.

The OECD Nuclear Energy Agency

The Nuclear Energy Agency (NEA) of the OECD conducts a programme to assist Central and Eastern European countries and the newly Independent States of the former Soviet Union in the field of nuclear safety and regulation. Priority areas include: long-term isolation and decommissioning of Chernobyl; strengthening of safety authorities; transfer of safety knowledge and experience; enhancement of safety research; and safety of WWER-1000 reactors.

Bilateral assistance

The following is a sampling of bilateral assistance.

Canada

Canada pledged US $24 million in 1992 to provide assistance under its nuclear safety initiative, although the allocation of the assistance between the multilateral fund and bilateral assistance has not yet been determined.

France

Russia's Ministry of Atomic Energy and France's utility Electricité de France, signed an agreement in 1992 pledging closer co-operation among their nuclear power plant operators. The agreement also called for the creation of a joint venture in engineering for nuclear power plant operations. Bilateral French assistance currently amounts to US $9.7 - 10.6 million.

Germany

For 1993, the German government has earmarked $12.6 million for bilateral assistance to the former Soviet Union. In a joint arrangement with France, Germany will spend some US $1.2 million to provide Russian nuclear regulators with a data communications network and other equipment, and about US $ .5 million to provide the same to Ukrainian regulators.

Japan

Japan's Ministry of International Trade and Industry (MITI) and Science and Technology Agency (STA) have launched programmes of short- and long-term technical assistance and a major training effort. The co-operation programme with Russia on the leak detection system has started to examine its applicability to RBMKs as part of the short-term technical assistance.

With the sponsorship of STA of the Japanese Government, the Japan Atomic Energy Research Institute (JAERI) held the International Seminar on Nuclear Safety to provide participants from countries of Central and Eastern Europe and the former Soviet Union with information about safety technology related to nuclear facilities and to give them opportunities to discuss safety culture and technology by visiting nuclear facilities and research laboratories. The seminar is to be extended to include radioactive waste management and spent fuel storage in fiscal year 1994.

Long-term aid included the installation of a full-scale WWER-1000 simulator, at the Novovoronezh Operation Training Centre in Russia. Over the course of 10 years, Japan intends to invite one thousand specialists and engineers for training courses sponsored by MITI. Under this training programme, maintenance personnel and inspectors from Russia, Ukraine, Bulgaria, Hungary, Lithuania, and the Czech and Slovak Republics have participated in two-week training courses in Japan. In FY 1993, Japan planned to spend some US $31.5 million on six categories of bilateral safety-related assistance to nuclear programmes in Eastern Europe and the former Soviet Union.

The United States

Through its Nuclear Regulatory Commission (NRC) and the Department of Energy (DOE), the United States has initially allocated some US $25 million during 1992 under its Lisbon Initiative, which contains four elements which are being implemented:

- Establish two regional training centres (to provide operational safety training)—one in Russia at the Balakovo plant and one in Ukriane at the Khmelnitsky plant with a computer-based simulator for WWER-1000 reactors. The centres will train technical and maintenance staff as well as operators and establish comprehensive safety management systems for existing reactors.
- Provide immediate operational safety enhancement through improved emergency operating procedures for the WWER-440/230, the WWER-1000 and the RBMK, and improved nuclear plant equipment servicing and maintenance practices, and provision of guidelines, standards, and training; support to keep safety procedures and training materials updated; development of alarm response procedures; improved diagnostics methods and hardware; and, training for technical support personnel at nuclear power plants.
- Provide risk reduction measures for RMBKs and WWER-440/230s through

improved confinement performance for severe accidents; development of methods to prevent uncontrolled hydrogen explosions; installation of dedicated emergency diesel and feedwater pumps in protected areas; and improved basic fire detection capability.

- Assist regulators in developing consistent and effective safety standards and procedures and provide training in nuclear materials safety, safeguards accountancy, regulatory law, use of radioactivity monitoring equipment, and development of regulatory management structure, and the establishment of a basis for licensing and inspecting plants.

In addition to Russia and the Ukraine, Bulgaria, Hungary, and the Czech and Slovak Republics are all the focus of several country specific programmes inititiated by the United States. All U.S. assistance includes active participation of the local specialists.

Status of Nuclear Energy in Eastern and Central Europe and the Former Soviet Union

The Russian Federation

Nuclear energy provides 10% of Russia's electricity with thermal power (coal, gas and oil) providing 75% and hydropower providing 15%. The Russian nuclear sector is the largest in the former Soviet Union and there are plans to increase it drastically in the next few decades. The Russian Federation has other means to generate electricity, unlike other former Soviet republics; however, with present economic difficulties, it needs to sell most of its natural gas, oil and coal supplies for required hard currency. Therefore, nuclear power is seen as a source for national electricity production.

The Ministry of Atomic Energy (MINATOM) set goals in early 1993 for the development and use of nuclear energy in the Russian Federation until 2010. One major goal is to replace older and unsafe nuclear plant units as they are permanently shutdown or decommissioned. Another is to expand the use of nuclear power to replace worn out conventional power plants.

RUSSIAN FEDERATION

Location	Model/Type	Units	MWe
Balakovo	WWER 1000	3	2,850
Kalinin	WWER 1000	2	1,900
Kola	WWER 440/213	2	822
	WWER 440/230	2	822
Kursk	RBMK	4	3,700
Novovoronezh	WWER 440/230	2	770
	WWER 1000	1	950
Smolensk	RBMK	3	2,775
Sosnovy Bor	RBMK	4	3,700

The Russian Federation now has some 12 WWER-1000 units under construction and some 25 units in operation in seven nuclear energy producing plants.

Balakovo

Balakovo consists of three WWER-1000 units, with a fourth expected to come on line in 1993. Prior to the commissioning of the last unit, a series of experiments and supplementary tests, as well as government and independent public assessments were conducted.

Under the U.S.'s Lisbon Initiative, Russia's first nuclear training centre is to be located at Balakovo.

In February 1992, the Russian Federation requested an IAEA ASSET mission to examine the effectiveness of the plant's policy to prevent incidents based on the analysis of its 14 years of operating experience. The team noted that plant management officials had improved plant performance and were knowledgeable and dedicated to safety and prevention of accidents. However, the team identified two pending safety issues including poor reliability of instrumentation and control equipment and lack of procedures to support personnel actions. Recommendations were made and a follow-up team will be conducted in two-three years.

An ASSET training seminar designed to train operators and regulators to identify safety issues, assess their consequences and eliminate root causes of likely incidents and accidents took place in 1993. An ASSET follow-up mission to assess progress made in safety performance is scheduled for the Fall of 1994. A "twinning" arrangement with the German Biblis plant has allowed plant operators to visit each others' facilities.

Beloyarsk

Beloyarsk is a fast-breeder reactor initiated in 1981 generating 560 MWe. The sole operating unit, BN-600, is a sodium-cooled breeder reactor which generates new fuel as it operates.

According to reports, BN-600 has posed no major problems in its first ten years of operation. The former Soviet Union had planned to use the BN-600 as the commercial prototype for future breeder reactors.

Work on a larger breeder reactor, BN-800 at the Beloyarsk site has slowed, but Russian plans call for completion after the year 2000 as well as the construction of three other BN-800 units at the South Urals site by 2000.

Kalinin

Kalinin has two WWER-1000 units in operation with a third under construction which is expected to be completed in 1995. The plant has announced plans to replace its steam generators and has signed a contract with Framatome in France for assistance in these efforts.

Work has begun for a training simulator for the Kalinin site and plans have been announced to install upgraded insulated cabling. Other activities include WANO sponsored exchanges between the Kalinin plant and Pennsylvania Power & Light's Susquehanna plant, as well as Carolina Power & Light's Shearon Harris nuclear power plant in North Carolina. An arranged partnership with Germany's Brokdorf plant also exists.

An ASSET mission to analyze the Kalinin plant's safety performance has been requested to take place in July 1994. An ASSET seminar on prevention of incidents is scheduled at Kalinin NPP in early 1994.

Kola

Kola has four units in operation, two WWER-440/230s and two WWER-440/213s. Certain upgrades have taken place in the last few years, including fire-fighting protection, better separation of safety systems, and better personnel selection, training, and management.

An IAEA ASSET mission visited the two first generation WWER units at Kola in 1991. Although the units still do not meet international standards, the findings showed that the reactors demonstrate good management and high professionalism, the frequency of safety-significant events has been reduced and no major areas of concern for operational safety were found. A follow-up ASSET mission took place in the Fall of 1993 to assess improvements in incident prevention as a result of implementation of ASSET recommendations. A Safety Review Mission (SRM) in late 1991 pointed out operational concerns such as control room staffing, plant material conditions and inadequate operating procedures. A follow-up mission is scheduled for 1994.

A total loss of electrical power supplies (black out) on the units caused by a tornado in early 1993 highlighted the inherent safety margins of the WWER-440/230 reactor type that is capable of withstanding a total blackout for about 10 hours. However, it also revealed some poor maintenance practices that led to failure in starting the two diesel generators.

Russian authorities have announced plans to build three new 630 megawatt WWER reactors with enhanced safety features at the Kola site, scheduled to be operational by 2010.

Other activities include a special co-operative arrangement between the Kola plant and Norway to contribute to improvements in five areas including emergency power supplies, international communications, fire protection, instrumentation renewal, and operator training in Norway.

Under a contract with a German company, Kola will receive plant systems for loose parts, noise and vibration along with technical expertise to enable Russia to manufacture the systems.

Kursk

Kursk NPP has four RBMK reactors. A fifth unit is under construction and is included in Russian plans to add an additional 7,000 megawatts of generating capacity to the power system.

In mid 1992, Russian leaders requested an IAEA ASSET team to visit the plant to analyze its operational safety performance and recommend further enhancement of the prevention of incidents.

An ASSET follow-up mission to assess progress made in safety performance is planned for 1995.

WANO-sponsored exchange visits occurred between operators at the Kursk plant and those at the Susquehanna nuclear power plant in Pennsylvania.

Novovoronezh

Novovoronezh NPP has three units, two WWER-440/230 prototypes (WWER-440/179s) and one WWER-1000. Corrective actions to reduce embrittlement and in fire prevention have been carried out in the two WWER-440/230s and upgrading continues. A U.S. Department of Energy and Institute of Nuclear Power Operations (INPO) working group continues to assess the status and assist in the upgrading of these two plants.

An IAEA ASSET mission to Novovoronezh in 1991 identified three major areas for in-depth root cause analysis including: insufficient work coordination and control, insufficient procedural guidance, and insufficient reliability of a safety support function. A planned follow-up ASSET mission is scheduled for late 1993 to assess progress made in the prevention of incidents, concentrating on specific items such as preventive maintenance, component integrity, emergency operating procedures and training.

RUSSIA'S 20-YEAR PLAN

Reactor Type	Unit Name	Target Date of Operation
RBMK	Kursk-5	by 1995
WWER 1000	Balakovo-4	1993
	Kalinin-3	by 1995
WWER 1000	Balakovo-5	2001-2005
	Balakovo-6	2001-2005
WWER 1000	Novovorenezh-6	2001-2005
	Novovorenezh-7	2001-2005
WWER 630	Kola-5	2001-2005
	Kola-6	2001-2005
	Kola-7	2001-2005
Pilot WWER 630	Sosnovy Bor-5	1996-2000
WWER 600	Far East-1	2001-2005
	Far East-2	2001-2005
	Primorskaya-1	2001-2005
	Primorskaya-2	2006-2010
BN-800	South Urals-1	1996-2000
	Beloyarsk-4	1996-2000
	South Urals-2	2001-2005
	South Urals-3	2001-2005
Graphite Light	Bilibino-5	2001-2005
	Bilibino-6	2001-2005
	Bilibino-7	2006-2010
District Heating	Voronezh-1	1996-2000
	Voronezh-2	1996-2000
	Khabarovsk-1	2001-2005
	Khabarovsk-2	2001-2005

A safety review in mid-1991 recommended the implementation of a quality assurance programme, improvements in operator training and improvements in operating procedures. In a follow-up safety review in mid-1993, many improvements in plant management and safety culture aspects were noted.

Japan's Agency for Natural Resources and Energy and Russia's MINATOM have concluded a training agreement for the operating staff of the Novovoronezh NPP. The Japanese Ministry of International Trade and Industry (MITI) is installing a full-scope simulator to train WWER-1000 reactor unit operators. The Japanese Government has pledged bilateral assistance valued at US $25 million for the programme.

Smolensk

Smolensk has three RBMK reactors. An IAEA team which reviewed the design of the three units in mid-1993 found that although additional upgrades are still needed, many positive safety features had been added. These changes included a modification of the emergency cooling system. More significant changes to improve safety are still desirable, such as improvements in reactor control and shutdown systems.

An IAEA ASSET mission was requested to visit the Smolensk NPP in mid 1993 to analyze its operational safety performance. A number of recommendations were made to further enhance safety through effective prevention of incidents. A follow-up ASSET mission to assess progress made is planned for 1995.

Smolensk plant operators were, however, found to be well-qualified in the operation of the plant. Smolensk operators undergo about six years of university studies and training on the plant's simulator before being examined by a board and placed on a work shift as an assistant for three years.

Scottish Nuclear has signed a contract with Russia to carry out improvements at the plant to upgrade safety standards. Scottish Nuclear plans the installation of a system to control and schedule maintenance activities and to train Russian workers to operate additional equipment for testing pipework.

Under the Lisbon Initiative, Western representatives completed a fire-hazards walkdown of Smolensk to determine the remedial equipment required, and a U.S. Department of Energy approved firm is supporting the construction of a control room simulator for Smolensk. Under the sponsorship of WANO, exchange visits occurred between representatives from Smolensk and Georgia Power's Hatch plant.

Sosnovy Bor (formerly Leningrad)

Sosnovy Bor has four RBMK type reactors. The first phase of planned upgrades focused on unit 1 included a modernized feedwater system; replacement of 1600 pressure tubes; and restoration of graphite blocks in the core and the installation of a new instrumentation and control system. The second phase of upgrades is focused on units 2 and 3 and includes seismic and fire protection improvements, a new diagnostic system and an upgrade of instrumentation and control. A third phase of upgrades is scheduled for 1995. In addition, Minatom announced that the two oldest units would be the first RBMK reactors in Russia to be decommissioned.

In mid 1993, an IAEA ASSET mission was requested to analyze the four Sosnovy Bor units' operational safety performance and to recommend further enhancement of incident prevention. An ASSET follow-up mission to assess progress made is planned for 1995.

A U.S. company is implementing a $13 million contract to design a RBMK simulator, a 3 1/2 year project. And, Finnish and Swedish representatives visited the Sosnovy Bor plant in late 1992 and reported that conditions had been vastly improved. The group assessed the plant's quality and safety using IAEA methodology. A twinning relationship with Germany's Isar-1 plant has also been established.

Further assistance in the form of research projects have been proposed by Switzerland. In conjunction with the Paul Scherrer Institute (PSI), pressure tube parts from the fuel channel damaged in the March 1992 incident at Sosnovy Bor-3 will be studied and the application of modern computer codes for safety analysis of RBMK reactors may be used.

Lithuania

Lithuania is the largest producer of nuclear-generated electricity among the CIS countries. Out of the four countries previously part of the Soviet Union, it has only one two unit plant at Ignalina and depends on it to provide more than 60% of Lithuania's electricity while 39% is generated through coal, oil and gas and slightly more than 1% through hydroelectric plants.

Lithuania's Ignalina nuclear power plant is the largest RBMK built in the former Soviet Union. It currently exports electricity to Latvia, Belarus and the Kaliningrad region of Russia.

Ignalina

Ignalina has two RBMK units, with one under construction. It was the focus of the first IAEA ASSET review in the Soviet Union in 1989 where the team studied the plant's operating history and incident prevention programmes. The team found the two units to be operating within international standards and stated that unplanned shutdowns were at a minimum and the occurrence of safety significant events, such as leaks and pipe ruptures, was decreasing. The team also recommended that management establish a surveillance policy to assess personnel proficiency, performance in safety and reliability, and operational events to ensure feedback. The ASSET was followed up in early 1993. The follow-up team reviewed operational safety performance and

LITHUANIA

Location	Model/Type	Units	MWe
Ignalina	RBMK	2	2,760

assessed the appropriateness of corrective actions taken by management to further improve incident prevention.

A six-nation consortium of representatives from the UK, France, Germany, Italy, Sweden and Finland is studying the safety of RBMK plants. Sweden's Nuclear Power Inspectorate is leading the study of the Ignalina units and has worked with Lithuanian officials to help create a Lithuanian nuclear safety authority. Lithuania is also a participant in the IAEA International Programme on Safety Assessment of RBMK Reactors which includes safety reviews of proposed modifications, specialist meetings on specific topics and missions to assess plant-specific design features, operational practices, safety significant events and seismic safety.

A programme to compare safety at Ignalina with that at the Barsebaeck plant in Sweden found that the plant was not built according to its design. As part of the ongoing effort, called "Barselina," Swedish, Russian and Lithuanian officials are determining if operating and maintenance procedures need to be changed and if better information is needed on plant component reliability.

Additionally, an IAEA ASSET training seminar took place in mid-1993 to train operators and regulators in the use of the ASSET methodology to identify safety issues, to assess their consequences and to eliminate the root causes of likely future accidents and incidents.

Also, Ignalina officials are working with French authorities to develop a training simulator for plant personnel. In 1993, Ignalina operators travelled to Berlin for training by Germany's GRS (Institute for Reactor Safety). WANO sponsored exchange visits took place between Ignalina and the Iowa Electric Light and Power's Duane Arnold nuclear power plant.

The Ukraine

The Ukraine is the second largest producer of nuclear-generated electricity of the former Soviet republics. The 14 nuclear power units (12 WWERs and 2 RBMKs) in the Ukraine account for some 30% of all electrical power in the republic with 66% percent supplied by coal, oil and gas and 4% from hydroelectric facilities.

Due to the energy shortage in the Ukraine, the Ukrainian Parliament decided in October 1993 that the Chernobyl nuclear power station should continue to operate and that the ban on the commissioning of new nuclear units should be lifted. The decisions by the Parliament mean that the two power units at Chernobyl will remain in service for now, although the Parliament had previously decided that Chernobyl should be closed by the end of 1993. This decision paves the way for the commissioning of three almost completed nuclear power units, unit 6 at the Zaporozhye plant, unit 4 at Rovno and unit 2 at Khmelnitsky.

GANU — the State Committee for Nuclear and Radiation Safety — has launched a safety analysis programme for all the country's WWER reactors. The programme, due to be completed in 1994, includes beyond-design-basis accident analyses, prob-

UKRAINE

Location	Model/Type	Units	MWe
Chernobyl	RBMK	2	1,850
Khmelnitsky	WWER 1000	1	950
Rovno	WWER 1000	1	950
	WWER 440/213	2	745
South Ukraine	WWER 1000	3	2,850
Zaporozhye	WWER 1000	5	4,750

abilistic safety analyses, operational experience analyses and the development of possible corrective measures for any problems identified.

An IAEA ASSET training seminar on the prevention of incidents was conducted in the Ukraine in 1992 in the town of Neteshin near the Khmelnitsky plant. It was attended by representatives from nuclear plants, regulatory bodies and research institutes. It covered reporting criteria, International Nuclear Event Scale (INES) event rating, ASSET root cause analysis, and the Ukrainian incident report system.

NRC working groups have observed on-site environmental and health effects of the Chernobyl accident, fire-management techniques at Zaporozhye, and loss-of-coolant studies at Rovno. A memorandum of agreement between French and Ukrainian officials solidified a two-year programme focused on improving WWER 440 and 1000 designs. Germany's GRS (Institute for Reactor Safety) and France's IPSN (Institute of Nuclear Protection and Safety) are partners in the effort to develop secure nuclear licensing capability by Ukrainian authorities.

An agreement between Russia and the Ukraine was signed in 1993 on economic cooperation and joint research and development in the nuclear power field. The agreement covers design and construction of power plants and reactor equipment, the nuclear fuel cycle, research reactors, operating procedures and staff training, decommissioning, and radiological protection and safety. Under the agreement, the two countries will provide assistance with plant operation, maintenance and spare parts supply, and will also exchange information on incidents.

Under the Lisbon Initiative, certain Ukrainian plants will be the target of "expert groups" involved in the joint U.S./Russian/Ukrainian effort to improve Soviet reactors. The initiative will address training, risk reduction and the development of regulatory functions. In addition, U.S. Department of Energy (DOE) approved technology exchanges between U.S. companies and the former Soviet republics are part of U.S. assistance to the Ukraine as well as assistance in training operators at Chernobyl.

Chernobyl

Two of Chernobyl's four RBMK units are operational. Unit 4 was destroyed by the 1986 accident, and unit 2 has not operated since a fire in its turbine building in 1991. A revised IAEA analysis of the Chernobyl accident in 1993 attributed the main root cause to the reactor's design and not to operator error. The 1986 analysis originally cited the operators' actions as the principal cause. The 1986 Chernobyl accident was not analyzed by the systematic ASSET root cause analysis methodology.

Following the Chernobyl accident, a major backfitting programme to upgrade RBMKs began in the Ukraine and international assistance was sought to improve the emergency core cooling systems of units 1 and 3. Currently, a U.S. firm is assisting the Ukrainians in building a control room simulator for Chernobyl.

In mid-1992, an IAEA ASSET team was requested to analyze the root causes of the 1991 fire at unit 2 which had rendered the reactor's emergency feedwater system inoperable. The intention behind the ASSET was to issue generic recommendations that would be beneficial to other nuclear power plants, including RBMKs. The generic recommendations covered areas such as checking generators, fire systems, feedwater systems and personnel awareness of the importance of operational feedback programmes.

The ASSET team also made specific recommendations that a structured management programme be implemented to target quality control, preventive maintenance, surveillance and the implementation of corrective actions. The team concluded that the general situation at the plant did not appear to be favourable for its safe operation.

Following the Chernobyl accident, Ukrainian officials built a concrete sarcophagus over the unit to prevent the escape of additional radiation. It was erected, however, using remote construction methods — because of the high radiation field — and without full information to gauge the structural integrity. Three options were studied by the Soviet government in 1991 to deal with the weakened sarcophagus: build a new, separate structure on top of the existing one; fill the existing one with a special concrete; or decommission the reactor buildings and the sarcophagus.

The Nuclear Energy Agency (NEA) of the OECD provided experts in nuclear safety and waste management to help evaluate the options. In early 1992, the panel concluded that the option to fill the existing sarcophagus with a special concrete was the preferable one, although Moscow stated that the newly independent Ukraine might not follow the panel's advice.

The request for an ASSET mission to analyze the Chernobyl NPP operational safety performance and to promote incident prevention enhancements has been canceled following the decision of the Ukrainian Parliament to shut down the plant.

Khmelnitsky

Khmelnitsky has one WWER-1000 plant operating with three additional units under construction. With the new decision by the Ukrainian Parliament, construction on unit 2 is likely to be resumed and could be completed in 12-18 months.

In 1992, the IAEA sponsored an ASSET seminar at Neteshin near the Khmelnitsky plant. It was attended by representatives from six nuclear plants, regulatory bodies and research institutes and covered reporting criteria, INES event rating, ASSET root cause analysis, and the Ukrainian incident report system. A WANO-sponsored exchange resulted in Khmelnitsky personnel visiting the Wisconsin Electric Power's Point Beach nuclear power plant in 1992. Under the Lisbon Initiative, Khmelnitsky is to be the site of the Ukraine's first nuclear training centre.

An ASSET mission took place at the Khmelnitsky NPP in early 1993 to analyze its operational safety performance and to enhance incident prevention. A follow-up ASSET mission is planned for late 1995 to assess progress made in safety.

Rovno

Rovno has two WWER-440 model V213 units and one WWER-1000 unit. The Ukrainian Parliament's lifting of its 1990 moratorium, should result in construction of a fourth unit at Rovno being resumed and likely to be completed in 12-18 months.

International technical exchange and assistance activities to Rovno have centred on problems with steam-generator tube breaks. Working Group 2 of the U.S./Soviet Joint Coordinating Committee for Civilian Nuclear Reactor Safety has used the Rovno station as the basis for studies of a hypothetical loss-of-coolant scenario and has compared results with a similar study of the South Texas Project in the U.S. An NRC working group studied Rovno's fire-protection techniques and assessed the plant's fire-protection standards to determine whether safe shutdowns could be carried out in the event of a fire. And, under the PHARE programme, funding has been proposed for reactor safety analyses and upgrades at the plant.

Rovno was the site of the IAEA's first OSART mission to the former Soviet Union. The purpose of the 1988 mission was to review operating practices at unit 3 and to allow a technical exchange of experience on pursuing excellence in operational safety. The team recommended that plant management be given more responsibility; that equipment design, manufacture, installation, operation and maintenance be verified by more effective quality assurance activities; and plant management should revise training materials, use more modern training aids and train operators on a full-scope simulator. France has also arranged a partnership between its Golfech plant and the Rovno plant.

An ASSET seminar on prevention of incidents took place at the Rovno NPP in June 1993. An ASSET mission is scheduled for late 1993 to analyze safety performance of the two WWER-440/213 units and offer recommendations to further enhance safe operation. A follow-up ASSET mission is scheduled for 1996.

South Ukraine

South Ukraine has three WWER-1000 units and has had the highest number of unplanned shutdowns among Ukraine's plants. In 1992, an event at the plant registered Level 2 on the International Nuclear Event Scale that was the result of a defective core instrumentation and led to the failure of a steam isolation valve. South Ukraine is one of three WWER-1000s in the former Soviet Union to receive specialized machinery to remove bolts from steam-generator manhole covers manufactured by a French firm. They will also be provided to the Kalinin and Zaporozhye plants. A WANO-sponsored exchange resulted in South Ukraine personnel visiting the Louisiana Power & Light's Waterford nuclear power plant in 1991. There is also a partnership between South Ukraine and the German Grohnde plant.

An ASSET seminar at South Ukraine NPP is scheduled for March 1994 with an ASSET mission planned for later in 1994. An ASSET follow-up mission is scheduled for 1996.

Zaporozhye

Zaporozhye has five WWER-1000 units which have experienced corrosion problems in the steam generators, water damage from an accidentally activated fire extinguisher, and a fire in the oil system compartment of some make-up pumps. The Ukrainian Parliament's 1990 moratorium halted construction on the sixth unit, which should now resume construction with the lifting of the moratorium.

NRC working groups have focused on regulatory inspection practices, fire-protection approaches, and internal communications. Zaporozhye is one of three WWER-1000s in the former Soviet Union to receive specialized machinery to remove bolts from steam-generator manhole covers manufactured by a French firm. They will also be provided to the Kalinin and South Ukraine plants. A WANO-sponsored exchange resulted in Zaporozhye personnel visiting Duke Power's Catawba nuclear power plant in South Carolina. Germany's Neckar plant is the arranged "twinning" partner for Zaporozhye.

In February 1994, an ASSET team will conduct a seminar at the Zaporozhye NPP, to be followed by an ASSET mission in October 1994. The follow-up ASSET mission will be conducted in 1996. In addition, Zaporozhye is being used as the reference plant for the IAEA's WWER-1000 programme.

Armenia

Armenia is equipped with one nuclear power plant 28 kilometers from the capital, Yerevan. The plant consists of two Soviet-designed WWER-440/230s that were shutdown in February and March of 1989 as a safety precaution following a devastating earthquake in December of 1988.

At present, due to the country's severe need for power, the Armenian government is considering reopening the nuclear plant. There is concern about the safety of the units should they be put back into operation. In 1991, the Armenian Prime Minister asked Framatome and Electricité de France to assess the safety of its units. The assessment was positive,

ARMENIA

Location	Model/Type	Units	MWe
Armenia	 WWER 440/230	2	Shut down in 1989

document and plans of the reactors were available, the Russians had built additional safety seismic precautions onto the plant after the earthquake, and there were no major technical obstacles impeding the plant from being put back into operation.

At the end of 1992, Framatome came back to the plant to formalize a final report for the European Commission, to update the 1991 report and assess the upgrading needed. In one year, the plant had deteriorated drastically. Aside from an exorbitant loss of appropriately trained operators, personnel and regulatory supervision, there was a visible degradation of structures and equipment, and weak security. These findings were equally witnessed by experts from the IAEA and the World Bank who visited the site reporting that the maintenance was not good, offering assistance in further assessments and advice for urgently needed remedial action.

Framatome received a credit of 2 million Francs from the TACIS programme, but insists that the financing for the Armenian upgrading project is secondary to the main concern of actually upgrading the plant. Framatome estimates that the project would require two years to complete and a workforce of approximately 100. The study for the upgrading of the plant is to be carried out in three phases:

- to upgrade the safety to the same level of Soviet reactors of the same type,
- to improve the reactor to IAEA recommendations, and
- to reinforce the anti-seismic protection.

Czech Republic and Slovak Republic

The Czech Republic and the Slovak Republic each operate four WWER-440 units. In the Slovak Republic, nuclear power supplies 49.5 percent of all electricity generated with coal, oil and gas accounting for about 40 percent and hydro for about 10.5 percent. In the Czech Republic, nuclear plants supply 20.7 percent of electricity with 76.7 percent from coal, oil and gas and 2.6 percent from hydro.

Both republics have nuclear plants under construction — four WWERs at Mochovce in the Slovak Republic and two WWER-1000s at Temelin in the Czech Republic. Both the Czech and Slovak governments continue to support the use of nuclear energy and reportedly intend to develop their own energy policies soon. Specifically, the Czech government advocates the completion of the Temelin nuclear plant, the backfitting of some lignite-fire power plants and the closing of some old fossil plants.

Plant operators and regulators sought assistance from Western firms to enhance the safety of the WWER-440 model 230 units even before the collapse of the Communist regime. In the last several years, requests for assistance from both republics have increased.

CZECH AND SLOVAK REPUBLICS

Location	Model/Type	Units	MWe
Bohunice (Slovak)	WWER 440/213	2	816
	WWER 440/230	2	816
Dukovany (Czech)	WWER 440/230	4	1,632

Bohunice

In 1990, the IAEA undertook a programme to document the special measures that had been taken at Bohunice 1 and 2 to improve plant safety. This included a technical exchange visit to review equipment upgrades and modifications, personnel qualification, and surveillance. An ASSET mission in 1990 visited Bohunice to assess the adequacy of the WWER-440/230 plants and examined its operating history and incident-prevention programme. The team noted that future safe operation of units 1 and 2 would require further efforts and recommended the development of a comprehensive programme to prevent incidents, including increased surveillance and preventive maintenance.

An ASSET seminar was held in early 1992 at the Bohunice NPP. A follow-up mission was conducted in mid-1993.

Bohunice operates two WWER-440/230 models and two WWER-440/213 units. In 1991, the government instituted a phased safety-related backfit programme of some 81 improvements to Bohunice 1 and 2 which is expected to be completed in 1993.

Safety related improvements to Bohunice have included the supply of German loose-parts monitoring systems and component vibration monitoring systems; lead-monitoring systems, analyses of the reactor safety systems including instrumentation and control technology; and French assistance in the supply of security systems.

In 1991, an IAEA safety review mission visited Bohunice 1 and 2 to assess the basic design deficiencies as well as plant modifications. The review pinpointed shortcomings in the identification and correction of safety issues by management, deficiencies in fire protection,and incomplete vital operating procedures. The team also recommended review of seismic upgrading.

A follow-up mission in 1992 noted progress by plant management in responding to IAEA recommendations. While good progress had been made in the design area, the mission recommended the development and implementation of quality assurance programmes, operating procedures, improvement of operating shift staffing and plant reorganization efforts. A follow-up mission to the 1990 ASSET mission took place in July 1993.

In April 1992, the CSFR government announced that a study of instrumentation and control system replacement in the model 213 reactors would be carried out under the PHARE programme.

WANO-sponsored exchanges resulted in Bohunice personnel visiting the Swiss Gosgen and Beznau plants and Toledo Edison's Davis-Besse plant. Bohunice's German partner plant is Grohnde. France's Nogent plant has been linked in partnership with Bohunice, as well.

Dukovany

Dukovany operates four WWER-440 model 213 units and enjoys a good operating history of normal range of reportable events and low exposure of plant employees. Attempts to build an interim storage facility for spent fuel at the plant has run into local opposition. Remaining storage space will run out in 1995.

In response to design deficiencies in the WWER-440/230 units, the Czech utility requested Western assistance in upgrading the plant. German companies supplied loose-parts monitoring systems and component vibration monitoring systems. Under the PHARE programme, a new instrumentation and control system will be studied with replacement expected in 1995 in addition to development of a simulator.

In 1992, a major overhaul of Dukovany unit 3 was completed. This included modifications to upgrade operational safety. Between 1994 and 1996, plans include evaluation of the integrity of all units' primary circulation, steam and feedwater piping. According to plant management, major upgrading of all four units, based on a probability safety assessment is planned for 1996.

In 1989, an IAEA OSART mission reviewed safety at Dukovany-3 and called the plant's operating history impressive and said that its safety practices would become a model for other plants. The team recommended streamlining the plant's organization structure and strengthening the quality-assurance function and recommended an increase in control room personnel. A 1990 follow up OSART mission noted improvements including a new organization structure, improved quality assurance, and more efficient feedback of operational experience. Additionally, the team noted areas where little progress had been made including simulator training for control room personnel, recording capability for plant disturbances, and advanced training for firefighters.

In 1991, an OSART Technical Exchange mission reviewed the plant's maintenance practices and found that the plants practices compared with those at Western plants. The team noted the plant's preventive maintenance programme was comprehensive and supported nuclear safety and suggested plans to optimize its programme. The team also recommended that critical path analysis be used in the scheduling and follow-up of refueling outages.

The St. Alban plant in France has been partnered with Dukovany for the sharing of operating experience and exchange visits.

An ASSET mission visited the Dukovany NPP in October 1993 and a follow-up mission is planned for late 1995.

Hungary

Hungary operates one nuclear power plant with four WWER-440/213 units at Paks on the Danube River. Nuclear power supplies 49 percent of Hungary's electricity with coal-fired plants generating about 23 percent, oil about 4 percent and gas about 21 percent. Prior to 1989, Hungary planned to build two new additional units at the site but canceled its order for the WWER-1000 units and expressed an interest in Western-made units.

International cooperation and assistance to Hungary has included a programme with the U.S. NRC to exchange information and cooperation on state supervision of nuclear facilities, analytical safety methods, operational experience, next-generation reactors, life extension, failures and incidents, and treatment and transportation of radioactive waste. An agreement with the French Atomic Energy Commission covers nuclear safety, radiation protection, radio-ecology and waste-management research and development. A joint venture with a Spanish company is being negotiated for reactor pressure-vessel inspection services and cooperative arrangements with Foratom, the umbrella group of 14 European nuclear industry forums.

The IAEA conducted an ASSET seminar in Budapest in 1990 on training nuclear operators and regulators in the investigative methodology used by ASSET missions, and to train in incident prevention.

HUNGARY

Location	Model/Type	Units	MWe
Paks	WWER 440/213	4	1,729

Another ASSET seminar was held at the Paks plant and focused on extending the assessment of safety significance of operational issues to all types of nuclear facilities and covered the root cause analysis method. An additional ASSET mission took place in Novemeber 1992, with a follow-up ASSET mission planned for November 1994.

Paks

Paks operates four WWER-440/213 model units and enjoys an untroubled operating history. In 1988, an IAEA team reviewing unit 3 found several indicators of good performance including cumulative availability above 86 percent and low numbers of unplanned outages. In a follow-up visit, the IAEA team noted that plant modifications and upgraded procedures would help Paks maintain and improve its safety record and noted that management had begun programmes to increase the flow of operating experience among plant operators.

An OSART mission in 1988 reviewed operating practices of unit 3 and found safety performance at a high level. Recommendations suggested improvements to enhance the plant's strong safety record: a strengthened operating organization, additional independence in quality assurance, and improved industrial safety. An OSART follow-up mission in 1991 reviewed the plant's response to the recommendations and found that 91 percent of the OSART mission's recommendations had been carried out or were under way.

The Paks plant has raised its performance level with the help of a new full-scope simulator which serves the dual purpose of testing emergency procedures as well as a simulator to train staff. A topical meeting is under preparation to discuss technical and methodological aspects and options for the regional use of the training centre by countries operating WWER-440 model reactors.

The Paks plant has contracted with several Western firms for upgrades to the four WWER-440 213 model units including a Finnish firm for a plant simulator, and another Finnish firm to provide inspection and quality-control support, and safety and construction consulting. A Spanish company is supplying Paks with a system of acquisition and processing of data from ultrasonic in-service inspection of pressure vessels and other components and the Hungarian Atomic Energy Commission has launched a study of Paks to ensure that the plant meets Western safety standards to be completed in 1994.

In 1992, Hungary requested an ASSET mission to Paks to review operating experience, assess the appropriateness of corrective actions, and exchange views on further enhancing incident prevention. The team found that the plant's operational statistics compared well with world averages and that the plant appeared to have entered a period of steady operation since the commissioning of unit 4 in 1987. On the basis of root cause analysis of incidents that did occur at the plant, the team made recommendations to help plant management further develop the safety awareness of the plant staff, the preventive maintenance of instrumentation and control equipment, and the effectiveness of operating experience feedback by paying more attention to human factors.

An ASSET follow-up mission is planned to take place in late 1994 to assess progress made in safety performance of the four Paks units. Paks has been partnered with Germany's Isar-2 plant for technical and experience exchange. A study on the concept of the I&C reconstruction for unit one at the Paks NPP has also been initiated, with high priority given to the reconstruction of the reactor protection system.

Bulgaria

Bulgaria operates four WWER-440 model 230 units and two third-generation WWER-1000s at Kozloduy nuclear power plant. Nuclear power supplies about 34 percent of the country's electricity, although in the last couple of years, that share has often risen to 50 percent because of thermal plant inefficiency, fuel shortages and inadequate rainfall for hydropower. Coal-fired plants account for 56 percent of all electricity generated, oil for about 3 percent, natural gas for about 1 percent, and hydropower for about 6 percent.

The operating culture and physical condition of the older model WWER-440/230s at Kozloduy have raised safety concerns. The construction of four WWER-1000 units at Belene was suspended until a Parliamentary committee could study the safety of

BULGARIA

Location	Model/Type	Units	MWe
Kozloduy	WWER 1000	2	1,906
	WWER 440/230	4	1,632

the proposed plant. Three Western companies were contracted to conduct seismic analyses. A Bulgarian energy research institute — Energoproject — said that officials were considering resuming construction at the Belene site.

In 1990, the Bulgarian government requested a Pre-OSART mission to Belene where the two WWER-1000 units were under construction to review construction activities and preparations for plant operation. The team recommended development of a comprehensive quality assurance programme; improvement of management controls and systems; improvement of overall safety attitudes; and provision of additional equipment and computer systems.

Previously, the former Soviet Union had been responsible for training operators at the Kozloduy plant. The training of plant personnel since the collapse of the Communist regime in Bulgaria has been seriously compromised. The plant has no simulator and no written materials or manuals for classroom training on basic nuclear technology, the WWER-

1000 unit or plant operations. Plant operators were trained on the WWER simulator at the Novo-voronezh plant in Russia.

The UK government has provided equipment for the training centre and a U.S. firm is participating in providing a three-phase simulator programme for the plant. Through the PHARE programme, funding has been earmarked for projects to study Bulgaria's electrical grid and alternative electricity-supply option and a "twinning programme" in which the staffs of Kozloduy and nuclear plants in Western Europe will share operating experience; a plant "housekeeping" programme; and a special WANO-organized, six-month safety analysis.

At the request of the Bulgarian authorities, the IAEA has conducted a series of ASSET missions related to the safety performance of the Kozloduy NPP.

The first IAEA review of units 1-4 WWER-440/230s was an ASSET mission in November 1990 which highlighted a lack of safety culture that might be detrimental to the safe operation of the Kozloduy NPP. A number of pending safety problems were identified and the analysis of their root causes called for a series of improvements in management control to enhance the prevention of incidents. This became a reality with the assistance of WANO later on.

In March 1992, the IAEA conducted an ASSET training seminar on prevention of incidents in Sofia that was attended by staff from Kozloduy, the regulatory agency and two energy research institutes. A second ASSET training seminar was held at the plant at the request of WANO in September.

In June 1992, another ASSET mission took place at the Kozloduy NPP to assist plant management in completing implementation of the recommendations of the November 1990 ASSET mission.

In September 1993, an ASSET follow-up mission was requested to assess progress made in safety as a result of the extensive work done in three years by WANO, EDF, the operating organization and the regulatory body. An ASSET mission has recently been invited to Kozloduy units 5 and 6 (WWER-1000s) in November 1994.

A consortium of European safety authorities including France's IPSN, Germany's GRS, the UK's Nuclear Installations Inspectorate and AEA Technology, and Belgium's AIB-Vincotte Nucleaire are helping the Bulgarian authorities to set up a Western style licensing procedure.

In 1993, Electricité de France (EDF) and Bulgaria's National Electric Company signed an agreement for the purchase of equipment and spare parts for Kozloduy. EDF, along with the UK's Nuclear Electricity, will assist Bulgaria in getting financing to upgrade the Kozloduy reactors.

Bulgaria has also applied to the World Bank for a US $93 million loan to help rebuild the country's energy infrastructure and to help connect the country's electricity grid to that of Western Europe. A utility partnership programme sponsored by the U.S. Agency for International Development and the U.S. Energy Association pairs the NEC with Central Maine Power Company in which the plants exchange technical and economic information, seminars, and visits by managers.

Kozloduy

Kozloduy operates four WWER-440 model 230 units and two WWER-1000s. The first IAEA ASSET mission in November 1990 noted that several serious incidents had occurred at the plant, one of which resulted in the radioactive contamination of ground water on the site. The mission also found that 217 workers had received excessive exposure to radiation over the plant's operating life and five "hot spots" had been found at the plant, along with several other safety-related problems.

The first IAEA inspection to Kozloduy was an OSART mission to unit 5 in 1990 which focused on operations, maintenance and technical support. The team recommended better living and working conditions for the staff; less bureaucratic red tape; open exchange of information; and simple but efficient organization structures. An IAEA ASSET mission visited units 1-4 in 1990, as part of the series of ASSET missions requested to the WWER-440/230 reactors after Greifswald in Germany, Bohunice in Slovakia, and before Kola and Novovoronezh in Russia. The team noted a lack of attention to the prevention of operational events and said that safe operation demanded major improvements by plant management and called for another ASSET mission to complete the review.

In 1991, an IAEA SRM mission to units 1-4 galvanized Bulgarian authorities and Western organizations into action. The team identified the lack of a safety culture; poor work practices; industrial safety hazards; poor radiological protection; lack of structured training for operators; and incomplete operating procedures. The findings were that the team suggested that continued operation of units 1-4 would be "imprudent." Following the mission, the Bulgarian authority announced the shutdown of unit 4 for safety-related improvements and that unit 3 would remain shut following a refueling until improvements had been made. Units 1 and 2 were also shut down for extensive modifications. Unit 3 and 4 resumed operation during the year.

A month later, an OSART mission to unit 5 found that despite the unit's good operational performance, fundamental changes were needed to break with past practices and establish a safety culture.

Units 5 and 6, the plant's third-generation WWER-1000 units, have been troubled by electrical problems with the generators. Staffing problems and management changes plagued the plant during 1991. The construction of a low-level radioactive waste treatment facility at Kozloduy has also been delayed.

The EC announced assistance through the PHARE programme to improve the safety at Kozloduy in three areas: immediate repairs to restore the units to original operating condition; a three-year improvement programme beginning with a six-month phase of on-site advice by an international team of nuclear engineers to evaluate the safety of units 1-4 and to help authorities apply IAEA safety standards; and "twinning" Kozloduy with nuclear power plants in EC countries for ongoing exchanges of technical and operating information.

Assistance to the plant came from Germany in the form of spare parts from the Greifswald NPP, the EDF pairing the plant with its Bugey nuclear plant and contracts to carry out the most urgent work from the U.S., Spain, France, and Belgium. The consortium, along with WANO, Kozloduy operators and Bulgarian regulators agreed on a three-year outage management programme that would cover plant restoration, equipment requalification, engineering, documentation, operational feedback, formation of a safety committee, and training.

In late 1992, the full inspection of unit 2's safety-related systems and equipment by an international consortium and a Bulgarian government commission resulted in approval for restarting the unit. Unit 1 came close behind.

During 1992, assistance from the World Bank identified short-term modifications and longer-term improvements to Kozloduy that would enable safety levels at the plant to approach those of nuclear plants in the West. In 1993, members of the G-24 Working Group on Nuclear Safety met at Kozloduy to decide on the next steps in the plant's assistance programme. Upgrading of units 1,2 and 3 should be completed in 1993 and the two WWER-1000s are to be included in the upgrade programme.

In June 1993, the EBRD decided to finance a project to provide equipment for the Kozloduy NPP from the Nuclear Safety Account.

An ASSET mission in 1992 to units 1-4 visited the plant to assist management in implementing previous ASSET recommendations on quality control, preventive maintenance, surveillance, root cause analysis, and repairs and remedies. The team noted that plant management had paid proper attention to the recommendations of the previous ASSET mission. The team observed that management was dedicated to making technical and organization changes and was taking full advantage of international assistance offered in this effort. The team noted that the importance of quality assurance and safety culture was understood at the top management level.

A follow-up ASSET mission took place in September 1993 to assess progress made in the management of safety performance as a result of the extensive three years' work done by all the parties involved: WANO, EDF, Regulatory Body and the operating organization. A follow-up SRM in mid-1993 found significant improvements in management, operation and maintenance of units 1-4.