EXECUTIVE SUMMARY

1. BACKGROUND

This Environmental Impact Assessment (EIA) has been prepared with reference to a proposal by the Ukrainian national nuclear power utility, Energoatom (formerly Goskomatom), to complete and upgrade Unit 4 of the Rivne (R4) and Unit 2 of the Khmelnitsky (K2) nuclear power plants (NPPs). The EIA relates to K2; a separate EIA has been prepared for R4. The two EIAs have many features in common because the contexts are similar. However, there are significant differences between the nature of the environment at the two sites and between the systems that will be used for providing cooling waters and for utilising cooling waters in the various NPP systems.

The objective of the EIA is to provide Energoatom's possible financial partners (e.g. EBRD, EURATOM) with an assessment of the extent to which environmental and radiological impacts associated with the proposed project have been addressed to date, or will be addressed during further development of the project. The EIA also provides a basis for the continuing public consultation process.

The EIA is based on an earlier study, supplemented by information that has been obtained, or comments that have been provided by, various parties subsequent to that earlier study. The EIA work is ongoing, particularly concerning the development of an Environmental Action Plan (EAP) that will be covenanted into the project financial and legal documentation.

The EIA provides a factual account of the legislative background, the existing site, the proposed project, radiological protection arrangements, nuclear safety issues, and potential discharges of radioactive and non-radioactive materials to the environment. For the identified potential discharges, it provides the results of an assessment of their radiological and environmental impacts, taking into account both normal operation and abnormal conditions. These impacts are compared where possible with those that might arise from the base case alternative i.e. maintaining the Chornobyl NPP in operation. Measures are identified to mitigate possible environmental and radiological impacts. An Appendix provides a summary of the public consultation activities that have been undertaken to date.

2. POLICY, LEGAL AND ADMINISTRATIVE FRAMEWORK

The political changes of 1991, and the subsequent dissolution of the Soviet Union, resulted in substantial changes in the legal system of Ukraine.

The Ukrainian Government has taken considerable steps towards the development of a sound and comprehensive legal regulatory framework. A particular change is the move towards a system that renders the operators of NPPs responsible for the safety of their installations, and national safety authorities responsible for setting objectives and verifying that adequate procedures, hardware and software are developed and implemented during design, construction and operation of NPPs. This represents a complete change of approach for which it may take some time for full implementation.

The legal and regulatory framework is being developed to conform with international standards. The Ukraine Government is a signatory to several international treaties and conventions which are directly relevant to the licensing process for nuclear plant.

Further changes in the legislative framework and in the mechanisms by which it is implemented will be required to complete the transition to a system whereby the operator is fully responsible for all aspects of nuclear safety, and whereby the regulator is fully independent and sufficiently funded and staffed.

3. LOCAL ENVIRONMENT

The Khmelnitsky NPP is in the northwestern part of the Slavuta District within the administrative region of Khmelnitsky, close to the eastern border of the Ternopil administrative region. Netishin, with a population of 34,200 and located 4 km from the NPP, is the largest town close to the plant and provides the base for the NPP personnel. Within a 30 km radius of the NPP there are 211 inhabited locations with a total population of 250,700.

The NPP is situated on the Goryn river, 462 km distant from its confluence with the Pripyat river, and close to the confluence of its main tributaries, the Viliya and the Gnilyi Rig. The Goryn river is the largest water artery flowing through the Khmelnitsky region and its waters are used for a variety of domestic, industrial and agricultural purposes.

The climate in the region is temperate and is characterised by a mild and humid winter, cool and wet summer, damp autumn and unsettled transitional periods. The mild winter with frequent thaws is created by western and eastern winds with sharp cold spells in winter and spring induced by the penetration of Arctic air. Snow melt in spring generally results in the greatest flows of the Goryn and Gnilyi Rig but rain-induced floods in winter and summer can exceed snow-melt floods once in ten years.

The NPP site is located within the eastern borders of the Volyno-Podilsky artesian basin in the zone of its junction with the Ukrainian crystalline massive, with a widely developed system of groundwaters related to the Proterozoic and Cainozoic strata. Construction of a dam at the base of Gnilyi Rig to provide an artificial reservoir for the NPP, along with other construction activities, locally modified the natural hydrology and hydrogeology of the site. This, in conjunction with long-term changes in climate, particularly reduced average precipitation, has led to a series of changes in hydrogeology, the exact causes of which have yet to be determined. Local earthquakes at the site have not been registered.

Approximately 50% of the land within 30 km of the NPP site is utilised for agricultural purposes, the remainder is either forest or, particularly near the flood plains of the rivers, marsh, swamp or scrub. The agricultural land is used both for the production of cattle, pigs and sheep and their fodder, and for production of arable crops such as winter wheat, barley, oats, buckwheat, peas, sugar beet, chicory, potatoes, fruits and vegetables.

The forests and marshes provide a natural setting for a wide range of flora and fauna including several species that are listed in the Red Data Book of Ukraine. They also provide a setting for a number of sanctuaries of historical, recreational and nature conservation interest.

Substantial background information exists on air and water quality parameters in the vicinity of the NPP, including information on radionuclide concentrations in various environmental media.

4. THE PROPOSED PROJECT

The Khmelnitsky NPP currently operates one VVER-1000 nuclear reactor. Construction of a second VVER-1000 unit was stopped in 1991 at which time it was 90% completed. The second unit is of the same type as eleven other VVER-1000s which are currently operating in Ukraine. The proposal is, with an appropriate upgrading and modernisation programme, to complete the second unit; this essentially concerns electrical and control command equipment.

The VVER (a pressurised water reactor, PWR) is a concept that was developed during the 1970s. The power plant incorporates three principal heat transfer cycles. The first is the nuclear steam supply system, where the process of controlled nuclear fission is used to generate energy that is transferred to the pressurised primary coolant circuit. In the VVER-1000 Model 320, there are four primary coolant loops, each incorporating a steam generator heat exchanger, where heat is extracted from the coolant and used to raise steam in the secondary circuit.

The second heat transfer cycle is the power conversion system, where the steam in the secondary circuit is used to drive turbines connected to generators that produce electrical power. For the VVER-1000 Model 320 there is one 1000 MWe generator per reactor unit. Thermodynamic limitations allow for only one third of the thermal energy in the steam to be converted to electrical energy.

The third heat transfer cycle is the cooling water system, where the remaining energy is rejected to the environment as heat. At Khmelnitsky NPP this system is based on an open reservoir.

The existing reservoir receives all the flow of Gnilyi Rig and is maintained by abstraction of water from the Goryn river. Water supply requirements are dominated by the needs of the cooling water system and vary with season with less required in winter than in summer. For operation of the two reactor units it is estimated that between 16 and 19 million m^3 of water will need to be abstracted from the Goryn river per annum, a large fraction of which is required to maintain the status of the reservoir rather than for use in processes other than cooling within the NPP. Cooling waters are obtained from and returned to the reservoir with only blow-down water returning directly to the Goryn.

The NPP generates or accumulates five main liquid effluent streams: treated radioactive effluent, chemical water treatment effluent, oily water treatment effluent, domestic effluent, and rain water. All radioactive effluents produced within the plant are treated within the plant, with subsequent wastes from the treatment process stored in tanks following filtration and evaporation. Effluent streams other than domestic sewage are subject to separate treatment and monitoring within the plant prior to discharge to the reservoir. Domestic sewage is treated outside the plant prior to discharge to the reservoir.

The main sources of treated radioactive emissions to the atmosphere during normal operation are from routine degassing of the primary circuit coolant and residual losses of coolant from the primary circuit. Atmospheric emissions pass through the reactor building ventilation system, which incorporates various types of filter, before being discharged through the unit stack. The main non-radioactive emissions to air are water vapour and water droplets from the reservoir.

VVER reactors are operated on a cyclical basis. They are designed to be run continuously and then to be shut down each year for one to two months for routine maintenance and partial refuelling. During refuelling, approximately one-third of the fuel assemblies are removed and transferred to a storage pond alongside the pressure vessel. In addition to spent fuel, refuelling operations give rise to treated radioactive effluents and atmospheric emissions that are of a similar nature to those arising during normal operation. Maintenance activities result in the production of a variety of wastes contaminated with radioactive material.

Spent fuel is stored for a period of not less than three years to allow for the decay of short-lived radionuclides. In the past, spent fuel from the Khmelnitsky NPP has been shipped to Russia for reprocessing. Although this practice is continuing, the project includes plans for the development of long-term storage of spent fuel on site based on dry-storage methods which meet international safety and environmental standards.

Unit 2 at Khmelnitsky will make use of facilities provided by the existing 'special purpose building' to provide the first stage of treatment of operational wastes generated in the nuclear plant. Plans are already developed for the construction of a new facility for radioactive waste handling at Khmelnitsky. This facility will contribute to reductions in the volumes of wastes arising from the operation of unit 2 or already in storage as a consequence of operation of unit 1. In the longer term, various concepts exist within Ukraine for the development of a national radioactive waste disposal centre which will provide for secondary treatment of solid wastes and conditioning prior to disposal.

A package of regulatory documents dealing with the subject of decommissioning is currently in preparation. These define the general requirements for decommissioning and the strategy and general solutions to be taken to decommissioning. It is a requirement that, prior to the commissioning of VVER reactors, the operator shall have demonstrated during design an assessment of different strategies for decommissioning.

According to its extent, decommissioning and dismantling will result in the production of large volumes of both non-radioactive and radioactive wastes. The State programme on radioactive waste management has taken into account wastes likely to arise from decommissioning in the preparation of plans for a national radioactive waste disposal system.

5. RADIOLOGICAL PROTECTION ARRANGEMENTS

Ukraine operates a comprehensive and systematic approach to control of radiation exposure for both operators of NPPs and members of the public. Under recently introduced legislation, the standards that are applied will be at least as rigorous if not more rigorous than those recommended by the International Commission on Radiological Protection (ICRP).

For employees of the Khmelnitsky NPP, a comprehensive personal dosimetry and record keeping system has been established based on both external and internal exposure monitoring. A detailed programme of re-training in radiological protection, involving frequent assessment and training has also been established. The overall radiological protection system is controlled by a documented Quality Assurance programme. Application of internationally accepted principles of radiological protection, including that which requires that all exposures must be kept as low as reasonably achievable (ALARA) taking into account social and economic factors, will further ensure adequate protection of the workforce.

An environmental monitoring system for the zone within 30 km of the Khmelnitsky NPP is already well-established. This is based on regular monitoring of concentrations of radionuclides in media such as air, water, precipitation, soils, plants and animal products. It also includes dose rate measurements at a number of locations and several non-radioactive parameters. Existing results provide an adequate baseline against which the environmental and radiological effects of the K2 completion project can be evaluated.

In conjunction with all appropriate local, regional and national authorities, a comprehensive set of emergency plans has been developed. Regular emergency exercises are undertaken in line with international principles. The project allows for further development of such plans and for their approval by the nuclear regulatory authority before fuel can be loaded.

6. ENVIRONMENTAL IMPACTS

Ukrainian regulations set a limit on the total radiation dose to individual members of the public from operation of nuclear power plants of 0.25 mSv/yr with 80% of the actual dose allowable from atmospheric discharges and 20% from liquid discharges. This figure is consistent with, if not lower than limits recommended by ICRP. Assessments of the potential impacts of predicted discharges from K2 during normal operation, indicate that the annual dose to the most exposed member of the public located in the direction of the prevailing winds 3 km from the NPP i.e. at the boundary of the sanitary protection zone would be in the order of 4×10^{-4} mSv/yr i.e. substantially less than 1% of the regulatory limit. This dose is extremely small relative to natural sources of radioactivity and would mostly be not detectable against the background imposed by natural and man-made sources.

The situation regarding aquatic discharges to the cooling reservoir requires further investigation given the fact that the reservoir is already used for fish farming and that this practice could be extended. Preliminary but cautious calculations indicate that the individual annual dose to a member of a reference group consuming fish produced in the cooling reservoir and drinking water from the reservoir might approach 0.027 mSv/yr. This figure is 54% of the corresponding limit applied in Ukraine. This limit is, however, extremely restrictive relative to those that can be derived from ICRP. The calculations will be refined as part of the Environmental Action Plan for the project.

The annual collective dose to the population residing within 30 km of the NPP is estimated to be in the order of 0.01 man-Sv/yr. This corresponds to a population exposure of 0.00001 man-Sv per MW-yr of generation, a figure which is consistent with international experience.

Transport of fuel and spent fuel to and from the NPP will be in accordance with international safety standards which have been designed to ensure a very high level of safety.

Environmental impacts may arise during completion of the construction and operation of K2. The main kinds of impact during construction works in general are those associated with noise, effects of transportation, emissions to air, discharges to water, and disposal of solid wastes. These impacts can be mitigated by good working practice. Effects of impacts such as noise and transport are reduced due to the imposition of a sanitary protection zone within 3 km of the NPP; beyond 3 km from the NPP such impacts are of little significance.

The main potential impacts to be considered for the operational situation are those associated with residual discharges of potentially toxic or nuisance materials to air or water, discharges of heat to atmosphere and water, and impacts on local hydrology and hydrogeology. A programme of mitigation measures will be put in hand to prevent or minimise the discharge of hazardous materials from the Khmelnitsky NPP to the surrounding environment. This, in conjunction with an appropriate Environmental Management System, will help to ensure that there are either no adverse effects on the environment or that any such effects are minimal.

The K2 project will make use of the existing system of abstraction and cooling. Water abstraction from the Goryn river and loss to the atmosphere as vapour or droplets, could have potential associated environmental impacts. Abstraction of water from the Goryn river is currently limited to non-vegetative seasons and this practice will be continued. The non-vegetative period is also the period when the flow in the river is greatest. A revised assessment of the impacts of abstraction and use of water for cooling purposes will form part of the Environmental Action Plan for the project. This assessment will consider the potential seasonal accumulation of both radioactive and non-radioactive contaminants in the waters of the cooling reservoir.

7. SAFETY STUDIES

A detailed safety evaluation of the project has been completed. The partner companies in the organisation that undertook this study act as independent technical safety advisors to nuclear regulatory agencies in Germany and France. The conclusion of the study was that the project would allow the safety of the plant to be comparable to that achieved in the European Union for NPPs recently re-approved by national safety authorities.

An assessment has been undertaken of the potential consequences of the worst-case design-basis accident (DBA) for K2. This concept is used to provide a robust demonstration of the plant fault tolerances and of the efficiency of the safety systems. In line with international practice, a deterministic analysis of the potential consequences associated with a range of potential accidents, namely the design basis accidents, is required. For PWRs, the double-ended rupture of a large primary pipe (LOCA-LB) is the most serious. The assessment, utilising pessimistic assumptions for factors such as meteorological conditions, indicated that the maximum potential committed effective dose to hypothetical individuals located 3 km from the NPP would be less than 0.1 mSv, and that the maximum individual thyroid dose would be less than 1 mSv. It therefore indicates that the consequences of such an accident would be far below the lower threshold for internationally accepted criteria for the implementation of emergency countermeasures i.e. 50 mSv. Nevertheless, a complementary deterministic evaluation of the radiological consequences of the DBA, including ingestion pathways, will form part of the Environmental Action Plan for the project.

A further assessment has been undertaken to estimate the collective dose for the population within 200 km of the NPP. This indicated an expectation value of 1.2 man-Sv. This figure is very small when compared with the size of the population. It is considered extremely unlikely that any health consequences could be detected in any post-accident epidemiological study.

A comparable assessment has been carried out for assessing the potential consequences of the beyond design-basis accident. Such conditions are associated with events or combinations of events which have a very low probability of occurrence, but which would have serious consequences. The analysis of such events is required by the ‘Basic Safety Principles for NPPs’ (INSAG-3-IAEA 1988). The scenarios include the so-called ‘Anticipated Transients Without Scram’ (ATWS), the total loss of steam generators feedwater, the total loss of normal and emergency on-site and off site electrical power. The assessment made use of a source term which has still to be confirmed in the frame of the safety analysis for the plant that is currently in preparation. It indicated that the lower intervention level for implementation of protective countermeasures was not reached at the boundary of the 3 km zone. The assessment will be repeated once the safety analysis has been completed and submitted to the nuclear regulatory authority and prior to the unit being put into operation.

8. ENVIRONMENTAL ACTION PLAN

An outline of the contents for the Environmental Action Plan (EAP) has been prepared as a basis for discussion with all relevant parties. The EAP addresses those issues for which further investigations will be required prior to the plant being put into operation, as well as the system of environmental management that will be applied during operation of the plant to ensure that identified mitigation measures are implemented and that their effects are monitored. The EAP is to be developed in discussion with the NPP management and to be agreed with regulatory authorities and those organisations contributing to the financing of the project.

9. PUBLIC CONSULTATION

Public consultation has been undertaken at two stages during the EIA process. First during the scoping stage, and secondly during preparation and publication of the EIA report. The objective of the first stage was to allow the public and other parties to raise issues which should be addressed in the EIA. This stage was initiated in August 1996 and involved three scoping meetings, one in Kyiv in November 1996, one in Netishin in December 1996, and one in Rivne also in December 1996. The outcome of these meetings was taken into account when agreeing the initial and revised terms of reference for the EIA project.

The objective of the second stage is to actively seek public consultation during preparation of the EIA and on publication of the EIA report. A list of contents of the EIA was made available at a number of locations in Ukraine during early summer 1997, followed by a public meeting in Kyiv during September 1997. The results of that meeting were recorded and the comments received, along with those submitted in writing subsequent to or following the meeting, were taken into account in preparing the present version.

10. ‘BASE CASE ALTERNATIVE'

The EIA has not included a comparison of the environmental impacts of the proposed project with alternatives. Such alternatives could, for example, include construction of completely new NPPs, the refurbishment of existing non-nuclear power generation facilities, the construction of new thermal power stations based on oil, gas or coal, and the implementation of methods to reduce Ukraine's energy requirements.

Given that the project has been proposed as an alternative to continuing to operate the Chornobyl NPP, an initial comparison has been provided for the “base case alternative”. In this comparison it is assumed that operation of two of the four Chornobyl RBMK reactors is continued following the completion of an appropriate upgrading and safety programme.

It is concluded that routine discharges of radioactivity from two RBMK units operating at Chornobyl would significantly exceed those arising from operation of two VVER-1000 units. It is noted that the RBMK reactor is inherently less safe than is the VVER reactor. The no-change option therefore would result in both increased discharges of radioactivity to the environment during normal operation and an increased risk of a catastrophic accident leading to widespread contamination.