REPUBLIC OF BULGARIA

NATIONAL REPORT

SECOND EXTRAORDINARY MEETING UNDER THE CONVENTION ON NUCLEAR SAFETY

Sofia, May 2012

CONTENTS

A. INTRODUCTION

The Republic of Bulgaria joined the Convention on Nuclear Safety (the Convention) in 1995. The Convention was ratified by an Act of the 37-th National Assembly on 14.09.1995, and entered into force on 24.10.1996. With its accession to the Convention, the country confirmed its national policy to maintain a high level of nuclear safety, to ensure the required transparency and to implement the highest safety standards.

As a Contracting Party, the Republic of Bulgaria took part in the five previous review meetings, held respectively in 1999, 2002, 2005, 2008 and 2011, organised pursuant to Article 20 of the Convention. In accordance with Article 5, at each of them Bulgaria presented its National Reports on fulfilment of the obligations under the Convention.

BACKGROUND

On 11-th March 2011, Japan suffered the biggest earthquake in its history, called by the Prime Minister of Japan Naoto Kan, "the most serious challenge since the Second World War." Confirmed casualties are about 16,000 people and 4,000 are missing, while nearly 500,000 buildings were damaged or destroyed. The earthquake with epicentre in the Tohoku region and magnitude 9.0 on the Richter scale was recorded about 110 miles from the site of NPP Fukushima Dai-ichi (Fukushima 1). Earthquake generated a tsunami that at the region of Fukushima reached a height of 15 m. Following the earthquake and in particular the tsunami, a severe nuclear accident occurred at the Fukushima Dai-ichi NPP, which was rated at Level 7 on the INES scale (the highest level).

Despite the fact that a tsunami is not a real threat to the territory of Bulgaria, the government took urgent measures to analyze the current situation in the light of the accident.

As a full EU member, Bulgaria actively participates in the "stress tests" of the European nuclear reactors in operation, as a systematic reassessment of facilities safety margins against disastrous natural events that could lead to severe accidents.

NATIONAL NUCLEAR PROGRAMME

Bulgarian nuclear energy program was initiated in 1974 with the commissioning of the first unit of the Kozloduy NPP. Country nuclear power capacities are concentrated at the Kozloduy NPP site.

NATIONAL POLICY

Nuclear energy is a major factor in the country energy mix, in terms of high technology and production efficiency, competitive prices, and maintaining a high level of nuclear safety and radiation protection. A fundamental principle in the development of nuclear energy in the country is the national responsibility to ensure the safety of nuclear facilities.

Bulgarian Energy Strategy till 2020 provides for the retention of the share of nuclear generated electricity. This strategy will be implemented by lifetime extension of existing nuclear units and construction of new nuclear capacities.

Accepting that peaceful use of nuclear energy contributes to economic and social development and raise of living standards, the Republic of Bulgaria confirms that in the use of nuclear energy, protection of the health of individuals, the public as a whole, including future generations and the environment are of first and highest priority.

NUCLEAR FACILITIES

Nuclear facilities, finally shutdown for decommissioning

Kozloduy NPP Units 1 and 2 were finally shutdown for decommissioning in 2002. These two units are completely free of nuclear fuel and for this reason will not be considered in the report.

Kozloduy NPP Units 3 and 4 were finally shutdown for decommissioning in 2006. For Units 3 and 4 it should be noted that irradiated fuel assemblies are stored at the lower racks of the near-reactor Spent Fuel Pools (SFP) of the two units, respectively SFP-3 and SFP-4. Despite the fact that complete release of the units from nuclear fuel it planned for the end of 2012, SFP-3 and SFP-4 were analyzed against extreme external impacts and loss of safety functions.

Facilities, related to the safe storage of SF and RAW

A facility for storage of spent nuclear fuel from WWER-1000 and WWER-440 reactors is available at the Kozloduy NPP site. The storage facility is a wet type and operates under an operating license issued by the BNRA. Safety analyses performed for the facility are reported hereafter.

A new spent fuel storage facility of dry type is being constructed. The facility is located on-site and its capacity is sufficient to host all the spent fuel expected with from the operation of WWER-440 units. At present, the new facility is in a commissioning stage. The safety of the facility was reassessed for the purposes of this Report.

Reactors in operation

Kozloduy NPP Units 5 and 6 are equipped with WWER-1000/V320 type reactors and were commissioned respectively in 1987 and 1991. Since October 2009 Units 5 and 6 have renewed operating licenses - till November 2017 for Unit 5 and October 2019 for Unit 6. In light of the Fukushima Dai-ichi nuclear accident, the main focus of the performed safety reassessment falls over these two units.

New Nuclear Capacity

The Republic of Bulgaria planned the construction of a new nuclear capacity at the Belene site. Belene NPP was intended to include two WWER-1000 units of the A 92 design. Plant design was being reviewed by the Bulgarian Nuclear Regulatory Agency (BNRA) for more than four years. Numerous internal and external expert reviews and analyzes were conducted by both Bulgarian and international expert organizations.

In March 2012 the Bulgarian government took a decision to terminate the Belene NPP project. This decision was lately confirmed by the Parliament. Irrespective of that fact, the report provides information on design safety reassessment performed.

REPORT CHARACTERISTICS

This Extraordinary National Report gives an overview of the main results of the thorough safety reassessment of the nuclear facilities in Bulgaria. Special attention is paid to the reassessment of the design basis and evaluated safety margins, as well as the planned improvement measures (at the level of government, regulatory authority, and licensee).

The report was prepared by the Nuclear Regulatory Agency with the active cooperation of licensees, other state authorities and organizations involved. The report was approved by the Council of Ministers of Bulgaria.

STRUCTURE

The report is structured in accordance with the guidelines issued by the International Atomic Energy Agency (IAEA) in the document "Second CNS Extraordinary Meeting (August 2012) Guidance for National Reports, Addendum". An attempt was made to prepare a self-standing document with format and content, which does not require familiarization with the separate detailed licensees reports in respect to the various external events.

Country actions in response to the Fukushima Dai-ichi NPP accident are presented under Section B of the report. Section C presents the detailed results of the analyzes. A summary table of planned measures, including the responsible organization and implementation timeframe is included as Appendix 1 of the report.

SCOPE

Reported analyses cover all operating nuclear facilities, located on the Kozloduy NPP site, namely:

- Spent Fuel Pool of Unit 3 (SFP-3);
- Spent Fuel Pool of Unit 4 (SFP-4);
- Unit 5 – WWER-1000;
- Unit 6 – WWER-1000;
- Spent Fuel Pool of Unit 5 (SFP-5);
- Spent Fuel Pool of Unit 6 (SFP-6);
- Spent Fuel Storage Facility (SFSF) wet type;
- Dry Spent Fuel Storage Facility (DSFSF);

In accordance with the guidelines for the preparation of national reports, analyzes are focused on the following initiating events:

- earthquake;
- flooding;
- other extreme weather conditions.

For each of these events, the analyzes are directed towards:

- definition of design basis and current status of components and structures;
- identification of safety margins;
- establishment of preventive measures against the respective impact.

To determine the robustness of the abovementioned facilities against the initiating events, analysis also cover assessments of the consequences in case of loss of safety functions:

- loss of power supply;
- loss of ultimate heat sink;
- combinations of the two.

The following issues in respect of severe accident management are also included:

– protective and management measures in loss of core cooling;

– protective and management measures in loss of spent fuel cooling in SFP, SFSF and DSFSF;

– protective and management measures in respect of containment integrity.

B. COUNTRY RESPONSE TO THE ACCIDENT

IMMEDIATE ACTIONS

Immediately after the Fukushima NPP accident, the Bulgarian Government stressed on the need for urgent action to reassess Kozloduy NPP preparedness to respond to emergencies. A meeting of the Prime Minister with the Kozloduy NPP management was held on 21-st March 2011, where the government requested the implementation of urgent actions at national level.

INITIAL REVIEW AND VERIFICATION

On 24-th March 2011, BNRA objectified the Government initiative and specified to Kozloduy NPP the regulatory requirements for review and verification of:

- technical status, working conditions and operability of structures, systems and components (SSCs) involved in management of severe accidents;
- monitoring and protection from external events (earthquake, external flooding, extreme weather conditions);
- the provision of power supply to on-site consumers from the grid and from the independent sources of power supply;
- monitoring and heat transfer to the ultimate heat sink.

BNRA also requested verification of adequacy and applicability of the instructions and procedures for operators actions in case of design and beyond design basis accidents, as well as the capabilities of the operators and the emergency teams to follow them.

These requirements aimed at taking prompt and short-term actions to reassess plant safety till the adoption of uniform requirements for all EU nuclear power plants, recently known as "stress tests". The operator was given one month to develop respective programs and three more months for implementation and reporting of results.

Kozloduy NPP fulfilled these requirements and on 10-th June 2011 submitted to BNRA the respective review report. Main report findings demonstrated: compliance of the technical conditions of safety important SSCs with the design requirements; availability and applicability of instructions and procedures; and staff preparedness to act in emergencies. No significant gaps that require urgent safety improvements or restrictions on plant operations were identified.

Despite the good results, a need was identified for optimization of Kozloduy NPP response to simultaneous impact to on-site facilities by external hazards. Proposed improvements could be divided into the following groups:

- measures to improve preparedness for severe accident management;
- measures to improve plant response to external and internal events and improve response preparedness;
- measures to improve the reliability of external and independent power supply;
- measures to improve staff preparedness of act in radiological emergencies, including review of the emergency plans; etc.

REGULATORY CONCLUSIONS

BNRA accepted the Kozloduy NPP report and assessed as adequate the improvement measures proposed. BNRA opinion is that assessment report does not highlight any significant deficiencies, which require urgent actions to increase plant response against external hazards, similar to those that caused the Fukushima event.

EU STRESS TESTS

Following the Fukushima NPP accident, the European Community declared that ".. the safety of all nuclear power plants in the European Union should be reviewed on the basis of comprehensive and transparent risk assessment (stress tests)". On 25-th March 2011, the Council of the European Union asked the EU countries, including Bulgaria to conduct "stress tests".

"Stress tests" were developed based on initial ideas of WENRA (Western European Nuclear Regulators Association) and in May 2011 ENSREG (High Level Group on nuclear safety, spent fuel and radioactive waste) and the European Commission adopted a Declaration on the upcoming "stress tests". Specific methodology, deadlines for submission of national reports, transparency issues, etc. were presented in the Annexes to this Declaration.

According to the ENSREG Declaration of 25 May 2011, "stress tests" are targeted reassessments of NPP safety margins, in the light of the Fukushima NPP accident: extreme external events, which could impact the fulfilment of the safety functions and result in a severe accident. Declaration was published on the ENSREG website. As a result, in late May 2011, the Nuclear Regulatory Agency has formally requested from the Kozloduy NPP to perform the demanded safety reassessment using the ENSREG methodology.

Plans for submission of assessment reports were as follows:

	Progress reports	**Final reports**
Licensee reports	15 August	31 October
National reports	15 September	31 December

The main purpose of progress reports was to show that the Member State had already initiated the safety reassessment and had adopted and consistently applies the ENSREG methodology.

Kozloduy NPP submitted its progress report in time (August 15, 2011), and the BNRA respectively submitted the Bulgaria National Progress Report to the European Commission also in time (September 15, 2011). The report is published on the BNRA website www.bnra.bg. All Member States progress reports are published on the ENSREG website.

Bulgaria sent to the European Commission its final report on the stress tests in time (December 31, 2011) and published it at the BNRA website. According to the ENSREG Declaration, national reports are subject to peer reviews. Respective peer review mechanism, management board, team leaders and members were approved by ENSREG in October-November 2011.

Submission to Council of the European Commission report on the final results from the "stress tests" is planned for the end of June 2012. It should be noted that issues of safety and security of European NPPs are reviewed in parallel and that terrorist threats are not included in the stress tests.

STRESS TESTS OF THE BELENE NPP DESIGN

On 30 May 2011, BNRA requested from the NEK to perform "stress tests" of the Belene NPP design, although since April 2008 this design is being licensed by the BNRA and formally it does not fall into the category of nuclear power plants, for which safety reassessment against extreme external events is required. BNRA objective is to obtain further information in respect to Belene NPP safety, which to be used in the ongoing licensing process.

REVIEW AND ASSESSMENT

The following external initiating events were reviewed and reassessed by the stress tests:
- earthquakes;
- flooding;
- extreme weather conditions.

The reassessment cover the extent and frequency of occurrence of the maximum design initiating event, its progression and how structures, systems and components are designed and qualified to withstand the maximum design event. Review of initiating events cover also the evaluation of existing safety margins for the NPP as a whole and for individual structures, systems and components. Following the assessment of these margins, licensee should propose possible improvements to expand safety margins and to prevent or mitigate the consequences (cliff edge effects).

Analyses cover the following key effects from loss of safety functions:
- loss of power supply;
- loss of ultimate heat sink;
- combinations of the two.

CONCLUSIONS

General conclusions from the performed review and assessment of Belene NPP design are as follows:
- with respect to beyond design basis accidents, the design provides appropriate safety systems, the automatic operation of which to maintain or restore the safety functions. If "Control of reactivity" is affected (failure of the scram system) two other safety systems are triggered: the quick boron injection system (passive system) and the emergency boron injection system (active system);
- In impacts to the "core cooling" function, if the active systems for emergency core cooling are inoperable, water supply to the primary circuit is performed by passive systems (hydro accumulators: first and second stage);
- In design and beyond design basis accidents, heat removal from the secondary side is performed by the SGs emergency cooldown system (active system). In unavailability of that system, SGs cooldown is carried out by the passive heat removal system (PHRS);
- Beyond design basis accident (rupture of a primary pipe with a maximum diameter) and simultaneous loss of all on-site power sources lasting for 24 hours (design condition) does not lead to severe accident: no core melt, no steam-zirconium reaction, and respectively no risk of hydrogen explosion. The transfer to severe accident conditions is after the specified time interval if action to recover power supply are not taken. Severe accidents do not lead to loss of containment integrity.

Loss of emergency power supply for more than 24 hours

Even in total loss of AC power, safety functions are fulfilled by the passive systems and the Unit could be shutdown and maintained in a safe state for a long time. Analyses show that irrespectively of the combination of initiating events and the postulated additional failures, operation of only two of the PHRS trains ensure the safe state of the reactor fuel (no outcrop) for 159 days and in operation of the all 4 trains of the PHRS for 231 days.

Loss of ultimate heat sink and containment cooling

Even in loss of the main cooling water and loos of the spray ponds, the PHRS is capable of cooling down the reactor installation. Analyses of all postulated failure scenarios, that lead to severe accidents, show that with the operation of the passive safety systems containment design pressure will not be exceed.

Loss of SFP cooling

In loss of SFP cooling and loss of make-up capabilities and using conservative assumptions, there is sufficient time available before fuel outcrop in all possible arrangements of the spent fuel in the SFP.

Management of severe accidents

Severe accident management principles, incorporated in the design, are in conformity with the requirements towards last generation NPPs and respectively the design provides for the required technical measures to ensure implementation of the procedures for severe accident management.

DESIGN IMPROVEMENT MEASURES

As a result of the Belene NPP design stress tests, the following potential measures for further design improvement were proposed:

- Enhancement of plant robustness against extremely low levels of the Danube River;
- Enhancement of SFP robustness against decrease of cooling water level by implementation of administrative and technical measures;
- Increase of safety functions monitoring time by provision of additional mobile AC sources or battery recharging;
- Analyses of the possibilities for forced reduction of containment pressure as a supplementary measure in respect of severe accident management.

As a conclusion, Belene NPP design stress tests demonstrated that plant design basis and plant safety level in case of occurrence of the analysed initiating events are properly addressed. Respectively, plant design provides for sufficient safety margins. Through the availability of both active and passive systems for severe accident management, Belene NPP is prepared for beyond design basis, namely major radioactive releases to the environment will be prevented.

IAEA PEER REVIEW OF THE BELENE NPP DESIGN STRESS TESTS REPORT

On a BNRA request, an IAEA international expert team performed peer review of the Belene NPP design stress tests report in the period 12-16 December 2011. The expert team included representatives from Czech Republic, France, Germany and the IAEA. Peer review was carried out on the basis of IAEA safety standards (including latest publications).

Main findings

- **In respect to assessment of seismic hazards**

At the last IAEA mission to review the Belene site held in 1997, the suggested existence of a fault along the Danube banks was rejected. Following this mission, a probabilistic assessment of site seismic hazards was carried out using the state-of-the-art methods. The results of this evaluation are consistent with the results from the assessment of seismic hazards for the Bulgaria territory. An important study result is that the annual probability of exceeding the beyond design basis earthquake level (which is 40% higher than the design level) is about 10^{-5} times per year (i.e. once in 100 000 years).

- **In respect to seismic design**

Main design requirement is that the plant shall be safe at beyond design basis earthquake, which exceeds the design basis one with 40 %. Respectively, Belene NPP possesses significant inherent robustness against earthquakes.

Conclusions

According to the international experts, Belene NPP design ensures adequate technical provisions to cope with the entire spectrum of accidents, which should be considered by the design of the latest generation of NPPs (III +). Regarding the ENSREG "stress tests" criteria, as well as the IAEA safety standards, it was proven that significant safety margins and response time are available for almost all accident conditions. This is achieved mainly by application to the safety systems of various diversified principles, and due to the availability of large water inventory inside the containment structure.

Another major experts finding is that the Belene NPP design includes certain inherent safety features to prevent severe accidents and to mitigate their consequences. The "stress tests" report conclusively demonstrated that the Belene design is reliable in terms of prevention and mitigation of severe accidents, since these accidents are analysed in the design. This includes preventive part of accident management, which is extremely reliable due to the combination of redundant active safety systems, supported by passive safety systems, as well as the specialized systems for mitigation of severe accidents consequences.

According to the analyzes, core damage frequency is about $5{,}11 \times 10^{-7}$ r/a with all events at reactor power operations; shutdown state; external fires, and respective external events being considered. These values indicate a high level of safety. The contribution of external events is only about 1.6% of the total core damage frequency.

C. PRESENTATION OF TOPICS – KOZLODUY NPP

TOPIC 1 - EXTERNAL EVENTS

EARTHQUAKE

INITIAL SEISMIC DESIGN BASIS OF KOZLODUY NPP

According to the design of Kozloduy NPP Units 1 and 2 (of 1973), the seismic activity in the region had been evaluated as below VI degree of the Medvedev-Sponheuer-Karnik seismic intensity scale (MSK-64). Following the March 1977 earthquake, with epicentre in the region of Vrancha mountain, site seismic re-evaluation had been performed. The Operational Base Earthquake (OBE) was set to VI degree with Peak Ground Acceleration (PGA) of 0.05g and Design Basis Earthquake (DBE) to VII degree with PGA of 0.1g.

The following site maximum seismic impact had been adopted in the design of Kozloduy NPP Units 3 and 4:

- OBE - VI degree by MSK-64 scale
- DBE - VII degree by MSK-64 scale;
- Surface response spectrum – the spectrum of Vrancha earthquake accelerogram dated 04.03.1977, recorded in Bucuresti and aligned to PGA of 0.1 g.

The design of Units 5 and 6 had been developed based on the following seismic characteristics:

- OBE - VI degree by MSK-64 scale with PGA of 0.05g for recurrence period of 100 years; and
- DBE - VII degree by MSK-64 scale with PGA of 0.1g for recurrence period of 10000 years.

The SFSF had been designed in the period from 1982 to 1984 with the following seismic characteristics: DBE = VII degree by MSK-64 with PGA of 0.1g for recurrence period of 10 000 years.

The DSFSF had been designed and constructed after 1992 and its design incorporated the actual seismic characteristics of the site, as defined in 1992:

- OBE Seismic Level 1 (SL1) with PGA of 0.10g for recurrence period of 100 years;
- DBE Seismic Level 2 (SL2) with PGA of 0.20g for recurrence period of 10000 years.

CURRENT SEISMIC DESIGN BASIS

Current seismic characteristics of the Kozloduy NPP site were defined in the period 1990-1992 and are valid for all facilities located on the site.

REASSESSMENT OF SEISMIC DESIGN BASIS

In the period 1990-1992, under a joint IAEA project BUL 9/012 “Site and Seismic Safety of Kozloduy and Belene NPPs”, new site seismic characteristics were defined. Seismic levels for recurrence period of 100 and 10000 years respectively were determined using probabilistic and deterministic methods. Thus, for Kozloduy NPP site were defined:

- For recurrence period of 100 years - PGA of 0.10g;

- For recurrence period of 10000 years - PGA of 0.20g; and
- Resultant floor design response spectra and respective three-component accelerograms for duration of 61s.

Following an IAEA recommendation, a floor design response spectra and respective three-component accelerograms (for duration of 20 s) were additionally defined for local earthquakes.

The seismic characteristics – seismic levels, resultant design floor response spectra and respective three-component accelerograms were reviewed and confirmed by IAEA experts in the period from 1992 till 2008. The so called Review Level Earthquake (RLE) was also defined. This is the level, for which all SSCs of 1st seismic category of plants already designed and commissioned should be reviewed in respect of seismic resistance.

METHODOLOGY FOR REASSESSMENT OF SEISMIC DESIGN BASIS

The reassessment of site seismic characteristics performed in the period 1990-1994, under an IAEA project BUL, followed the existing at that time IAEA documents, namely:

- Safety Series No.50-SG-S1 (rev.1) "Earthquake and associated topics in relation to nuclear power plant siting";
- Safety Series No.50-SG-D15 "Seismic Design and Qualification for NPPs".

The two standard levels of peak ground acceleration with recurrence periods respectively 100 (SL1) and 10000 years (SL2) are determined based on tectonic, geological, geomorphologic, seismic and geophysical data using probabilistic and deterministic methods. The RLE is defined by application of the rules for defining SL2.

The methodology for probabilistic analysis of the seismic hazard is based on standardized mathematical model of Cornel and the software of McGuire 1976 and Toro and McGuire 1988.

Results summary highlighted the following main conclusions:

- in the investigated area there are no large faults with high energy potential (there is no data of existence of a capable fault).
- Kozloduy NPP site is located in the relatively most stable part of the Moesian platform. This conclusion is confirmed also by the data, accumulated in the existing already for 14 years database of the local seismic monitoring network located around the site.

The earthquake database, which was used, covers the period from 375 till 1990. The catalogue contains 812 independent seismic events with defined MSK-64 intensity. Uncertainties in the seismic input data were studied and considered through the so called logical tree (logic diagram). 24 seismic hazard curves were defined. The characteristics of the design seismic impact were defined as well – design floor response spectra and respective three-component accelerogram, taking into account site geological conditions.

ASSESSMENT OF THE ADEQUACY OF THE REASSESSED SITE SEISMIC DESIGN BASES

All aspects and stages of seismic characteristics reassessment were discussed by multiple international missions involving IAEA experts and leading specialists in this area from Bulgaria, Macedonia and Romania. The seismic input databank was adopted and validated by the follow-up international activities and international expert missions.

COMPLIANCE WITH APPLICABLE LEGISLATIVE DOCUMENTS AND STANDARDS

Reassessment of site seismic characteristics had been performed mainly based on the IAEA Safety Standard. Using comparative analysis it was confirmed that site seismic characteristics, as reassessed in 1992, together with the additional studies of 1995 meet the requirements of both current documents: the IAEA Safety Standards Series No. SSG-9 "Seismic Hazards in Site Evaluation for Nuclear Installations", 2010; and the Regulation on Ensuring the Safety of NPPs of 2004, namely:

- the site shall not be located directly over a capable fault;
- peak ground acceleration during an earthquake with recurrence period of 10000 years shall be less than 0.4g.

CONCLUSION ON THE ADEQUACY OF THE CURRENT DESIGN BASES

Kozloduy NPP site seismic characteristics, reassessed in 1992, together with the additional studies of local earthquakes and the probabilistic definition of seismic impact performed in 1995 meet the requirements of existing legislation, namely:

- in the investigated area of the Kozloduy NPP site, there are no large faults with high energy potential (no evidence of a capable fault);
- Kozloduy NPP site PGA is defined for an impact with recurrence period of 10000 years and PGA is 0.2g.

PROTECTIVE MEASURES AGAINST RLE AT UNITS 3 AND 4

SSCS REQUIRED TO MAINTAIN THE FSP 3 AND 4 IN SAFE CONDITIONS

Equipment actual state and operability have been determined on the bases of a review of seismic qualification of the elements (components) and the method for seismic qualification of seismic category 1 SSCs.

Following the implementation at Units 3 and 4 of the Short-term Programme and the Comprehensive Modernization Programme, all safety related design and operation deficiencies have been eliminated and the facilities comply with the current safety standards and the international practice.

Seismic categorization of the individual elements of the main buildings had been completed with consideration of related factors and the results of modifications and improvements of the original design V230. Reinforcement of reactor buildings was implemented in 2001, which significantly improved structures reliability. The seismic qualification of major civil structures of seismic category 1 and seismic category 2 was confirmed.

The initial deign classification of Units 3 and 4 systems had been carried out on the bases of the existing at that time Regulation No. 3 on Ensuring the Safety of NPPs at Design, Construction and Operation (1988) and the Russian Requirements on Ensuring the Safety of NPPs at Design, Construction and Operation OPB-82. Later on, systems and components have been classified in accordance with the current legislation. Qualification procedure compliance with the international requirements is verified. Systems and equipment have been re-qualified as follows:

- Safety classification was performed according to IAEA 50-SG-012: Periodic Safety Review of Operational Nuclear Power Plants, A Safety Guide, 1994 as the fundamental document, and other IAEA documents were used as supplementary;
- Seismic classification was performed based on the IAEA Guide NS-G-1.6 Seismic Design and Qualification for Nuclear Power Plants Safety Guide, while the

requirements of Russian PNAE G-5-006-87 Norms for design of seismically resistant NPPs were also considered.

The qualification was performed for the components included in the Safe Shutdown Equipment List (SSEL) and those needed for the safe storage of Spent Fuel (SF) in the Spent Fuel Pool (SFP). Seismic qualification and operability of the equipment ensuring the safe storage of SF in the SFP has been confirmed.

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KEY OPERATIONAL MEASURES TO MAINTAIN SFP 3 AND 4 IN A SAFE STATE FOLLOWING AN EARTHQUAKE

According to the updated Safety Analysis Report (SAR) of 2004, measures have been planned and implemented at Units 3 and 4, which ensure the required protection against seismic impacts and fires. Additionally, to ensure the safe and reliable storage of SF in the SFP, seismic qualification of the systems ensuring SFP operations was carried out. With respect of the requirements of the Regulation on the SF Management, the updated analysis of postulated initiating events for shut down state confirm: compliance with the criteria at different water density, as well as sufficient redundancy in SFP cooldown and filling systems.

The SFP civil structure is capable to perform design functions and possess the required robustness and carrying capacity at different load combinations, including in emergencies - thermal and seismic impacts at DBE. Robustness of SFP racks at different modes has been confirmed as well. Procedures have been developed, which specify personnel actions in reaching of the SFP storage safety limits and for implementation of measures only by using of specific programmes (to be agreed by BNRA).

Following the Fukushima Dai-ichi accident, events in, a set of technical and organizational measures was developed, aimed at a comprehensive review and assessment of the current status of safety related equipment. Special attention was given to Beyond Design Basis Accidents (BDBA) and adverse external and internal impacts to the storage of spent fuel in the SFP. The following measures have been developed and implemented:

– a list of BDBA scenarios for Units 3 and 4 was developed;
– a BDBA scenarios training programme was prepared for the operating personnel of Units 3 and 4.

EVALUATION OF THE INDIRECT IMPACT OF THE EARTHQUAKE

Assessment of potential failures of SSCs - not qualified seismically

Analyses of the conditions of the ventilation reinforced concrete chimney of Auxiliary Building 2 (AB-2) demonstrate proper robustness. According to the analysis (REL-880-FR-01-0), it was concluded that if during RLE seismic impact, one third of the ventilation chimney length (50 m from the top) fall down, the debris will fall over the AB (south-east part) and the radioactive contamination could complicate the access of the personnel to some areas, for example the building of the Additional SG Emergency Feedwater System (AEFWS).

Potential loss of off-site power

In Loss Of Off-site Power (LOOP), backup power supply to SFP cooldown pumps is ensured by the AEFWS sections (additionally to the power supply from the diesel generators).

A conservative scenario involving an earthquake and parallel accidental conditions at other nuclear facilities on-site, the use of a Mobile Diesel Generator (MDG) in two different places will be required. Respectively, it becomes obvious that availability of at least two MDGs is needed.

Loss of ultimate heat sink

According to the safety analysis, there is a possibility to connect additional alternative systems to fill up and cooldown the SFP. These systems could provide sufficiently large flow-rate in order to maintaining the SFP level till the elimination of the leakage or the transfer of the fuel into the reactor core.

The AEFWS is involved in the scenario with loss of Ultimate Heat Sink (UHS). In case of loss of Bank Pumping Station (BPS) and the standard systems (primary and secondary circuits) remaining operational, to cooldown SGs, the water inventories enclosed in between the fore chamber of Central Pumping Station 2 (CPS-2), the fore chamber CPS-1, and the underwater barrier (at curve 8), which prevents cooling water flow back to the BPS are used.

The service water system for essential consumers ensures supply of cooling water to the heat exchangers for SFP cooling. System back-up is provided by the Fire Extinguishing System 2 (FES), through two collectors cut into the service water surge lines.

An emergency pumping station was built in close proximity to BPS-2 and BPS-3. The emergency pump station ensures independent water supply from the fore chamber of BPS-2 and BPS-3 to the cold channel.

If due to any reason, the operability of the spray ponds is lost, the AEFWS-3,4 systems are to be used for cooling of the nuclear facilities. The AEFWS-3,4 tanks are provided with backup supply of water by both the FES and the artesian wells on-site.

SEISMIC PROTECTIVE MEASURES FOR RLE AT UNITS 5 AND 6

SSCS REQUIRED TO PUT INTO AND MAINTAIN UNITS 5 AND 6 IN SAFE SHUTDOWN STATE

Based on the existing plant SSEL, the SSCs required for plant shutdown and maintaining it in safe condition and which should remain available during and after an earthquake have been identified.

The analyses focused mainly on the reactor installation at power and in particular on the limits ensuring the integrity of the second protective barrier – fuel elements cladding. The SFP stress tests cover the respective structures at manipulation of SNF (the most adverse operational states allowed by the technical specifications) with the same objective – to preserve the integrity of fuel elements cladding.

Within the Modernization Programme, the seismic resistance of all safety related buildings and structures was reviewed in respect of site specific impacts. The seismic qualification of main structures of seismic category 1 was confirmed.

Seismic qualification of safety related equipment as well as verification of compliance with international standards were performed as part of the Modernization Programme. Equipment qualification status was verified and lists of the equipment required for the safe shutdown of the units were developed:

– SSSL (Safe Shutdown Systems List);
– SSEL (Safe Shutdown Equipment List);
– HECL – Harsh Environment Component List.

Following the analysis of the current qualification status of the equipment, these lists were reconsidered and updated, as part of a contract between Kozloduy NPP and VNIAES – Moscow. Recently, seismic qualification of the remaining not qualified equipment is being carried out. The process of plant seismic qualification continues in a systematic way, including during supply of new equipment, maintenance and improvements. Lists of the qualified equipment are kept up-to-date (Safety Shutdown Equipment List).

Safety Systems

Initial design classification of the systems had been performed according to the Regulation No. 3 on Ensuring the Safety of NPPs at Design, Construction and Operation (1988), which is similar to the Russian Requirements on Ensuring the Safety of NPPs at Design, Construction and Operation OPB-82.

In the framework of the Modernization Programme of Units 5 and 6 (and in accordance with the IAEA regulations), classification of systems and components in terms of safety, seismic resistance and quality was performed according to the legislation in force.

The safety classification was performed using OPB-88/97 and PNAE G-01-011-97, as the main documents and using the functions from IAEA Safety Series No. 50-SG-D1: Safety Functions and Component Classification for BWR, PWR and PTR. The seismic classification was performed based on the IAEA Guide: Safety Series NS-G-1.6 Seismic Design and Qualification for Nuclear Power Plants, 2003 with due consideration of Russian PNAE G-5-006-87 Norms for design of seismically resistant NPPs.

Reactor

Classification of systems and components was performed within the framework of the Modernization Programme. Reactor and reactor internals were originally designed for seismic impact of 9 degrees by MSK-64 (PGA= 0,4g). These requirements were specified in the Terms of Reference and were confirmed. Reactor modernization activities are summarized in the Updated SAR.

Reactor building main equipment

Reactor building main equipment was designed for 9 degree by MSK-64 (PGA= 0,4g. Modernization activities in respect of the primary circuit and related systems are described in the Updated SAR. Programme analysis were performed, seismic resistance of main equipment and safety systems equipment was calculated, and proposals for needed reinforcements were developed.

The seismic qualification of primary pipelines, equipment and fixing elements was verified by the measures of the Modernization Programme with the results are summarized considering the new seismic requirements and results were summarized with consideration of the new seismic requirements for the site.

Equipment of the emergency power supply systems

Power consumers are divided into 3 categories, depending on electricity type and the reliability of their power supply. Consumers of category I are AC and DC users, for which in any mode, loss of power supply for more than a half period - 20 ms is not acceptable. Consumers of category II are also AC and DC users, but for them the allowed loss of power supply is 1 min (time of DGs start-up and automatic consumers loading). Consumers of category III are powered up by the normal operation systems.

Robustness against loss of power supply (during an earthquake) is ensured by the following design features:

- any safety system is provided with 2 (for category II) or 3 (for category I) independent power supply sources, namely: house loads transformers; DGs; and accumulator batteries;
- each unit is provided with four DGs (3 by the original design and 1 installed during the Modernization Programme), all located in separate rooms;
- availability of passive devices, which assist the most important safety systems to fulfil assigned functions in station blackout, such as: gravity driven actuation of the reactor protection system; hydro-accumulators; safety valves; etc.

All the equipment is seismically qualified for seismic category 1.

Fuel storage, refuelling and transportation system

Systems are seismically qualified with assigned seismic category 1.

Support systems, working with water

Systems are seismically qualified with assigned seismic category 1.

Main steam lines system from SG to main steam isolation valve

Analyses of possible rupture locations of main steam and feedwater lines, as well as of brakes effects were performed, as part of the Modernization Programme. Following that, limiting supports and protective devices against the line breaks effects were designed and installed.

Reactor Protection System

The two physically separated sets are seismically qualified - seismic category 1.

MCR and ECR boards

The metal structures of MCR and ECR boards and panels are seismically qualified for category 1. The Instrumentation and Control (I&C) equipment is seismically qualified.

I&C equipment

Safety systems I&C equipment is operable in all operational modes of the unit, including loss of house loads power supply. The systems are seismically qualified as seismic category 1.

Neutron Flux Monitoring Equipment (NFME)

The hardware of the neutron flux monitoring equipment, as well as equipment of the reactor protection system withstand a DBE seismic impact - 8 degree by MSK-64 at the elevations + 24,6 m, + 13,2 m, minus 4,2 m – category I. Equipment of automatic power controller and power limiting controller is qualified for category II. The NFME is in conformity with Russian regulations NP-031-01 Norms for design of seismically resistant NPPs, Moscow, 2001.

MAIN OPERATIONAL MEASURES TO PUT INTO AND MAINTAIN UNITS 5 AND 6 IN SAFE SHUTDOWN STATE

As the results of the performed review, the following main operational and emergency measures were established to prevent core or SNF damage following an earthquake:

- seismic monitoring and control system was installed and personnel action plan for and after an earthquake was developed;

- communication and coordination system of Kozloduy NPP and the national emergency services was established in respect of the on-site emergency plan. On-site response activities were incorporated in the National Emergency Plan;
- personnel action plan for and after an earthquake was developed and is in use;
- Emergency Procedure on Plant Shift Supervisor Actions at an Earthquake was developed and is in use;
- Symptom-Based Emergency Operating Procedure (SBEOP) for an earthquake was developed and is in use;
- mobile equipment was supplied. A mobile diesel generator is provided. Mobile diesel pumps for water pump out in emergencies were recommended;
- Unit 5 and 6 equipment surveillance programme was developed and is being followed;
- equipment physical and functional tests are being performed. The activities on review of SSCs technical condition are planned to ensure prevention before real failures occur with the objective to reduce failure probability;
- periodic inspections and tests of SSCs are properly recorded;
- automatic actions are provided – earthquake automatic reactor scram system was installed;
- an automated plant information systems was established, which is conducting continuous radiation monitoring within the 3km zone around the site. The system is integrated with the similar national system;
- other measures to prevent, recover from and mitigate accident consequences.

Following the accident at Fukushima Dai-ichi NPP, a work programme was developed to review and assess Kozloduy NPP preparedness for beyond design basis accidents, external and internal events and for mitigation of their consequences. The results of programme work already done are summarized and analysed. According to the analyses, the number of portable submersible pumps should be optimized, in respect of better response to internal flooding (measure B-2-3). Additional measures were proposed for improvement of protection from external and internal impacts. Measures that were not implemented are included in the table - Annex 1 to this report.

Actions have been taken for development and updating of the emergency procedures for Open Switchyard (OSY) personnel (in departments, where needed) in case of an earthquake, flooding, fire and explosion.

Emergency teams capabilities to apply the emergency plan and the respective procedures were practically tested during earthquake and flooding exercises and drills. Responsible persons from the Accident management Team are familiar with the procedures and follow them properly.

ASSESSMENT OF INDIRECT EFFECTS FROM THE EARTHQUAKE

Assessment of potential failures of SSCs not seismically qualified

In the review, plant common systems, which are not seismically qualified but are important for coping with the secondary post-earthquake effects are identified and analyzed. Measures taken to preserve their functionality during and after the earthquake are reviewed.

Measures are provided to ensure that damages of components of lower seismic qualification will not lead to failure of SSCs, which are required for the safe shutdown of the installation and maintaining it in a safe shutdown state.

Within the framework of the Modernization Programme, the following measures to prevent seismically induced interactions were analyzed and implemented:

- ensuring free seismically induced movement of the cableways;
- turbine hall reinforcement;
- reinforcement of turbine hall structural elements located over the cable ducts;
- installation of constraints at the steam lines to prevent damage to closely located equipment of the safety systems.

Potential loss of off-site power

Following analyses of possible scenarios, the following accident states were defined, which could result from a RLE seismic impact or lower.

- **Total loss of AC power**

SGs makeup from diverse systems in case of total loss of AC power was provided and system functional tests were performed. The system is capable to provide makeup to the steam generators in initiating events with total loss of electric power supply of categories II and III, as well as in case of unavailability of SG emergency makeup pumps. The system operates independently from the unit standard systems and uses only partially the piping of one train of the SG emergency makeup system.

- **Loss of OSY**

As the OSY is not qualified as seismic category 1, it is likely to be lost at a seismic impact lower than RLE. Moreover, the national electric grid is seismically designed by industrial standards for impacts lower than RLE and OBE. Thus, even at earthquakes lower than RLE, permanent loss of off-site power is possible due to failures and damages in the national power generation system and the national grid.

The logic diagrams of generator voltage are installed by “generator – transformer" unit logic. Connection between units is provided at the side of 400kV of unit transformers. Circuit breakers are installed to improve reliability. Auxiliary transformers are connected in-between the circuit breakers and unit transformers.

Thus, house loads users could be supplied with power from the auxiliary transformers with the generators being switched off. Connections between the elements of the unit Main Circuit Diagram and the auxiliary transformers nodes are made using phase-by-phase capsulated busses 24kV. In auxiliary transformers, there is no switch-over equipment resulting in enhanced reliability.

To increase reliability and reduce the likelihood of total loss of power supply to OSY 400 kV, the switchyard is designed as double sectioned bus bar system. To improve units reliability, the principle of connection to the 400 kV side by circuit diagram of “two circuit breakers for connection” was adopted.

- **Loss of power supply to safety systems**

Three accumulator batteries are available - one for each of the safety system trains. The batteries operate in continuous charging mode and their charging is provided by rectifiers, which are part of the Uninterruptible Power Supply (UPS) system. By tests it was identified that batteries last over 10 hours under real load.

- **Loss of category II emergency power supply**

Fuel and oil reserves, required for continuous operation of the emergency category II power supply sources are ensured, as follows:

- DG stations 5 and 6: total operational fuel inventory ensures continuous operation of each DG for at least 3 days;
- Additional DGs 5 and 6: operation for 70 hours is ensured;
- Diesel pumps at CPS-3,4: 24 hours' operation of all pumps (8) simultaneously;
- DG "Emergency preparedness": 8 hours of continuous operation at nominal load without refuelling.

Loss of ultimate heat sink

The principles of redundancy, physical separation and independence of the trains are applied in the design of the Essential Components Service Water System (ECSWS). No specific measures are applied in the design of Non-Essential Components Service Water System to ensure the supply of cooling water. In case of loss of ECSWS, reactor fuel cooling could be provided by use of the AEFWS, and cooling of the fuel in the SFP could be provided by the SFP make-up systems.

Six spray pools are built at Units 5 and 6. System trains operate by a closed circuit with water cooling in the spray pools. Each spray pool is designed to remove the total amount of heat, which is generated by the unit in accident conditions. Normal and emergency makeup of the spray pools is provided. Pools makeup is provided by normal electric pumps and in the case of loss of off-sire power by diesel pumps. The pumps are located in CPS 3 and 4. Pools emergency makeup is provided by 6 Shaft Pump Station (ShPS), located in the Danube River Valley. The Shaft Pump Stations receive power supply from the BPS through cable-overhead lines 6kV from the section V - 6kV of BPS and section IX - 6kV of the "Reliable power supply". A procedure for temporary power supply of ShPS by the BPS DG was developed.

Other indirect impacts caused by fires or explosions

- **Seismically induced internal floods – at the site or inside the buildings**

Existing analyses of internal flooding hazards, as well as seismic qualification status of the pipelines on-site and inside the buildings were assessed. Measures are provided to prevent adverse internal flooding effects on plant safety resulting from ruptures of non-seismically qualified pipelines on-site or inside the buildings.

- **Analyses internal flooding consequences**

Under the Modernization Programme, analyses of the consequences from internal flooding were performed. Individual analyses were developed for flooded compartments, for all respective fluid systems, located inside the reactor building, outside the containment, and in the turbine hall. The study was performed for Unit 6 and respective differences of Unit 5 were considered. Conclusions are made for each separate compartment, depending on flooding impact on safety systems equipment and on civil structures.

- **Measures to cope with fires**

The fire extinguishing system is composed of sub-systems and constructed in accordance with the following requirements:

- to reduce fire hazard;
- to ensure physical separation of the systems required to achieve safety targets.

- **Protective measures against explosions**

The analysis performed included safety assessment of the impact of the petrol station owned by Kozloduy NPP and located on the territory of Auto park 2. A new requirement was specified: the total amount of fuel inventory in the petrol station shall not exceed 3 tons. Impacts of a potential explosion of the petrol station fuel inventory on neighbouring on-site facilities and structures were reviewed and assessed. The results demonstrated that no components of the safety systems will be affected.

PROVISIONS MADE FOR SFSF PROTECTION AGAINST RLE

SSCS REQUIRED FOR MAINTAINING SFSF IN A SAFE STATE

Analyses are performed on the bases of the available Kozloduy NPP documents and the results of respective studies and reviews. The review is based mainly on SFSF SAR, SFSF Technical Specifications, and the SAR of Unit 3. Analyses cover all operational states, taking into account the most unfavourable conditions (operational boundary conditions). SSCs lists were developed to cope with different accident scenarios.

The SFSF civil structure was designed in the period 1982-1984 according to specifications of the Russian side (as general designer) and using the applicable legislation, which had been in force at that time. Following the reassessment of site seismic characteristics, a project on civil structure reinforcement had been implemented, which properly considered the new seismic levels.

After the seismic reinforcement on the main support structure, it could withstand all combinations of DBE seismic impact and operational loads. Additionally, combinations cove permanent, useful, and temporary loads plus thermal impact in anticipated operational occurrences or dynamic loads from fuel channel head falling into the pool.

MAINTAINING THE SFSF IN A SAFE STATE FOLLOWING AN EARTHQUAKE

In the period 1994-2000, a series of projects and technical modifications were developed and implemented with the objective to improve SFSF safety. They covered seismic qualification and seismic reinforcement of buildings, equipment and components.

Main structure was seismically reinforced and qualified. Railways were strengthened. Equipment, valves and piping of the safety important systems and SFSF technological equipment (involved in fulfilment of safety functions) were qualified.

Level sensors (alarms) located in the -7.20m elevation compartments were included in the SSCs flooding lists (for accident management and mitigation of consequences in case of a beyond design basis accidents in SFSF, internal and external events). In this respect, due to lack of a referent qualification document, their seismic qualification status shall be confirmed.

ASSESSMENT OF EARTHQUAKE INDIRECT EFFECTS

Assessment of potential failures of SSCs, not seismically qualified

SFSF Building is located on-site, southern from Auxiliary Building 2 (AB-2). AB-2 ventilation stack (chimney) is situated at 36 m from the SFSF north-east corner. The ventilation stack possesses the required seismic resistance and in case of RLE no damage to SSCs (SFSF building, emergency DG building) or hindered access to them are expected.

Potential loss of off-site power

Loss of off-site power supply shall "a'priori" be considered in the DBE accident analysis. SSCs (SFSF emergency DG and plant mobile DG) are provided to ensure power supply to SFSF consumers from independent sources of category I and II power supply. To ensure reliable functioning of the systems in case of loss of off-site power, the required inventories of fuel and oil are maintained at the SFSF.

Other indirect impacts, caused by fires or explosions

Active and passive measures have been taken to ensure, to the extent possible, the SFSF fire safety:

- passive measures – the main civil structures are built out of reinforced concrete, the roof is constructed with fire-preventing beams (zones) made out of non-combustible materials installed at every 6m.
- active measures – they include: external fire protection ring; internal fire fighting installation (compartments equipped with fire taps and dry tubing for water fire extinguishing on the roof).

Fulfilment of fire safety requirements guarantee SFSF safety in case of fire. Possible explosions at receiver sites were reviewed. Possible events defined do not endanger the SFSF safe operation.

MEASURES TO PROTECT DSFSF SEISMIC DESIGN BASES

SSCS REQUIRED TO MAINTAIN DSFSF IN A SAFE STATE

The analyses are performed in respect of DSFSF technical design, approved by the BNRA. The Interim SAR was mostly as a source of input information.

All storage safety functions are maintained in a passive way, as there is no need of active safety systems. All DSFSF SSCs are classified considering their safety functions and in accordance with the referent documents. DSFSF building, 145 t crane, containers CONSTOR® 440/84, shielding doors and doors operational alarms are of seismic category – Design class 3.

DSFSF building could withstand SL1 and SL2 earthquake without a catastrophic damage. The crane is designed for SL1 and SL2 earthquake with no destruction of the structures or load falling. Improper operation of the crane, electric and measuring components do not lead to dangerous conditions. CONSTOR® 440/84 containers are designed not to roll-over in DBE.

DSFSF design complies with the requirements of the Regulation on Ensuring the Safe Management of SF and respectively defence-in-depth principle is applied.

DSFSF seismic design basis

Two design earthquakes are defined, namely:

- SL1 with occurrence 1 E-02 /year (PGA 0,1 g);
- SL2 with occurrence 1 E-04 /year (PGA 0,2 g).

Analyses have been performed of all normal and specific loads and load combinations thereof, according to the applicable European standards and IAEA TECDOC 1347:

Consideration of external events in the design of nuclear facilities other than nuclear power plants, with emphasis on earthquakes.

Similar to the building, the crane was also reviewed in respect of the following adverse combinations of load conditions:

- OBE (SL1 - 0,1 g) with operating crane 145 t
- DBE (SL2 - 0,2 g) with standby crane 145 t.

Both, the building and the crane are designed for OBE and DBE without damage to the structures or load falling.

Containers stability against roll-over was confirmed for seismic loads for OBE (SL1 - 0,1 g) and DBE (SL2 - 0,2 g).

MAINTAINING THE DSFSF IN A SAFE STATE FOLLOWING AN EARTHQUAKE

DSFSF has installed a fire alarm system ensuring local warning and warning in the continuously operating control centre, which notify the on-site fire fighting services. Proper access to DSFSF and the corridor between DSFSF and SFSF is ensured for fire fighting vehicles.

ASSESSMENT OF EARTHQUAKE INDIRECT EFFECTS

On-site facilities that may impact the DSFSF after a seismic event are SFSF and AB-2 chimney. As a result of the analyses performed, various strengthening activities were done (additional steel joints, frames and supports, as well as the construction of new monolith concrete walls). AB-2 chimney was analyzed against the new site seismic characteristics. It is important to note that even in stack damage scenario, the chimney will not impact the DSFSF, because of its distance from the building.

The conclusion is that the DSFSF will not be affected by other on-site facilities following an earthquake.

Assessment of potential failures to SSCs, not seismically qualified

Potential failures of SSCs, which are not seismically qualified were assessed and which by mechanical impact or through internal flooding could compromise the safe and stable state of the containers. This scenario assesses the consequences to a container, which is overwhelm with debris. This could result from extreme external initiating events, such as an earthquake, gas explosion or airplane crash. Calculations using conservative assumptions show that for 100% debris overwhelming, the maximum cladding temperature may be exceeded after more than 2 or 3 days.

Considering roof structure, the expected realistic degree of overwhelm is below 50%. This increases the available time to implement countermeasures to more than 7 days. Even for the worst scenario of loss of heat removal, there is sufficient time available to take adequate countermeasures, i.e. to remove the debris and restore natural ventilation.

Potential LOOP

The total blackout scenario is not relevant for the DSFSF, due to the availability of a passive system for decay heat removal.

Other indirect impacts, caused by fires, explosions, flooding

As an initiating design basis event, the earthquake may cause a fire with a thermal impact on the containers. To avoid fire negative effects on safety the following provisions are made:

- minimization of fire ignition sources and of fire loads;
- fire detection system is provided at the DSFSF building;
- fire resistant design of the containers (containers are designed to withstand the boundary severe fire accident of constant 600 ° C temperature for 1 hour, for which time the fuel cladding temperature is maintained below 330° C).

DSFSF building and containers design analyses include a scenario with an on-site explosion or an explosion of a vehicle passing by the DSFSF. Internal explosions could be excluded, since there are no explosive materials inside the facility. The DSFSF building storage hall is designed to withstand the pressure wave from a gas cloud explosion. However, the fall down of debris from the roof structure (thin metal plates) into the storage hall could not be excluded.

POTENTIAL OFF-SITE IMPACTS

To assess possible adverse effects, of seismically induced damage to the national infrastructure around the plant, on its ability to maintain safety functions it is necessary to investigate when and what seismic failures and damages could be expected. Possible adverse impacts on the plant are mainly limited to:

- loss of off-site power;
- destruction of roads and bridges;
- large demolitions in the nearest settlements, which could lead to impossibility of gathering plant operating staff, etc.

Additional analyzes of the behaviour of site vicinity infrastructure under seismic event, as well as safety impacts are being carried out.

ASSESSMENT OF SAFETY MARGINS AGAINST EARTHQUAKE

For the purpose of reassessment of safety margins, review of safety functions parameters and the conditional probabilities (fragility curves) for destruction of individual SSCs was conducted. The objective of seismic vulnerability analyses is to determine acceleration values at which the seismically induced conditions at the respective component (located at a definite point of the structure) will exceed its capacity.

The analysis consists of sequential review of all ranges of seismic impacts and safety related SSCs that fail are determined for each particular range. Changes in facilities performance (changes in the progression of accidental sequences) and changes in fulfilment of safety functions are identified. This approach allows, in a systematic way, the fulfilment of the main objective of the safety reassessment, namely to define the limiting values of the accelerations, which the unit could withstand without a significant fuel damage or environmental release of radioactive substances.

EVALUATION OF UNITS 3 AND 4 SAFETY MARGINS AGAINST EARTHQUAKE

According to the final report of earthquake analyses, Units 3 and 4 margin is 0,16g or 80% of RLE (PGA=0,2g), i.e. the units could withstand (without fuel damage) an earthquake 1,8 times greater than the DBE, valid as of 30.06.2011.

Assessment of the seismic impact leading to severe fuel damage

Based on the analyses, conclusion could be made that the fuel damage could not be prevented at PGA over 0,36g, i.e. at acceleration where liquefaction of sands under fire protection station-2 and CPS-2 is anticipated. Till this impact level, the unit ensures reliable fuel cooling in the SFP (or the reactor). Partial fuel assemblies untightness is possible in the upper range 0,26<PGA≤0,36 due to fall down of heavy object over the SFP.

Scenario of beyond design basis earthquake followed by beyond design basis flooding

According to the analyses, the only realistic scenario is the earthquake resultant destruction of hydroelectric dams “Iron Gate” 1 and 2. In this case, the maximum water level will be reached at a much later stage of the accident (about 20 hours after the earthquake).

At loss of off-site power and EDGs failure resulting from the earthquake, the consumers of the reliable power supply sections will lose power supply. According to the design, Metal Clad Switchgear (MCS) 0,4kV could be supplied by power from the AEFWS sections, i.e. from the AEFWS EDGs. The other possibility to restore SFP cooling pumps power supply is by using the MDG. In any case, to restore the power supply to SFP cooling pumps, access to MCS 0,4kV is required, which could be limited due to the earthquake. Due to the low decay heat of the fuel and the significant coolant inventory in the SFP, significant time is available to adequately arrange and effectively implement all measures required to re-establish the access to the MSC 0,4 kV.

After the water level reaches Kozloduy NPP site, AEFWS could be used only as an alternative source of power supply to SFP cooling pumps due to flooding of the AEFWS basement. The power supply from AEFWS is guarantees for 72 hours as each EDG fuel inventory is at least for 72 hours.

In case of simultaneous loss of off-site power and emergency power supply from the DGs of DGS-2, the only ultimate heat sink of the SFP cooling heat exchanger will remain the cooling water supplied by the diesel pumps of fire pump station 2. Obviously, the SFP decay heat removal function can be ensured at the selected scenario with combination of external events. At this scenario, the only significant consequence is associated with the seismic impact itself, i.e. with possible falling of roof elements over the SFP. Thus, fuel mechanical deformation could result in release of fission products from the fuel elements. This radioactivity will be released into the environment, as Central Hall building is not a leaktight compartment.

The general conclusion is that SFP fuel cooling function redundancy will be reduced to a greater extent as compared to the individual impacts of each external event scenario. If prior to the earthquake and the flooding, the fuel is placed inside the reactor, then due to loss of the normal cooldown system and loss of AEFWS pumps, heat removal could be provided only by the use of fire trucks or through the SGs by opening of SG SVs.

Regardless of the low fuel decay heat, the effectiveness of such cooling logic should be analytically verified (Measure A-1-2). When assessing the applicability of fire trucks cooling, the following complicating circumstances shall be considered:

- Building structures and facilities of the fire fighting service are designed using the national seismic standards. This means that in seismic impacts within the range of 0,26 < PGA ≤ 0,36g, the buildings will probably be severely damaged or destroyed, which could prevent the vehicle leaving the garage and respectively they could not be used for the process of heat removal through the SGs.

- use of fire trucks delivered from other locations, not affected by the scenario, is possible after 24 hours. This possibility shall be addressed in the emergency plan and in-depth reassessed taking into account that a lot of seismically induced fires will probably occur in the area and that the fire services in the neighbourhood will also be seriously affected.

Measures to enhance Units 3 and 4robustness

No specific measures are required to enhance robustness of these facilities, as fuel storage in the SFP of Units 3 and 4 is expected to end in 2012.

EVALUATION OF UNITS 5 AND 6 SAFETY MARGINS AGAINST EARTHQUAKE

According to the analyses, Units 5 and 6 margin is 0,13 g or 65% as compared to RLE (PGA=0,2g), i.e. the units can withstand (without fuel damage) an earthquake of 1,65 times greater than the RLE valid as per 30.06.2011.

Assessment of the seismic impact leading to significant fuel damage

Based on the analysis, it can be concluded that fuel damage cannot be prevented at PGA exceeding 0.33-0.35 g, i.e. at the acceleration for which liquefaction of the sands under the spray pools is expected.

Assessment of the seismic impact causing loss of Units 5 and 6 containment integrity

Units 5 and 6 Reactor Buildings are provided with containments, which protect the reactor and the primary equipment against extreme external events and which are the last barrier against radioactivity release to the atmosphere. Loss of containment integrity could occur at compromising the protective shell (containment structure), compromising of the interlocks or some of the penetrations.

Analysis main results in respect of the dynamic non-linear behaviour and seismic capacity of the containment structure could be systemized as follows:

- limited damage and cracks in the concrete, without loss of confinement – at PGA=0,75g.;
- loss of confinement due to plastic deformation of the steel lining – at PGA=1,7g.;
- damage of the structure due to rupture of support rope bundles and shear of the reinforced concrete section – at PGA=1,9g.

The most probable mechanism for loss of confinement is the shearing of the shell in the connection between the expanded cross-section at the basement and the standard cross-section of the cylindrical part. Conservatively estimated value of floor seismic acceleration is a_{Max} = 1.9g (9,5 times the DBE).

Scenario of beyond design basis earthquake followed by beyond design basis flooding

For reassessment of safety margins, hypothetic combination of beyond design basis earthquake and beyond design basis flooding is postulated, namely earthquake within the range $0,2 < PGA \leq 0,32$ g and water level above +33,20 m. According to the assumptions, at selection of such scenario a loss of emergency feedwater pumps is postulated too. It should be noted that this loss is completely induced by the water level impact and will occur at a much later stage of accident progression.

All scenario combinations of beyond design basis earthquake and flooding lead to loss of ShPS due to its flooding. Their loss leads also to loss of spray pools emergency makeup, i.e. the time with ensured ultimate heat sink will be limited. According to analyses, connection to the grid is lost at an earthquake within the range of 0,2 < PGA ≤ 0,32g, i.e. the units are in a loss of off-site power mode.

Description of accident sequences

- **Reactor. Cooldown process**

Analyses show that at loss of off-site power is anticipated at such seismic impact. As a result of the earthquake, reactor scram will be actuated on a signal by the industrial seismic protection system. Other reactor scram signals will also be generated in parallel.

It should be noted that a rupture of a SG connected pipeline could be anticipated as a consequences from turbine hall damage, i.e. the unit will be into an accident situation with an isolable break from the secondary side. Termination of the leak in the secondary circuit (which ensures suspension of non-controlled cooldown of the primary circuit and prevention of PTS process likelihood) required closing of all MSIVs. Seismic impacts of this range do not affect MSIV operability and the valves of its auxiliaries. Thus, it is accepted that SG isolation will be completely successful.

For the overall fulfilment of sub-criticality function to it is required that at least one the two systems: high pressure emergency boron injection system or medium pressure emergency core cooling system should remain operable. The analyses demonstrate that function could be fulfilled (at both units), because a high level of redundancy is preserved.

Primary circuit heat removal function will be affected both by the earthquake and by the flooding as:

- due to destruction of the turbine hall, safety function margin is determined by the emergency feedwater systems and SG alternative makeup system;
- emergency feedwater pumps fail as a result of flooding by water coming from nearby compartments. This failure, however is anticipated at a much later phase of the accident;
- SG alternative makeup system will not be affected by the earthquake or the flooding, however the MDG movement may be hampered. The system could be used for makeup of only one of the two units, as the power supply source MDG is only one.

The SG alternative makeup system is capable to ensure primary circuit heat removal only for a little bit more than 24 hours. This time is sufficient to cooldown one of the units to cold shutdown state. Should be kept in mind that the use of SG alternative makeup system depends on the capability of the MDG to reach the connection point. For the remaining unit (to which MDG is not connected), heat removal through the secondary circuit could not be done after the water level reach the site. In this case, to prevent reactor heating up and to restore reactor cooling, the operating personnel shall use the set of SBEOPs. In general, operators actions are limited to reactor cooldown to 150°C and decrease of primary pressure to a point at which start-up of the emergency and normal cooldown system is possible, i.e. implementation of feed-and-bleed procedure.

Obviously, at a scenario with combination of beyond design basis earthquake and beyond design basis flooding, of major importance is the time for which the water level will reach the site and the respective time for flooding of elevation - 4,20, i.e. the time from the earthquake till the loss of emergency feedwater pumps. According to the analyses, it could be accepted that about 28 hours are available from the moment of destruction of hydro dams “Iron Gate” 1 and 2 till the water level reach the to site. It is expected that the loss of emergency feedwater pumps will occur at the end of the reactor cooldown process or after cooldown is completed (depending on the cooldown rate). Therefore, based on the analyses it could be accepted that SGs water inventories are sufficient to successfully complete reactor.

Stable reactor cooling for 72 hours, without external supplies, could be achieved when the unit is in a cold shutdown state. Cooling is provided by the emergency and normal cooldown system, while the heat from the ECCS heat-exchanger is transferred by the essential components service water system to the ultimate heat sink – spray pools. The water in the spray pools and on-site inventories of diesel fuel are sufficient to ensure the safe cold shutdown state of the reactor for 7 days, without a need of additional supplies.

The core cooling function by the primary circuit will be affected by the combination of the external events, as follows:

- Unit 5: performance of the function using the line for planned and maintenance cooldown will be limited to only two trains of the emergency and normal cooldown system. Due to the flooding of ShPS, water inventories in the spray ponds guarantee function fulfilment for 60 hours when available trains are sequentially started up;
- Unit 6: The function will be fulfilled in accordance with the design, i.e. all system trains will be available, as they will not be affected by the earthquake. Due to the flooding of ShPS, spray ponds inventories guarantee function fulfilment for 90 hours when available trains are sequentially started up.

- **Reactor. Cold shutdown state**

In this state, decay heat is removed by the emergency and normal cooldown system through the planned or maintenance cooldown circuit. The ultimate heat sink is the spray pools.

When considering the scenario with combination of beyond design basis earthquake and beyond design basis flooding, the operability of available systems (emergency and normal cooldown system or essential components service water system) does not depend on the water level, i.e. fulfilment of safety functions is totally determined by the earthquake impact. Therefore, a scenario with combination of beyond design basis earthquake and beyond design basis flooding is not considered for this state, as the earthquake impact has been defined under the beyond design basis earthquake analyses.

- **SFP**

SFP fuel heat removal is provided by the joint operation of the SFP cooldown system and the essential components service water system.

When considering the scenario with combination of beyond design basis earthquake and beyond design basis flooding, the operability of available systems (SFP cooldown system or essential components service water system) does not depend on the water level, i.e. here also fulfilment of safety functions is totally determined by the earthquake impact. Therefore, a scenario with combination of beyond design basis earthquake and beyond design basis flooding is not considered for this state, as the earthquake impact has been defined under the beyond design basis earthquake analyses.

Measures to enhance Units 5 and 6 robustness

Following the completed analyses, investigation of possibilities for alternative residual heat removal in case of loss of essential components service water system is recommended to Kozloduy NPP Units 5 and 6. This recommendation refers to the possible use of AEFWS system (Units 3and 4), which is available on-site.

EVALUATION OF SFSF SAFETY MARGINS AGAINST EARTHQUAKE

The SFSF margin is at least 0,16g or 80% considering RLE (PGA=0.2 g), i.e. SFSF could withstand, without fuel damage, an earthquake that is 1,8 times greater than the RLE, re-evaluated and valid as per 30.06.2011.

Assessment of the seismic impact leading to significant fuel damage

Based on the analyses, it could be concluded that when complying with the requirements of the "Instruction to ensure the required fuel and lubricant inventories for a prolonged operation of emergency power supply sources", the SFSF could perform the functions for safe storage of spent fuel up to a seismic impact in the range of 0.36 – 0.39 g. Over this impact, the main support structure collapses and building capability for pool cooling by natural ventilation is lost. In this situation, further extension of fuel safe storage depends on the possibility to remove debris and recover the natural ventilation.

Evaluation of the seismic impact leading to loss of SFSF integrity

Analyses determine the seismic accelerations at which structure integrity loss is accepted and natural air circulation required for fuel cooling cannot be provided. The following values are obtained:

- destructive acceleration for columns by row D (190/50 cm) – 0.39 g;
- destructive acceleration for columns by row D (60/50 cm) – 0.44 g.

Therefore, at such seismic acceleration, destruction of the SFSF main support columns could be expected leading to roof and cranes fall over the pools. This may potentially lead to damage of fuel storage racks (shells) and to damage of the reinforced concrete structure of the pools resulting in significant leaks from the damaged sections.

Scenario of beyond design basis earthquake followed by beyond design basis flooding

According to the results of plant margins in case of external flooding, no SFSF SSCs will be affected by the MWL. Therefore, a scenario with combination of beyond design basis earthquake and beyond design basis flooding is not considered, as the impact from external events is defined within the framework of the beyond design basis earthquake analyses.

Measures to enhance SFSF robustness

No measures to enhance SFSF robustness are specified, as its safety margins are fully dependent on the capacity of the civil structure.

EVALUATION OF DSFSF SAFETY MARGINS AGAINST EARTHQUAKE

Performed analysis show that DSFSF margin is 0,11g or 55% of the DBE(0,2g), i.e. DSFSF can withstand, without fuel damage, an earthquake that is 1,55 greater than the DBE.

Assessment of the seismic impact leading to significant fuel damage

Based on the engineering assessment made in the analyses reports, a conclusion could be drawn that DSFSF is capable to perform its functions of spent fuel safe storage up to a seismic accelerations of about 0,31 g. Then, a collapse of the main support structure could be anticipated. In this case, the continuation of safe fuel storage depends on the capability to remove debris and restore natural ventilation.

Scenario of beyond design basis earthquake followed by beyond design basis flooding

According to the analyses of plant external flooding margins, no SSCs will be affected by a MWL. Therefore, a scenario with combination of beyond design basis earthquake with beyond design basis flooding is not considered for this nuclear facility, as external events impact is defined within the framework of the beyond design basis earthquake analyses.

Measures to enhance DSFSF robustness

No measures to enhance DSFSF robustness are specified, as its safety margins are fully dependent on the capacity of the civil structure.

CONCLUSION

According to the review of Kozloduy NPP site seismic characteristics, as re-evaluated in 1992 (Project BUL 9/012 "Site and Seismic Safety of Kozloduy and Belene NPPs") and the additional studies of 1995 (studies for local earthquakes and probabilistic definition of seismic impact for the purposes of seismic PSA), a conclusion could be made that re-evaluated site seismic bases comply with the current legal requirements.

Seismic resistance of safety related equipment involved in the emergency scenarios is analyzed and parameters of functions that describe its conditional failure probability (fragility curves) are determined. For all of the nuclear facilities, limits are defined of the seismic accelerations that the facility could withstand without a significant fuel damage or radioactivity release into the environment. Respectively, the analysis of beyond design basis seismic impact is sufficiently conservative and gives confidence that Kozloduy NPP SSCs are capable to ensure plant safety for the seismic impacts which are maximum possible for the site.

In respect to SFSF and DSFSF, no measures to enhance robustness are proposed, as their safety margin is completely dependent on the capacity of the building structure. As it is expected that storage of SF in SFP 3 and 4 will end by mid 2012, so no specific measures to improve robustness are proposed for those facilities.

The measures for improvement of plant robustness, as presented below, relate only to Kozloduy NPP Units 5 & 6:

- Provision of a mobile diesel generator for each unit (Measure A-1-1);
- Research and investigation of the possibilities for alternative ways of residual heat removal in case of loss of essential components service water system. This proposal relates to the potential use of AEFWS - system is available on-site (Measure A-1-2);
- Securing in shutdown mode the availability of at least one tank of the SGs Emergency Feedwater System in order to provide for the use of the SGs as alternative for residual heat removal (Measure A-1-3).

Following the review of licensee reassessment of safety margins in case of an earthquake, the BNRA considers that weaknesses and strengths have been correctly identified and accepts the proposed measures to improve plant robustness in case of an earthquake.

EXTERNAL FLOODING

DESIGN BASIS

FLOODING AGAINST WHICH THE PLANT IS DESIGNED

The potential sources of external flooding are the: maximum possible natural water levels of Danube River; destruction of hydro dams "Iron Gate" walls; accident at "Shishmanov Val" dam; slope waters from the "Marishkin Dol" locality; waters from the "Marichin Valog" valley; continuous heavy rains at the plant site; water blocking resulting from ice drifts; as well as waves from the water entering the valley.

Definition of MWL due to increase of Danube River level

Plant design and three additional new studies related to definition and re-evaluation of the on-site MWL were reviewed. Elevation +35.00 of the Baltic Altitude System was adopted as plant site Level 0,00.

Accumulation and movement of catastrophic waves, caused by the damage of walls of dams along the lower part of the Danube River were reviewed to determine the MWL. Of utmost importance is the scenario with subsequent damage of the walls of hydro dams "Iron Gate" 1 and 2, in which the catastrophic wave is accumulated to the basic water amount of Q_0 = 10 000 m^3/s. This scenario aims at defining the characteristics of the maximum wave resulting from the coupling of the two waves. The MWL obtained at the Kozloduy NPP is 32,53 m. This MWL is established 28 hours and 20 minutes after the postulated destruction of "Iron Gates 1" dam and will last approximately 2 hours. It is 30 cm higher than the design MWL in normal conditions, but is still 2,47 m below the elevation 0,00 of the site.

In all postulated events involving extreme increase in Danube River level, flooding MWL is below elevation 0.00 of the site, which confirms that plant site is "Non Floodable".

Influence by heavy rainfalls

The rain downstream Danube River and over the Kozloduy NPP is considered in the statistical determination of natural MWL and should not be double counted. Another is the case with a catastrophic wave caused by a destruction of "Iron Gates 1" dam. The rain from the valley around Kozloduy NPP and from the river bank could contribute to increase of the water level around the site. Catastrophic wave from destruction of the "Iron Gates" hydro dams and additional water level increase due to precipitations with p = 1% probability are postulated. Using expert judgement, additional increase in the water level with 10cm from heavy rains is accepted.

Waving

Strong waving is normally expected in combination with the high water level and rainfall. This could result from the uneven terrain, high unequal speed, and strong winds. Expert judgement gives wave height of 0,60 m, and respectively the level increase could be estimated as 0,30 m (half the wave height).

Water retention due to ice drift

Catastrophic wave due to damage of "Iron Gate" 1 and 2 dams and ice drifts are phenomena with low probability and should not be combined. Moreover, at extremely high water levels with water quantity over 20 000 m^3/s blocking by ice drifts is not possible. Respectively, water level increase and Kozloduy NPP flooding caused by ice drifts are not applicable.

Definition of MWL due to wall rupture of the "Shishmanov Val" dam

Plant site flooding due to wall rupture of "Shishmanov Val" dam were studied. Results show that following destruction of the wall and release of available water quantity of 2 885 600m3 the resulting water level will not exceed elevation 25.50 and will not endanger plant safety. Using expert judgement it was identified that flooding of the lowland northwest of the plant will not exceed elevation of 29.00m, i.e. this water level is not a direct danger to the plant which elevation is 35.00m. The only possible consequence is shaft pump stations to be taken out of service for a short time.

Definition of MWL from "Marichin Valog" valley

Another potential source of plant site flooding is the "Marichin Valog" valley. A small tributary of the Danube River is passing through, which is with non-constant water swelling and flooding possibilities had been eliminated.

Definition of MWL by slope water from "Marishkin Dol" locality

The risk of site flooding by slope water from "Marishkin Dol" locality had been eliminated by the construction of an additional drain channel.

CONCLUSION ON THE ADEQUACY OF PROTECTIONS AGAINST EXTERNAL FLOODING

The assumption of a sudden total damage of the "Iron Gate 1" dam is extremely conservative, as wall damage could not be complete or sudden. With realistic assumptions, wall damage will be gradual and will start from one side of the combined wall. Resultant wave will gradually develop and will have lower pick.

Latest studies conducted in 2010 show that in case of destruction of "Iron Gates" 1 and 2 dams (at base water quantity of 10 000 m^3/s) and in combination with destruction of Nikopol - Turnu Magurele hydro dam (if built), the maximum water level will be 34,51m. Even under these hypothetic conditions, Kozloduy NPP will not be flooded.

Finally, the following conclusions could be made:

- the Kozloduy NPP design MWL reflects all applicable factors, which is confirmed by the studies performed later on;
- at combination of low probability events, the following limiting value of MWL could be defined - 32,53 + 0,1 + 0,30 = 32,93 m

Kozloduy NPP site MWL is defined at 32,93m, within the current conditions of the hydro-technical structures along the Danube River. The respective scenario resulting in a MWL is a sudden and sequential break of hydro dams "Iron gates" 1 and 2 with accumulation of the two waves and water quantity of 10000 m3/s. Additional supplements are taken for local rainfall and waving. Analyses of plant safety margins are performed for MWL = 32,93m.

Dependencies of water levels where dike elevation (32,00m) is exceeded will differ from the cases of higher probabilities and lower levels. Overflow of protection dikes will significantly change the flooded area. Anticipated Danube River natural water levels, with probabilities 10^{-5} to 10^{-7} are as follows:

- $p = 10^{-5}$ water level = 32,40 m
- $p = 10^{-6}$ water level = 32,60 m
- $p = 10^{-7}$ water level = 32,70 m

Based on these water levels in normal state of Danube River, assessment of the combination of the two events could be done - natural extreme water levels of low probabilities (10^{-5} to 10^{-7}) and damage of "Iron Gate" 1 and 2 dams. It should be noted that a combination of the two scenarios will lead to an event with an extremely low probability of occurrence. Expected water levels are:

- $p = 10^{-5}$ water level = 32,98 m
- $p = 10^{-6}$ water level = 33,26 m
- $p = 10^{-7}$ water level = 33,42 m

Increase from local rainfall and waving could be added – additional 0,1 and 0,30 m respectively. Finally, in p =1 0^{-7} and MWL of 33,82m, Kozloduy NPP site still remains not flooded.

ENSURING PLANT PROTECTION AGAINST MWL

KOZLODUY NPP UNITS 3 AND 4

Protective measures to maintain supply of cooling water

The spent fuel pool cooling system is a two-train system in respect of: pools cooling pumps, heat exchangers, service water and power supply. No loss of spent fuel pool cooling system is anticipated at MWL.

Essential component service water system is the main source of cooling water. Pool cooling heat exchangers are always connected with the service water. Nominal temperature of the pool water is maintained by starting up and tripping of the pool cooldown pumps.

To provide redundancy of spent fuel cooling in the spent fuel pool, two independent headers are mounted to the pressure headers of the essential components service water system, which to provide additional cooling water from the fire protection system-2.

In case of inoperability of the cooldown system, SFP temperature is maintained below 65 ^{0}C by other ways (filling and draining) or using cooling logic not included in the design (following pre-developed procedures).

Protective measures to maintain emergency power supply

No loss of emergency power supply sources, located in DGS–2 is anticipated at MWL. Backup power supply is provided to the pools cooling pumps from the AEFWS sections. Thus, in case of loss of off-site power, pumps power supply is ensured both by the DGs and by the AEFWS emergency DGs.

KOZLODUY NPP UNITS 5 AND 6

Protective measures to maintain supply of cooling water

The essential components service water system is part of the safety systems. System trains operate by a closed circuit with water cooling in the spray pools. With consideration of spray pools dimensions, a change in water level of 1.5 m ensures operation of the essential component service water system for 30 hours, without feeding of the pools. Spray pools normal and emergency water makeup is ensured.

Normal makeup is ensured by 4 electric pumps for service water supply, and in case of loss of off-site power by 4 diesel pumps. Pumps are located in CPS-3 and 4, as each station has 2 electric and 2 diesel pumps. Spray pools emergency makeup is provided from 6 wells located in the Danube River lowland.

Protective measures to maintain emergency power supply

Units 5 and 6 sources of AC emergency power supply are the emergency DGs, the additional DGs and the mobile DGs. As the additional DGs are located above site elevation 0,00 and the powered from them normal operation sections are located at elevation 3.60, they are not potentially threatened by a MWL.

Power supply of safety systems equipment is provided by the emergency DGs (3 per each unit). Sections supplied by them are not potentially threatened by a MWL. Potential flooding risk exists for the cable ways located between the DGS and the reactor building.

The DGS equipment layout suggests that at potential flooding of the compartments, mostly support facilities will be affected. In this situation, the DG could operate till depletion of the fuel in the gravity tank (for about 7 hours at nominal power).

Systems for DC power supply to the safety systems (I, II and III train) are located at elevation 20,40 and are not affected by a MWL.

SFSF

No safety margins reassessment is required for the spent fuel sections cooling system, because according to the it may remain inoperable for up to four days. Additionally, in general operation of fuel storage pool cooling system is required for only a week in a month.

Power supply or category 1 and 2 equipment is provided by a transformer set equipped with two dry transformers with capacity of 630 kVA each and by a two-section switchgear with redundancy between the sections. Transformer set is supplied from the Units 3 and 4 6 kV sections through two independent cable lines.

DSFSF

In accordance with the ISAR, spent fuel storage hall is almost a continuous shielding structure, which prevents the access of significant water amounts. All structure vulnerabilities, such as shielding doors and emergency exits, could be promptly sealed.

Containers CONSTOR® 440/84 are hermetically sealed. The containers are designed with thick walls (480 and 500 mm) in order to eliminate neutron interaction between the fuel in the containers. Therefore, containers flooding could not affect fuel sub-criticality. The containers provide a double-tight barrier against water penetration inside, while the outside surfaces are free from contamination (within the allowed limits). Respectively, flooding does not cause liquid radioactive discharges into the environment.

MAIN DESIGN PROVISIONS TO PREVENT FLOODING IMPACT

Site selection

Kozloduy NPP site is located at an absolute elevation of +35.0m. The whole valley is protected by an embankment dike with elevations of 31.80 ÷ 33,00m.

Due to the permanently high groundwater level over a large area, drainage systems are constructed in the Kozloduy NPP lowlands, which cover also the water coming from the northern slopes. Drain systems include 3 types of channels: draining, collective and main. Using pumps the water of the main channels is transferred over the dikes into the Danube River. These drain systems are of particular importance for the site, as domestic wastewater and rainwater are discharged into the main collecting channels.

Site sewage system

Site sewage system is designed to collect domestic and rain water from the site and transfer them to drain channel No. 1 of the Kozloduy drainage system. Part of the industrial wastewater of Kozloduy NPP is also discharged into this network. Rain water sewage for the entire site is discharged directly into drain channel No. 1 and therefore through it water intrusion to elevation 32.93 is not prevented. At domestic sewage system of Power Generation 2, the water passes through a purification plant before discharge into drain channel No. 1. However, the availability of such a treatment plant does not solve the issue of water penetration through the domestic sewage system.

MAIN OPERATIONAL MEASURES FOR PROTECTION AGAINST EXTERNAL FLOODING

Danube water level is monitored by visual inspections and by the use of an automated water level monitoring system. Information is also received by the Executive Agency for Exploration and Maintenance of the Danube River. Monitoring of groundwater is also carried out.

Operating actions in the event of flooding or flooding induced accidents are specified by the emergency plans and operating documentation.

POTENTIAL OFF-SITE IMPACT

Potential impact on the nearby lowland facilities

The lowland is divided by the Kozloduy NPP hydro-technical channels into three zones. The western zone is confined by hot channel-2, Kozloduy NPP and to the west reaches and enters the town of Kozloduy. The medium zone is surrounded by hot channel-2, Kozloduy NPP and the double-channel. The eastern zone is bordered by the double channel and the bed of Ogosta River. The flooding of the lowland situated between Kozloduy NPP site and Danube River is considered below, separately for the three different zones, in order to highlight all indirect flooding induced impacts, which may influence plant operations.

- **Dike break in the area between hot channel-2 and BPS**

At dike break, initially shaft pump stations located in the immediate vicinity of the dike edge will be flooded. This will hinder the supply of makeup water to the spray pools. Access to the bank pump station by land is most likely to be lost. This will happen during the first hours following the dike break, as drain channels and roads to the bank pump station are at lower elevation and will be easily flooded. At lowland flooding and filling up to elevation 32.00m, damage of some power line columns (located on the wave path) could be anticipated.

Emergency pipelines of the emergency pump station of BPS are made of steel and are placed in a trench, but when crossing the drain channels are over ground and bridge the channels. These open areas are vulnerable and could be damaged by the wave.

All the sewage water from Units 1 to 4; reactor building; diesel generator stations; and Units 5 and 6 Turbine Hall are drained into the valley formed by hot channel-2, cold channel-1 and the Danube embankment. This could create conditions of water return through the sewage collectors for domestic and rain water and to reach the level of flooded valley. A possibility exist that site sewage pits be filled up to elevation 32,93 m. Site access from the town of Kozloduy will be possible through the bypass road and through Harlets access control point.

- **Dike break in the area between the town of Kozloduy and hot channel-2**

At flooding of the valley from this location, the final result will be similar to the one described in the previous item. The difference will be that only part of the power columns will suffer the initial wave impact as some are protected by hot channel-2.

- **Dike break in the area between BPS and Ogosta River**

At flooding of the valley from this location, most affected will be power transmission lines Harlets, Neutron and Danube. In the area there, are no other facilities related to Kozloduy NPP operation, besides the open storehouses. Under certain conditions of wave formation, the dike of hot channel-1 may be eroded and destroyed.

Loss of off-site power

Flooding of the valley to elevation 32.93 could be accompanied by the damage of some of the power transmission columns connecting Kozloduy NPP and bank pump station with the national grid (those on the wave pathway).

As these columns are constructed with a height, which follows the terrain, in some areas the distance between the power lines and the water surface will be reduced with about 5 - 5.5 m in respect to the initial one. This significant reduction in the distance may lead to short circuits and respectively failures of the available power lines not affected by the wave. As a result, even if OSY site is not affected, the plant may temporarily lose off-site power due to loss of part of the grid connections.

Loss of cooling water

According to the analyses, valley flooding will not lead to loss of cooling water.

According to Units 3 and 4 design, loss of bank pump station does not affect the availability of essential components service water pumps, as the service water drain from the heat exchangers can be supplied to the hot channel or to the spray pools. Flooding of the valley to elevation 32.93 will lead to loss of the ShPS and respective loss of emergency makeup to Units 5 and 6 spray pools. The normal makeup of the spray pools (from Circulation pump station

3 and 4) will be completely available. The fore chamber of Circulation Pump Station 3 and 4 provides for the required water amounts.

Possibility of intervention of support and external services to assist plant operation

The postulated MWL flooding of the area around the plant does not affect road infrastructure, as well as road access to the plant. In this case, full external support could be relied on, including vehicles access, equipment and materials delivery on-site. Personnel access is not restricted also, as personnel access to the plant is not delayed.

The overall process for providing for the SSCs, which are required to maintain the units in a safely shutdown state, ensuring the availability and preparedness of external mobile equipment and supplies (part of the emergency plans) does not differ from those described under "Assessment of safety margins against an earthquake" of this Report.

EVALUATION OF SAFETY MARGINS AGAINST EXTERNAL FLOODINGS

DEFINITION OF SAFETY MARGINS AGAINST EXTERNAL FLOODING

Based on plant walk downs it was confirmed that certain facilities of the Kozloduy NPP site could be flooded. Due to weaknesses in the sewerage network it is possible that water flow back through sewer headers for domestic and rainwater and to fill up the compartments up to the valley flooding elevation. Thus, in all buildings where the lowest elevation of rainwater or domestic sewer is below 32.93 water penetration from outside is possible. Physical flooding of a given compartment located below elevation 32,93 m depends on the availability of drains, manholes or damages.

Assessment of plant margins against external flooding is based on the individual margins of all buildings and facilities, which are directly related to plant safety. For the purpose of safety margins re-evaluation, the cases where critical equipment is located below the MWL elevation of - 32,93m are considered.

Following the assessment of plant design basis, it can be concluded that in external flooding from overflow or destruction of the protective dike of Danube River, the facilities located in the valley between hot channel-2 and double-channel will be directly affected, and those on-site - indirectly through the sewage network. Using expert judgement is was estimated that at intrusion into the valley the wave will move at a speed exceeding 5 m/s. From dike break till valley flooding, the process will continuously attenuate until the complete alignment of water levels.

Kozloduy NPP facilities, directly affected by a MWL

- **Shaft pump stations**

At dike overflow or break, the shaft pump stations will be flooded at first. They are located immediately next to dike edge at an elevation of about 25 - 26m. Their loss leads to a loss of the alternate makeup to the Units 5 and 6 spray pools.

- **Power lines**

Lowland flooding to elevation 32.93 will probably be accompanied by the damage of some power line columns, which connect the Kozloduy NPP with the grid (those on the wave pathway). Part of the power lines located in the lowland between hot channel-2 and double-channel will be lost at water penetration from the Danube River.

- **BPS and channels**

BPS elevation 0,00 corresponds to an absolute elevation of 33,00m. It is considered as non floodable for a MWL of 32,93m. However, at water level of 32,93, the pumps by their factory characteristics do not function.

At berm crown elevation of hot and cold channels - 33.00m and water level of 32.93, practically there will be one joint water mirror. Although dikes are not designed for such water level, initially they were tested on overflow over the middle dike with an average elevation of 32.80. Under these conditions, the hot channel will have the level of Danube River and will be joint with the cold channel through spillway of the middle dike (between the bridge “Valyata” and bridge “Heavy loads” - at elevation 32.80).

Another potential problem is that if the dry slope of the cold channel remains under water for a long time, there is a potential of slope sliding.

Buildings and facilities on-site, flooded through the sewage network

At external flooding, water penetration into the on-site buildings could occur both through the rainwater and domestic sewage. Shafts visual examination confirmed that water flow back up to elevation 32,93 is possible, irrespective of the availability of a treatment plant for domestic sewage.

All cable channels and process tunnels, which are drained into rainwater sewage and those located below 32.93m will be flooded. Corresponding penetrations entering the buildings, if not waterproof, should be considered as a source of flooding.

- **Kozloduy NPP Units 3 and 4**

The wastewater sewage system of Units 3 and 4, before discharge into drain channel-1, passes through the local treatment installations with elevation sufficiently higher than the flooding level, and pipelines are placed in waterproof protective channels. Accordingly, there is no risk of flooding safety related SSCs through them. The domestic and rain waters are discharged directly into drain channel-1 without treatment and the risk of water access to the buildings is particularly through them.

In respect of safety margins reassessment, a visual inspection was performed of the two buildings of the additional system for steam generator emergency makeup. System elevation 0,00 is established as 35.60m. Inspection confirmed that drain sumps are available at the two buildings of the system elevation 31,10m. The availability of these drain sumps determines the ability of rainwater flow back and respectively, the two buildings of the system could be flooded if water level exceed 31.10m. Obviously, the buildings of the additional system for steam generator emergency makeup have no safety margin against MWL external flooding.

Since a MWL does not affect the availability of normal provisions to ensure safety functions, it could be concluded that the flooding of the AEFWS building represent only a reduction of the redundancy of systems, which are capable to perform the same safety function.

- **Kozloduy NPP Units 5 and 6**

In the reactor building of Units 5 and 6, premises of drain pumps (next to first and second staircase) at elevation of -4,20m are examined, as it was found out that rainwater and domestic sewage are released from the reactor through these premises and respective shafts outside the reactor building. Lowest elevation of the sewer pipeline is 33.20m, which is 0,27m higher than the MWL. At MWL external flooding, water penetration into the reactor building through the sewage network is not expected.

An engineering assessment was performed of rupture of domestic sewage pipes and related leaks into the premises located next to first and second staircase. Based on the calculations, a flooding level of 0,32m was defined for the premises. From the value obtained it can be concluded that:

- There is a margin of 38cm till the flooding of the electric motors of the SGs emergency makeup pumps (installed on a concrete basement - 70cm above the floor);
- There is a margin of 8cm till the flooding of the emergency control room. The room has a 40 cm entry threshold and does not have a drain sump to the drain system. Room flooding starts after increase of water level above 40cm.

It should be noted that following a MWL, recovery to normal operational conditions require availability of the drain system.

The cable channels connecting the diesel generator stations and Units 5 and 6 reactor building are composed of elements with trapezoid cross-section. All cable routes are at elevation 31.00. Joints between the cable channels elements are not waterproof and at water level above elevation 31.00, free entry of water inside the cable channels is expected. Cable failures as a result of cable channels flooding will depend on the status of cable insulation.

Penetrations connecting reactor building cable channels and diesel generator stations are repaired under the Modernization Programme and are seismic-resistant and waterproof. Water access through these penetrations is not expected.

Summary of safety margins against external flooding

Based on the walk downs, documentation review and engineering assessment it was accepted that a possible scenario for flooding of on-site buildings and facilities is through the plant sewage network. Although, openings (drain sumps, sinks, etc.) are missing, direct flooding of the premises is possible trough pipe and through plugs and manholes.

The study identified no buildings or facilities, the flooding of which will directly impact plant safety functions. The facilities failure of which will lead to larger impacts on the nuclear facilities are the power transmission lines located in the lowland between hot channel-2 and double channel. Their loss could lead to loss of off-site power for the plant.

Important weaknesses identified by the analyses of plant flooding with MWL = 32,93m, could be summarised, as follows:

- loss of power generation and transfer to power supply by the diesel generators – due to loss of some power transmission lines connecting the plant with the grid;
- loss of water supply to the cold channel - due to loss of bank pump station and no accessibility by land;
- loss of alternate makeup to the spray pools - due to loss of the shaft pump stations;
- partial flooding the town infrastructure and plant access from the Kozloduy town using the bypass road - this does not affect access to the plant;
- partial flooding of underground communications network below level 32,93m – rainwater draining and untightness of the channels;

- at Units 3 and 4, loss of the backup system (alternate) for spent fuel cooling through the steam generators, when the fuel is in the reactor – failure of the pumps of the additional system for steam generators emergency makeup.

The situation is additionally complicated in case of dike overflow without dike destruction, because the water flooding the lowland between Kozloduy NPP and Danube River will remain accumulated in the enclosure of hot channel-2, double-channel and the dike. Thus, although the anticipated catastrophic wave will last only for few hours, the water retained in this area may remain for indefinitely long time - up to complete natural draining.

POTENTIAL MEASURES TO ENHANCE PLANT ROBUSTNESS AGAINST EXTERNAL FLOODING

Following the identification of plant weaknesses, measures to enhance and secure plant robustness against external flooding with MWL = 32,93m are proposed:

- Development of an emergency procedure for personnel actions in case of damage of “Iron Gate 1” and “Iron Gate 2” dams (Measure B-1-1);
- Investigation of the possibilities for protection of BPS 2 and 3 equipment in case of external flooding with MWL = 32,93 m (Measure B-2-1);
- Development of measures to prevent water intake in the plant sewage network in case of valley flooding (Measure B-2-2);
- Modernization of the sewage network and drain pump system in accordance with the available design for system reconstruction (Measure B-2-3).

CONCLUSION ON THE IMPACT OF EXTERNAL FLOODING

The MWL and its duration are defined. Likelihood of river blocking by ice drifts is investigated. Combinations of MWL and other hazards are assessed. Analyses confirm that the Kozloduy NPP site is non-floodable.

EXTREME METEOROLOGICAL IMPACTS

ACTUAL ASSESSMENT OF METEOROLOGICAL PHENOMENA USED AS DESIGN BASIS FOR SITE FACILITIES

The estimates of meteorological phenomena in the vicinity of Kozloduy NPP, for the past 11 years, confirm the trends in climate change as described in the fourth report of the Intergovernmental Panel on Climate Change (IPCC).

The following weather phenomena were analysed: extreme winds and tornadoes; humidity and icing; extreme rainfall; lightning; extreme snowfall; icing phenomena; extreme temperatures; and low levels of the Danube River. Relevant to the normal operation of Kozloduy NPP are also the following possible combinations of weather impacts:

- combination of temperature-wind-humidity within the range of: temperature 0 to -4 ° C, wind speed 0 to 5 m/s and relative humidity between 95 and 100%, thus creating preconditions for extreme icing;
- combination of high temperatures, extremely low rainfall and low levels of the Danube River - the likelihood of reaching the extreme low water level of 20.50m is less than 1% - this did not happen for the entire plant lifetime.

Evaluation of the frequency of occurrence of extreme weather conditions, postulated in the design basis

Table 1.1. Frequency of occurrence of extreme weather conditions and values adopted for the current assessment

Extreme meteorological conditions	Parameter value	Occurrence frequency
Extreme winds	Wind speed 45 m/s	1×10^{-4} per 1 year
	27 m/s	0,1 per 1 year
	20 m/s	Once per year
Sand spout	Max. speed 332 km/h, spinning speed - 263 km/h, motion speed - 69 km/h, radius - 45,7 m, for area of 12 500 km^2	$6,3\times10^{-7}$ per 1 year
	speed over 332 km/h	$1,26\times10^{-8}$ per 1 year
	max. speed 332 km/h, spinning speed - 263 km/h, motion speed - 69 km/h, radius - 45,7 m for area of 100 000 km^2	$5,05x10^{-6}$ per 1 year
	speed over 332 km/h	$1x10^{-7}$ per 1 year
Snowfalls	11-20 cm	24-30%
	70-80 cm	3%
High temperatures	+43.3°C Absolute maximum air temperature	2,5%
Low temperatures	-26,6°C Absolute minimum air temperature	2,5%
Extreme rainfall	518-558 mm	Annual precipitation, one of the lowest in the country
	Occurrence of ice on Danube River – ice in Oryahovo	62% from 100 years
	Freezing of Danube River – ice in Oryahovo	No data for freezing since 1963

Extreme meteorological conditions	Parameter value	Occurrence frequency
Lightning	Statistical data for 2005 and 2006: 3000-4000 Lightning for June, July and August, in noon and afternoon hours.	
Low levels on Danube River	No water level elevation 20.50m	99%

On-site facilities, with the exception of the AEFWS, FPS-2 and DSFSF are designed in the 80-ies of the 20th century using the regulations and standards applicable at the time. Changes in the legal framework modified design requirements and respectively large-scale safety improvement and Modernization Programs were implemented at all on-site nuclear facilities. Activities on re-qualification and provision of seismic resistance of the safety systems equipment and the civil structures in respect of increased seismic impact were completed in full-scale. Buildings, in which safety related systems and components are located are of seismic category I and are not directly affected by extreme weather phenomena.

CONCLUSIONS ON THE IMPACT OF EXTREME METEOROLOGICAL IMPACTS

ASSESSMENT OF IMPACTS OF EXTREME EXTERNAL EVENTS ON STRUCTURES

Following the amendment of the legislative basis and the respective extreme values specified, considered structures have the required robustness to withstand the increased loads caused by external events, with the following exceptions:

- The overground parts of the CPS 3 and 4 were not strengthened during the Modernization Program. Respectively, it could be concluded that their overground structures are vulnerable to extreme external events and extreme winds could affect some of their elements. In this case, if spray pool makeup pumps fail, pools alternate makeup is provided by 6 ShPS in the Danube River lowland, i.e. the safety functions are not violated;
- Prolonged snow cover with extreme thickness (80cm) could cause damage to some elements of the roof structures of the CPS 3 and 4 and the SFSF. Although the snow cover may last for maximum 1-2 days, monitoring of snow thickness is organized and measures are taken for cleaning of roof structures.

With regard to the wind spout, as it has small radius, concentrated impact on individual structures and systems could be expected, rather than a significant impact on the whole site. It can be concluded that if individual buildings fall into the "eye" of the wind spouts, the roofs and in particular the lighter ones, may be affected, but not at a degree as to jeopardize the operation of the equipment located therein.

Assessments of structures margins are made by using the most conservative approach. In fact, these margins are expected to be larger.

PLANT ROBUSTNESS AGAINST EXTREME EXTERNAL IMPACTS

Loss of spray pools water: Water evaporation in spray pools cause by extreme temperatures and winds is compensated by organizational and operational measures. Design flow of backup water supply sources is sufficient to compensate the losses by evaporation at extremely high temperatures. Pools operating temperature regime provides for no water freezing in extreme temperatures.

In a wind spout, the most dangerous in terms of safety, is when it appears above the spray pools. The very low probability of occurrence of such event at the site was already mentioned. It is even lower less when considering the probability of a wind spout in a particular small site area, such as the pools. However, if this happens, pools will be emptied, which will affect the RHR function. With respect to the small wind spout radius, it is likely that only one spray pool be affected, which means that the overall function will not be compromised. The mostly conservative scenario is the total loss of all the three pools, which is described in details under Topic 2 "Design Issues".

Freezing of spray pools nozzles: design features does not allow for freezing of the nozzles in operation.

Loss of power transmission lines: it could be expected that if a wind spout hits the OSY or particular power lines, this will result in a partial or complete loss of off-site power. Total blackout is the worst consequence from the wind spout and is discussed in detail under Topic 2 "Design Issues".

OSY icing: The current operational experience (since 1971t) shows that at the OSY thare was no failure of a power line or loss of off-site power due to freezing. Considering the large number of connections in different directions, the simultaneous loss of all lines is unlikely. Due to the fact that freezing is a rare phenomenon and has not occurred in recent years, the required data to determine its basic characteristics are not available.

Freezing and icing of the water before BPS: Designs of BPS and double channel provide for protective structures against freezing and icing of the water before BPS. To protect the BPS 2 and 3 fore chamber from floating missiles, a bridge-barrier reinforced concrete structure with immovable grid is constructed.

Freezing of CPS 1-4 pumps lattices: To provide for the required temperature regime and to protect CPS 1-4 pumps lattices against freezing, recirculation of hot water in front of CPS 1 is ensured.

Lightning: The existing lightning protection installations on-site establish a lightning protected zone with reliability over 99.5%.

Low level of Danube River: A procedure is available for actions in case of extremely low level of the Danube River.

Extreme temperatures: High temperatures (maximum measured in the region) do not cause mechanical loads on plant structures and buildings. According to design basis, extreme temperatures do not affect plant safety functions.

POTENTIAL MEASURES TO ENHANCE PLANT ROBUSTNESS AGAINST EXTREME METEOROLOGICAL IMPACTS

Analyses of structures technical conditions in respect of site typical external events (extreme winds, wind spout, snowfall and icing, extreme temperatures, extreme rainfall) and of organizational and technical measures to ensure power supply to and fuel cooling confirm that: safety related systems meet design requirements; and available procedures and instructions are applicable and adequate.

TOPIC 2 – DESIGN ISSUES

This section summarizes the analyses results in respect to Kozloduy NPP nuclear facilities response and robustness in case of loss of the power supply and loss of ultimate heat sink.

The legal requirements to the design and the safety assessments are completely harmonized with the WENRA Reference levels for existing reactors.

In this chapter, presentation of assessment results is focused mainly on design solutions that prevent events with loss of heat sink and loss of power supply, as well as on plant behaviour in case of subsequent degradation of the following safety functions:

- Decay heat removal from the reactor core at specific operational conditions and accidents, with maintained integrity of the reactor coolant boundaries;
- Heat transfer from the safety systems to the ultimate heat sink;
- Provision of the required safety systems support functions;
- Residual heat removal from the spent fuel, which is stored outside the reactor core, but within the unit site.

Assessment of the time available to the operators to take preventive actions in severe accidents is provided for the various scenarios. The following nuclear facilities are subject to the analysis:

- Nuclear reactors of Units 5 and 6;
- Spent fuel pools of Units 5 and 6;
- Spent fuel pools of the shut down Units 3 and 4;
- Spent fuel storage facility.

The analysis does not cover the DSFSF, as heat removal in it is provided using passive principle and atmospheric air is used as ultimate heat sink.

LOSS OF POWER SUPPLY

NUCLEAR REACTORS – UNITS 5 AND 6

Loss of off-site power

Operational power of Units 5 and 6 is provided through the house transformers, energized by the generator voltage. Backup power supply is provided by OSY-220 kV. Secondary backup power supply to the units is provided from the backup power supply bus bars of the twin unit (Unit 5 is supplied by Unit 6 and vice versa). Off-site power to the bank pumping stations is provided by OSY-220 kV, and the backup is provided from Bukyovtsy substation of 110 kV.

- **Design provisions at loss of off-site power**

Loss of the off-site power is defined as loss of all NPP connections with the grid. In case of loss of off-site power, safety-related consumers are supplied by the independent emergency power supply sources, located at the Units 5 and 6 site.

Each of the units is equipped with 3 independent automated DGs (emergency DGs), one for each train of the safety systems. Diesel generators, their support systems and the buildings are seismically qualified for SL2 and are of seismic category 1. They are located at the site level. Consumers, which are supplied from the emergency DGs are safety systems, SFP cooling pumps, and fire protection pumps.

In all operational modes, including total blackout, power supply of I category consumers is provided by accumulator batteries. Accumulator batteries supply the reactor compartment I&C, primary steam-gas removal system, Steam Dump to Atmosphere (SDA) and emergency lights.

Reliable power supply system for the bank pumping station is intended to supply power to consumers related to nuclear and fire safety (emergency service water pumps, shaft pumping stations, fire-annunciation system, fire extinguishing at BPS, as well as their support systems). BPS DG station is equipped with two DGs. Two accumulator batteries are installed in the BPS, which guarantee the uninterrupted power supply to the most important consumers ensuring the accident-free operation of the BPS.

- **Emergency power supply sources**

At operation of two emergency DGs (one per unit), the total fuel and oil inventory of the emergency DGs is sufficient for more than 7 days.

No measures to prolong accumulator batteries operational time are required, as one battery of a safety system train has a discharge capacity of more than 10 hours under full load.

Total fuel and oil inventory available at the BPS site ensures the uninterrupted operation of both DGs for 56 hours and 45 minutes.

Loss of off-site power and loss of emergency DGs

- **Additional emergency power supply**

Each of the two units has one additional independent DG with nominal power of 5.2 MW. Design functions of these DGs are to ensure supply to normal power supply busbars, through which – in case of loss of secondary circuit normal make-up – heated water is supplied to the SG from the deaerators, instead of cool water from the reservoirs of the secondary circuit emergency make-up system. Thus thermal stress to SG tube bundle is prevented. These DGs can be used also for decay heat removal, as well as in case of failure of the 3 emergency DGs. Additional DGs are kept in hot standby mode.

The additional DG is located in a container with seismic qualification for 0.24g, at a platform of 1m above the site seismically qualified for 0.1g. Additional DGs fuel and oil inventory ensure the uninterrupted operation of each of them for more than 4 days.

- **Accumulator batteries**

No possibility is provided to recharge the safety systems accumulator batteries from the additional or the mobile DG. Recharging is provided by the respective emergency DG of the safety systems train. Common-plant accumulator battery and that of the computer-based informational system can be recharged from the additional diesel generator.

- **Time to reaching a severe accident. Threshold values**

The following conditions of the units were assessed:

- Power operations;
- Cold shutdown (N=18 MW, 20 hours after shutdown), sealed primary circuit and drained SGs;
- Cold shutdown (N=18 MW, 20 hours after shutdown), sealed primary circuit and non-drained SGs;

– Cold condition (N=16.2 MW, 28 hours after shutdown), depressurized primary circuit;
– Outage cooldown of the primary circuit (N=12 MW, 72 hours after shutdown and N=6 MW, about 18 days after shutdown).

Operator actions to prolong the time till fuel damage are specified for each of the modes considered in the analyses.

Table 2.1. Time to fuel damage at loss of normal and backup power supply and failure of the emergency DGs

	Option	Time to fuel damage (h:min)
1	Power operations (Considered: actuation of MDG and use of water reserve in the tanks of SG emergency make-up system)	115:45 (4.8 days)
2	Shut down reactor, planned cooldown at pressurized primary circuit and drained SG (Considered: use of ECCS three hydro accumulators)	16:44
3	Shut down reactor, planned cooldown at pressurized primary circuit and non-drained SG (Considered: injection of ECCS three hydro accumulators, make-up of SG from high pressure deaerator, chemically demineralised water system tanks and SG emergency make-up system tanks)	More than 3 days and 19 hours
4	Shut down reactor, planned cooldown at depressurized primary circuit (Considered: use of ECCS three hydro accumulators)	19:45
5	Shut down reactor, outage cooldown (Considered: use of ECCS three hydro accumulators)	
	3 days after shutdown	25:51
	18 days after shutdown	50:12

The first threshold is the discharge of the accumulator batteries (about 10 hours after complete loss of AC). Following, shift personnel losses information on unit parameters. Till that time, the valves required for accident management shall be positioned (PRZ safety valves, SDA, steam/gas mixture emergency cooling line, etc.). However, emptying of accumulator batteries will not stop the already initiated processes of heat removal (motor-driven valves will maintain their position).

The second threshold is the water exhaust in demineralised water tanks (at make-up using a pump of SG auxiliary make-up system) and exhaust in the tanks of the SG emergency make-up system (at make-up using SG EMS). At power operations, exhaust of the three SG emergency make-up system tanks, of the high pressure deaerator water inventory and of the demineralised water tank is expected after more than 3 days.

The third threshold is the exhaust of fuel inventory of the additional and mobile DGs. Additional DG fuel inventory is sufficient for more than 4 days, and MDG inventory – for 60 hours. Oil inventories for both DGs are sufficient for the abovementioned time. If emergency DGs are inoperable, their oil and fuel inventories could be used at the available DGs, which will ensure their operation for more than 30 days.

Loss of off-site power, of the emergency diesel generators and of the additional diesel generator

- **Actions to provide mobile on-site or external mobile power sources**

A mobile DG (MDG) is available at the Kozloduy NPP site. MDG is mounted of a platform jointly with a fuel tank, control board and the power cable wound on the coil. Platform is transported by a tug truck. The mobile DG supplies the pump of the SG emergency make-up system (SG EMS) using own busbar. MDG may be connected to the SG EMS of only one of the two units, though its capacity is sufficient for both units.

Total fuel and oil inventory of the MDG ensures its continuous operation at nominal power for 21 hours and 40 minutes. To power up only the pump of the SG alternative make-up system, this reserve is sufficient for 60 hours.

- **Personnel competence and time required for connecting the mobile power sources**

An operators training system is established at the Kozloduy NPP. This system specifies the scope and duration of training for different job positions. Off-schedule trainings are carried out in respect of: changes to regulatory requirements; modification to systems, procedures and instructions, as well as to new ones; etc. Planning, conducting and analyses of training results are arranged. Additionally, training at a full-scope simulator and by emergency exercises and drills is held. All SBEOPs are simulated at the full-scope simulator. Emergency exercises involve the shift personnel and various emergency groups and teams, according to the NPP internal emergency plan.

Operators actions in response to loss of power supply are specified by “Instruction on elimination of anticipated operational occurrences and accidents” and by a SBEOP for actions at total blackout. Actions related to actuation and loading of additional DGs are specified by procedures - restoration of power supply to category III consumers of Units 5 and 6 from the plant auxiliary DG.

A procedure is available on MDG transportation and connection to the SG EMS pumps busbars, located inside the respective compartments. The established success criteria is: time from the alarm for a total blackout till pump actuation should be less than 2 hours. Fulfilment of the criteria was verified during the emergency exercises.

- **Time for providing of AC power supply. Threshold values**

The following conditions were assessed:
- Power operations;
- Cold condition, pressurized primary circuit and drained SG;
- Cold condition, pressurized primary circuit and non-drained SG;
- Cold condition, depressurized primary circuit;
- Outage cooldown of the primary circuit.

Operator actions to prolong the time till fuel damage are specified for each of the analyzed modes.

Table 2.2. Time to fuel damage at loss of normal and backup power supply, failure of all emergency DGs, failure of the additional DG

	Option	Time to fuel damage (h:min)
1	Power operations (Considered: passive make-up of SG; actuation of SG EMS, supplied from MDG. Time depends upon the configuration of the passive make-up of SG.)	45:00÷49:00
2	Shut down reactor, planned cooldown at pressurized primary circuit and drained SG (Considered: actuation of SG EMS, supplied by MDG; injection of the three ECCS hydro accumulators.)	66:44
3	Shut down reactor, planned cooldown at pressurized primary circuit and non-drained SG (Considered: actuation of SG EMS, energized from MDG; injection of the three ECCS hydro accumulators)	69:44
4	Shut down reactor, planned cooldown at depressurized primary circuit (Considered: injection of the three ECCS hydro accumulators)	7:28
5	Shut down reactor, outage cooldown (Considered: injection of the three ECCS hydro accumulators)	
	3 days after shutdown	9:15
	18 days after shutdown	16:53

Threshold (cliff-edge) effect on process development is the discharge of the accumulator batteries (after about 10 hours). Following, operators does not have the complete information on unit parameters when dealing with accident management.

If the event occur at power or in cold shutdown with pressurized primary circuit, threshold effect is the exhaust of water inventory in the SG emergency make-up system tanks. At power this effect is expected after about 28 hours, and in cold shutdown – after 50 hours.

In case of depressurized reactor, the threshold is the beginning of core heat up, which occurs relatively early – in less than 2 hours. For that time, the operator shall prepare and initiate the injection of the hydro accumulators (preferable initially to the cold part of the reactor). Injection of the three hydro accumulators delays core heat-up with 4 hours.

Loss of off-site power, of the emergency DGs, of the additional DG and of the mobile DG

- **Time required to provide AC power and to restore core cooling before occurrence of fuel damage. Threshold values in plant behaviour**

SAR modes were assessed. Operator actions to prolong the time till fuel damage are specified for each of the analyzed modes.

Table 2.3. Time to fuel damage at loss of normal and backup power supply, failure of all emergency DGs, failure of the additional DG, failure of the mobile DG

	Option	Time to fuel damage (h:min)
1	Power operations (Considered: passive make-up of SG from the high pressure deaerator)	16:15
2	Shut down reactor, planned cooldown at pressurized primary circuit and drained SG (Considered: injection of the three ECCS hydro accumulators)	16:44
3	Shut down reactor, planned cooldown at pressurized primary circuit and non-drained SG (Considered: injection of the three ECCS hydro accumulators)	19:44
4	Shut down reactor, planned cooldown at depressurized primary circuit (Considered: injection of the three ECCS hydro accumulators)	7:28
5	Shut down reactor, outage cooldown (Considered: injection of the three ECCS hydro accumulators)	
	3 days after shutdown	9:15
	18 days after shutdown	16:53

Threshold effect for accident progression is the discharge of the accumulator batteries (after about 10 hours). Following, operators does not have the complete information on unit parameters when dealing with accident management.

If the event occurs at power in cold shutdown condition with pressurized primary circuit and non-drained SG, threshold effect has the SGs dry-up. To prevent rapid increase of fuel temperature, provision of water supply to the SG is required within 6 to 8 hours (up to 9 in cold conditions).

In case of depressurized reactor, the threshold is the beginning of core heat up, which occurs relatively early – in less than 2 hours. For that time, the operator shall prepare and initiate the injection of the hydro accumulators (preferable initially to the cold part of the reactor). Injection of the three hydro accumulators delays core heat-up with 4 hours.

UNITS 5 AND 6 SFPS

Loss of off-site power

- **Design provisions for loss of off-site power**

Spent Fuel Pools are located inside the containments and are designed for temporary and middle-term storage of spent fuel (till reduction of decay heat to the specified level) - for not less than three years.

SFP cooling systems are the part of Units 5 and 6 systems. Respectively, normal and backup power supply of SFP cooldown system is the same as the units normal and backup power supply. These systems are classified as safety related systems for normal operation. They have three trains (redundancy 3 x 100%) and are powered from the emergency DGs.

- **Emergency power supply sources**

Diesel fuel in the seismically qualified tanks is sufficient for continuous operation of the emergency DGs for not less than 7 days.

Loss of off-site power and loss of additional DG

The following Table provides the times for water heating and evaporation down to the level of the heated part of the assemblies, in case of loss of off-site power and emergency power supply. Two options with different fuel quantities have been considered. The first scenario is the current amount of spent and the second is - all fuel is transferred from the core in the SFP following reactor shutdown for refuelling. The initial SFP level, for each case, is taken the level required for normal operation +28.80 m.

If the additional DG is available, the times as specified in the table are extended with at least 19 hours, due to the use of water inventory in the boron system tanks.

Table 2.4. Time to the main events in SFP in case of complete loss of AC power

Parameter	SFP 5	SFP 6
Spent fuel only		
Time for heating up from 50ºC to 100ºC [h:min]	22:52	39:53
Time from 50ºC till beginning of fuel outcrop [h:min]	136:21 (more than 5 days)	237:47 (more than 9 days)
Spent fuel and transferred core		
Time for heating up from 70ºC to 100ºC [h:min]	1:52	1:48
Time from 70ºC till beginning of fuel outcrop [h:min]	17:28	16:51

UNITS 3 AND 4 SFPS

Loss of off-site power

- **Design provisions for loss of off-site power**

After Units 3 and 4 shutdown at the end of 2006, their consumers receive power supply from the start-up auxiliary transformer, which is connected to OSY 220 kV. Units backup power supply is provided by OSY 110 kV through Units 1 and 2 (shut down, without fuel in the SFP) and through the connections between busbars of backup power supply between Units 1 to 4. OSY 400 kV connections could also be used for backup power supply.

In operating mode “E” (shutdown with no fuel in the core), Units 3 and 4 consumers, which require category II reliable power supply, receive power supply from 6 DG sets (three per unit, redundancy 3x100%).

At loss of off-site power and impossibility to supply power from the emergency DGs, SFP cooling pumps are provided with power supply from the emergency DGs of the additional system for SG emergency make-up (two per unit).

- **Emergency power supply sources**

Fuel and oil inventories of the emergency DGs ensure their continuous operation for more than 4 days.

Fuel and oil reserves of the AEFWS emergency DGs ensure their continuous operation for 5 days.

Loss of off-site power and loss of emergency DGs

Analyses of temperature increase and water evaporation in the SFP, at complete loss of all power supply sources and decay heat (as of 01.08.2011), indicate that time available to initiation of fuel outcrop is respectively:

- For SFP-3: 6.8 days;
- For SFP-4: 9.2 days.

As a result of subsequent transfer of half of the spent fuel from the Units 3 and 4 SFP to the SFSF, the time until the beginning of fuel outcrop with residual heat as of 15.03.2012 is more than 20 days

SPENT FUEL STORAGE FACILITY

Loss of off-site power

- **Design provisions for loss of off-site power**

Backup power supply is provided from the DG of the SFSF and from UPS devices. The backup DG provides power primarily to the systems for radiation monitoring, pool feed and make-up system, controlled leaks return system, ventilation systems. Other consumers may be supplied at a later stage. SFSF could receive power also by the mobile DG.

- **Emergency power supply sources**

Total fuel inventory ensures SFP DGs operation for 72 hours (3 days).

Loss of off-site power and loss of emergency power supply

Analyses of postulated initiating events due to loss of SFSF blackout show that spent fuel stripping will not be reached (for spent fuel located in the storage pool, in containers or racks). Analyses of water heat up and evaporation, performed for the most loaded part of the pool, show that fuel outcrop could begin after more than 29 days.

MEASURES TO IMPROVE ROBUSTNESS AT LOSS OF POWER SUPPLY

Units 5 and 6 nuclear reactors and SFPs

- Delivery of 2 new mobile DGs while the existing DG to remain as backup for the remaining on-site facilities (Measure A-1-1);
- Provision of recharging of one of the accumulator batteries of the safety systems by a mobile DG;

SFP power supply systems are the same as those fro Units 5 and 6, with the exception of the additional DG and the mobile DG. When proposed measures for Units 5 and 6 will be implemented, the reliability of the power supply to the SFP cooldown system will be enhanced.

Units 3 and 4 SFPs

Power supply to the systems for fuel cooling in SFP-3 and SFP-4 is provided from diverse physically separated sources (emergency diesel generators – three per unit, emergency DGs of AEFWS, mobile DG). At postulated total loss of cooling and low decay heat of stored fuel (as of August 2011), the available time margin before fuel outcrop is almost a week for SFP-3 and more than 9 days for SFP-4 and respectively more than 20 days for both with decay heat as of march 2012. Thus, no additional measures to enhance SFP-3 and SFP-4 robustness are required.

Spent Fuel Storage Facility

It is feasible to analyze the possibility for installation of an independent water cooling system for the SFSF sections, equipped with independent power supply (Measure C-2-4).

LOSS OF ULTIMATE HEAT SINK

UNITS 5 AND 6 NUCLEAR REACTORS

Design bases for heat removal to the main ultimate heat sink at different operational states

Decay heat sources of Units 5 and 6 are:
- Core decay heat;
- Fuel pool decay heat.

The main ultimate heat sink is the Danube River. Connection to the ultimate heat sink is provided on a direct line from the service water system through a pair of channels. Water from Danube River is supplied to the cold channel by the pumps, located at bank pump stations. Connection to the Danube River is backed up by an Emergency pump station, which ensure independent water supply to the emergency chamber of the cold channel using two independent surge steel pipelines.

Turbine condensers cooling water and components cooling water is delivered by circulation pump stations equipped with fore chambers and pumps, surge steel pipelines, and filtering installations. Hot water return systems are outlet steel pipelines, drain sump shafts and overflows, outlet channels, outlet shaft with a fore chamber and an overflow, collecting and inspection shafts. Totally 4 circulation pumping stations are constructed to cover Kozloduy NPP needs: one for each of the two pairs of shutdown Units 1-2 and 3-4 (WWER-440) and one for each of the two Units 5 and 6 (WWER-1000).

CPS 3 and CPS 4 supply the units in operation, namely Unit 5 and Unit 6. The two pumping stations are identical. At each pump station are installed:
- Motor-driven pumps for supply of cooling water to turbine condensers - intake at elevation 29 m;
- Motor-driven pumps for providing of service water to the components of the systems for normal operation located in turbine hall, reactor building, auxiliary building, and demineralized water system - intake at elevation 28 m;
- Motor-driven pumps for water supply to the spray pools - water intake at elevation 28 m;

- Diesel-pumps for water supply to the spray pools - water intake at elevation 26.3 m, practically from the bottom of the cold channel;
- Fire-protection pumps - water intake at elevation 26.3 m, practically from the bottom of the cold channel.

Series of design measures have been implemented to prevent loss of connection to the Danube River – measures to prevent loss of the pumping stations, means to prevent blocking of the main cooling water inlet, alternative water supply pathways, etc. Removal of used service water from the NPP site (Units 5 and 6) back to the Danube River is backed up by a second hot channel.

For water supply to Units 5 and 6 spray pools, an independent water supply is provided from the terrace of the Danube River using 6 shaft wells and 6 shaft pumping stations. Water amount, which can be delivered from the shaft pumping stations to the spray pools is sufficient to compensate for evaporation and blow away losses of the six spray pools at normal weather conditions. Water from the shaft pumping station is supplied to the spray pools through a separate steel pipeline.

Components cooling at Units 5 and 6 is provided by:

- Service water system, intended for cooling of the components of the systems for normal operation – ultimate heat sink is the Danube River.
- Service water system, intended to remove the heat from the safety systems components at all operational modes and emergency conditions. Each of the three trains of the system operate at a closed circuit and water is cooled down in the spray pools. Ultimate heat sink is the atmospheric air.

At units operation at power, the main pathways for heat removal to the ultimate heat sink are:

- Through the circulating water system – from the turbine condensers to the hot channel and via it – to the Danube River;
- Through the service water system of normal operation components – to the hot channel and via it – to the Danube River;
- Through the service water system of safety systems components – to the spray pools and then – to the ambient air.

Following reactor shut down, decay heat of core fuel is removed in two stages:

- at the secondary circuit: from steam-water mixture at hot conditions to a state at which cooldown using the emergency and planned cooldown system is possible.
- at the primary circuit: using the emergency and planned cooldown system through the cooling circuit. Cooling of safety systems consumers is provided through the respective service water system to the atmosphere. Subcriticality is ensured by control rods insertion and by injection of boron solution into the primary side.

At complete unavailability of the secondary systems, reaching of primary circuit parameters (at which circuit cooling is possible) the “feed-and-bleed” procedure should be applied.

At cold shutdown state, the main pathway for heat removal to the ultimate heat sink is through the service water system of safety system components via the spray pools to the atmosphere.

Loss of main ultimate heat sink

- **Design provisions and procedures for heat removal to alternate heat sinks**

At loss of access to the Danube River (due to simultaneous loss of BPS and/or outlet channels, and the emergency pump station and its pipelines to the emergency water volume), heat removal from the reactor core of Units 5 and 6 is provided on a closed circuit using the service water system of safety systems components into the spray pools and to the atmosphere.

Each spray pool is designed to remove the total heat released by the unit in accident conditions, and to ensure that inlet temperature of the service water for cooling of the safety system components is within the range of +4^{o}C to +33^{o}C.

- **Time limits for use of alternate heat sink and ways to increase available time**

At the initial water level (maximum) of any spray pool, the pool could operate without water feed for 30 hours. Following, the water level is decreased by 1.5 m. Water losses due to evaporation and blow away are about 170÷175 m^3/h. 2526 m^3 of water are needed to fill up a spray pool to the minimum required level, and respectively 7650 m^3 of water to fill it up to the maximum level. Water supply to the spray pools could be provided from:

- Motor-driven pumps of the service water system for cooling of normal operation components, 2 pumps per unit, each having a flow rate of 1440m^3/h. Pumps are operable at cold channel level above elevation 28 m.
- Diesel-pumps of the service water system for cooling of normal operation components, 2 per unit, each having a flow rate of 290 ÷ 500 m^3/h. Practically, these pumps take water from the bottom of the cold channel and could use the entire emergency water inventory, namely 52264 m^3 from the fore chamber of CPS-3 and 21762 m^3 from the fore chamber of CPS-4.
- Shaft pumping stations pumps, each having a flow rate of 180 m^3/h. These pumps are in two groups with diverse power supply. One pump of each group may operate at each shaft pump station. Total flow rate to the spray pools is 1080 m^3/h. In case of dike overflow or rupture, shaft pump stations will be flooded and their use to supply water to the spray ponds will not be possible.

Evaluation of emergency inventory exhaust time is done with the following preconditions:

- One train of the essential components service water system is sufficient to remove residual heat from the reactor and the SFP;
- One pair of spray pools ensures the cooling of at least one safety system train at both Units 5 and 6.

Postulated that at initial stage of water supply ponds are empty (water was drained completely), to fill up a pair of ponds to the minimum level at which they are operable – 2 x 2526 = 5052 m^3 of water is needed. The time to do that is:

- 53 min using the motor-driven pumps of the service water system;
- 2 h 35 min using the diesel pumps of the service water system.

To compensate for water evaporation and blow away losses in a pair of spray pools (340 – 350 m^3/h), operation of one of the motor-driven pumps or one of the diesel pumps is sufficient. Considering the CPS-3 and CPS-4 emergency water inventory (totally 74026 m^3) and the volume to be filled up in order to reach the required minimum level at the two spray pools (being totally dry), the water evaporation and blow away losses of all spray pools could be compensated for 197 hours (8.2 days).

Loss of ultimate heat sink and loss of alternate heat sink

- **External actions to prevent fuel damage**

Required external actions are related to the refilling up of a pair of spray pools. This should be done within 8 days following the initiating event.

- **Time needed**

The following table summarizes the analyses results on Units 5 and 6 robustness at loss of main ultimate heat sink and alternate heat sink. Analyses cover the following conditions of the units:

– Power operations (for initiating event 1 and initiating event 2);
– Cold shutdown (N=18 MW, 20 hours after shutdown), pressurized primary circuit and drained SGs (for initiating event 3);
– Cold shutdown (N=18 MW, 20 hours after shutdown), pressurized primary circuit and non-drained SGs (for initiating event 4);
– Cold shutdown (N=16.2 MW, 28 hours after shutdown), depressurized primary circuit (for initiating event 5).
– Outage cooldown of the primary circuit (N=12 MW, 72 hours after shutdown and N=6 MW, 18 days after shutdown) (for initiating event 6).

Table 2.5. Time to fuel damage at initiating events with loss of ultimate heat sink

Initiating event	Option	Time to fuel damage
	Loss of bank pumping station and shaft pumping station	
1	Loss of vacuum in the turbine condenser	Reduced to initiating event 3, initiating event 4 or initiating event 5
2	Complete loss of make-up water to the SG	Reduced to initiating event 3, initiating event 4 or initiating event 5
3	Loss of primary circuit cooling due to failure of emergency and planned cooldown system at pressurized primary circuit and drained SGs (Considered: make-up of SG with SG EMS and using one auxiliary make-up pump from demineralized water tanks)	> 295 h (12.3 days)
4	Loss of primary circuit cooling due to failure of emergency and planned cooldown system at pressurized primary circuit and non-drained SGs (Considered: make-up of SG with SG EMS and using one auxiliary make-up pump from demineralized water tanks)	> 298 h (12.4 days)
5	Loss of primary circuit cooling due to failure of emergency and planned cooldown system at depressurized primary circuit (Considered: injection of the three ECCS hydro accumulators)	> 204 h (8.5 days)
6	Loss of primary circuit cooling due to failure of	> 206÷209 h

Initiating event	Option	Time to fuel damage
	emergency and planned cooldown system during the mode of outage cooldown of the primary circuit (Considered: injection of the three ECCS hydro accumulators)	(8.6 days)
Rupture of the connections between the spray pools and nuclear power Units 5 and 6		
1	Loss of vacuum in the turbine condenser (Considered: make-up of SG with SG EMS and using one auxiliary make-up pump from demineralized water tanks)	> 99 h 30 min (4.2 days)
2	Complete loss of make-up water to the SG (Considered: make-up of SG with SG EMS)	27÷31 h
3	Loss of primary circuit cooling due to failure of emergency and planned cooldown system at pressurized primary circuit and drained SGs (Considered: make-up of SG with SG EMS and using one auxiliary make-up pump from demineralized water tanks)	97:50 h (> 4 days)
4	Loss of primary circuit cooling due to failure of emergency and planned cooldown system at pressurized primary circuit and non-drained SGs (Considered: make-up of SGs by SG EMS and using one auxiliary make-up pump from demineralized water tanks)	100:50 h (> 4.2 days)
5	Loss of primary circuit cooling due to failure of emergency and planned cooldown system at depressurized primary circuit (Considered: injection of the three ECCS hydro accumulators and use of the inventory of the boron control system tank)	19:45 h
6	Loss of primary circuit cooling due to failure of emergency and planned cooldown system during the mode of outage cooldown of the primary circuit (Considered: injection of the three ECCS hydro accumulators and use of the inventory of the boron control system tank)	
	3 days after shutdown	25:51 h
	18 days after shutdown	50:12

Loss of ultimate heat sink, in combination with station blackout

Simultaneous loss of power supply and ultimate heat sink is considered as:
- Loss of off-site power and loss of all on-site stationary AC sources (emergency and additional DGs);
- Loss of main ultimate heat sink, defined as loss of Danube River water intake facilities.

Following the postulated external initiating event, loss of operability is assumed for:
- Open switchyards;
- Emergency DGs;
- Additional DGs;

– Bank pumping stations and their structures, including DGs;
– Shaft pumping stations.

For accident management, the following could be used:
– Mobile DGs and the facilities supplied by them;
– Emergency water inventory in the cold channel;
– Pumps with own diesel motor, including fire-protection pumps;
– Consumers of Category I power supply till the discharge of accumulator batteries (10h and 18 min).
– Manually-operated valves;
– Other equipment, not affected by the initiating event.

- **Time of site self-dependence before fuel damage due to loss of primary water**

Units 5 and 6 response at different operational states is presented below.

Table 2.6. Time to fuel damage at initiating events with loss of power supply and loss of ultimate heat sink

No.	Unit initial conditions	Assessment results
1.	Power operations	Event is reduced to scenario of loss of normal and backup power supply, failure of all emergency DGs and the additional DG. Time to core damage: 45 – 49 hours
2.	Shut down reactor, planned cooldown at pressurized primary circuit and drained SGs	Event is reduced to scenario of loss of normal and backup power supply, failure of all emergency DGs and the additional DG. Time to core damage: 66 hours 44 min
3.	Shut down reactor, planned cooldown at pressurized primary circuit and non-drained SG	Event is reduced to scenario of loss of normal and backup power supply, failure of all emergency DGs and the additional DG. Time to core damage: 69 hours 44 min
4.	Shut down reactor, planned cooldown at depressurized primary circuit	Event is reduced to scenario of loss of normal and backup power supply, failure of all emergency DGs and the additional DG. Time to core damage: 7 hours 28 min
5.	Shut down reactor, outage cooldown	Event is reduced to scenario of loss of normal and backup power supply, failure of all emergency DGs and the additional DG. Time to core damage: - 3 days after shutdown: 9 hours 15 min - 18 days after shutdown: 16 hours 53 min

- **External actions to prevent fuel damage**

Use of the mobile DG is included in the Emergency plan.

UNITS 5 AND 6 SFPS

Loss of ultimate heat sink

At failure of all trains of the SFP cooling system and in containment isolation, decay heat removal from the stored fuel is provided through evaporation of pool water. To prevent inadmissible reduction of water level in fuel sections and respectively prevent fuel outcrop, an emergency feeding alignment is applied by the use of one containment spray pump taking water from the ECCS sump tank. Pump motor is cooled by the essential components service water system.

Facility response at loss of ultimate heat sink is the same, as at loss of power supply. However, in this case, heat removal is terminated at a much later stage – after emergency water inventory of the cold channel is exhausted and spray pools make-up is discontinued. Thus above mentioned available time (estimated for total blackout) is extended by 197 hours (8.2 days).

A possibility exists, to supply service water by the use of diesel-pumps. This is done from the fore chamber of CPS-3 (CPS-4) to the first train of the essential components service water system. Arrangements are made to provide cooling of pump motors by the use of the first train of the emergency core cooling system. Thus, due to water inventory in the sump tank, SFP evaporation could be compensated for 32 h 15 min (considering the most severe conditions - fuel is unloaded from the reactor and put into the SFP).

Using the boron solution reserve available in the boron control system tanks, time for which evaporation losses are compensated is extended by at least 19 hours. In this case, operation of the feeding does not depend on the operation of the service water system.

UNITS 3 AND 4 SFPS

Loss of ultimate heat sink

- **Design bases for heat removal to the main ultimate heat sink**

Removal of the decay heat from the SFP-3,4 spent fuel is provided by the SFP cooling systems. Heat is transferred through heat exchangers to the essential components service water system. After cooldown in the spray pools, the water is returned back to the cold channel.

- **Loss of main ultimate heat sink**

An alternative way for SFPs heat removal is the use as an ultimate heat sink the water in the fore chamber in-front of the CPS. Water is supplied to the SFP heat exchangers using diesel-pumps, located in FPS-2.

When impossible to remove the heat via the ordinary systems alignment, this could be provided by evaporation of water surface. To compensate for evaporation losses, two possibilities are provided: using the SFP feeding pump and water from the sump tank (Emergency Make-up Tank) or from other tanks and respectively using diesel-pumps of FPS-2 with water from the cold channel.

There are many alternative ways for SFP heat removal (described in emergency procedures), for which independent power supply (electric or diesel motors) is ensured and having diverse water sources. Thus, at loss of main ultimate heat sink, loss of the safety function "SFP residual heat removal" is not expected.

- **Loss of ultimate heat sink and loss of alternative heat sink**

At complete loss of all possibilities for cooling and filling up of the SFP-3,4, the times to occurrence of the main events and before outcrop of the fuel assemblies are the same, as those in the case of complete loss of AC sources.

SPENT FUEL STORAGE FACILITY

SFSF connection with the ultimate heat sink (Danube River) is provided by the service water system. SFSF is supplied with service water via two independent lines of the Units 3 and 4 systems.

At complete loss of the main and the alternative heat sinks, due to the low intensity of decay heat, heat removal could be done by evaporation to ambient air. The impact caused by loss of all possible ways to compensate evaporation losses is the same as in the case of loss of power supply. However, the times to occurrence of the main events, as assessed for complete loss of AC power should be extended with the time for which the emergency water inventory of the CPS-2 fore chamber will decrease below the level of water intake by the pumps of the essential components service water system.

An additional analysis was conducted for a beyond design basis accident with complete loss of SFP water due to beyond design basis earthquake, at which ground stability is affected and significant cracks open in the reinforced concrete of the SFP. Dry up of SF storage sections with the current SFSF load and simultaneous failure of all systems, combined with unavailability of natural ventilation will result in a significant increase in fuel elements temperature (up to 600°C) and of the civil structure temperature (up to 340°C), which is not acceptable in respect of safety limits for SF storage. Nevertheless, this will not result in fuel melt.

MEASURES TO IMPROVE ROBUSTNESS AT LOSS OF ULTIMATE HEAT SINK

- Conditions, efficiency and availability of emergency water supply from the Shishmanov Val dam should be carried out (Measure C-2-1).

No measures to enhance SFP 3,4 robustness at loss of UHS are required.

No measures to enhance SFSF robustness at loss of UHS are proposed.

CONCLUSION

A reassessment of the safety margins was performed in respect of events with loss of safety functions, which result in severe accidents. Reassessment covers: Units 5 and 6 reactors and spent fuel pools; Units 3 and 4 spent fuel pools; and the spent fuel storage facility. The reassessment is based on safety analysis performed using deterministic methods. Results of the analyses of postulated initiating events with loss of power supply and loss of ultimate heat sink show, in general, quite high robustness of the facilities, as well as availability of adequate time to undertake additional preventive actions, when needed.

Following the regulatory review of licensee report on reassessment of safety margins, a conclusion is made that strengths and weaknesses have been properly identified. BNRA accepts the measures proposed for further improvement of plant robustness against the loss of power supply and loss of ultimate heat sink. In addition, BNRA recommends that implementation of following design provisions shall be considered and analyzed:

- Ensuring power supply using mobile DGs to: systems involved in residual heat removal of the reactor coolant boundary; and systems involved in primary circuit make-up in case of an open primary circuit;
- Ensuring power supply using the accumulator batteries to the power operated motors of the valves installed at the hydro accumulators connecting pipes - in order to ensure feeding of the primary circuit in cold shutdown conditions and failure of the emergency DGs;
- Ensuring power supply using mobile DGs or the additional DG to the systems providing SFPs cooling or feeding.

TOPIC 3 - MANAGEMENT OF SEVERE ACCIDENTS

LICENSEE ARRANGEMENTS FOR ACCIDENT MANAGEMENT

PERSONNEL AND MANAGEMENT OF SHIFTS IN NORMAL OPERATION

Operational management of Kozloduy NPP facilities is performed by operating shifts 24 hours a day, 7 days a week. The personnel is distributed in 5 shifts and 2 more backup shifts are ensured.

The senior shift manager is the Plant Shift Supervisor, respectively the Plant Shift Supervisor of Energy Production -1 (EP-1) - for Units 1-4 and Plant Shift Supervisor of Energy Production -2 (EP-2) - for Units 5-6. The Plant Shift Supervisor is responsible to ensure compliance with the statutory requirements for operation of the installations and for organization and implementation of prompt actions in case of emergency, natural disasters and for first aid.

According to the instructions on Kozloduy NPP operational interactions in emergencies, the operational shift manager of a given unit performs the functions of emergency manager for that unit .

Kozloduy NPP personnel is trained and instructed to report to the respective operational manager for any event which may lead to degradation of the safety of plant facilities. This is a prerequisite to timely assess and identify emergency situations, as well as to take appropriate actions.

LICENSEE ARRANGEMENTS FOR ACCIDENT MANAGEMENT

Activation of the Kozloduy NPP Emergency Plan establishes the emergency arrangements, which includes also some of the arrangements for normal operation. Responsible person for overall management of activities is the Emergency Manager. Until gathering of the emergency response team, the duties and responsibilities of Emergency Manager are performed by the Plant Shift Supervisor, as follows:

- Plant Shift Supervisor (EP-1) - in case of emergency in Units 1-4 and plant common objects (Open switchyard, River bank pump station, Spent fuel storage facility);
- Plant Shift Supervisor (EP-2) - for Units 5-6 and the Specialized Enterprise "Radioactive waste - Kozloduy".

Emergency arrangements are organised in three levels according to the respective emergency situation:

- level "I" - for class "ALERT";
- level "II" - for class "LOCAL EMERGENCY";
- level "III" – for classes "SITE EMERGENCY" or "GENERAL EMERGENCY".

Emergency arrangements are based on a predefined and continuously maintained standby duty of the Kozloduy NPP full time personnel. It is regulated by a separate instruction, which provides easy formation of the respective emergency structures, depending on the location of the affected facility. The functional relationship between the emergency class, the composition of the response team and the location is specified by the Emergency plan.

After activation of the Emergency plan, emergency teams personnel receive the status of "emergency personnel". The status of "emergency personnel" receives also the personnel of the support teams (maintenance and other personnel of Kozloduy NPP and personnel of external organizations) used for implementation of emergency activities.

Particular personnel responsibilities and the order of their implementation are regulated by separate instructions and procedures. This documentation is distributed and is maintained on the working places, where emergency teams gather after activation of the Emergency plan. Staff actions in performing activities under the Emergency plan are regulated in separate plans, agreed and approved as required.

A Management Group is gathered in all emergency situations, which reports directly to the Emergency Manager. Until the arrival and assembly of the Management Group, its functions are performed by the operating personnel on shift under the management of the respective Plant Shift Supervisor. Depending on the emergency situation, the members of the management group and the emergency personnel (operating and standby) are located at:

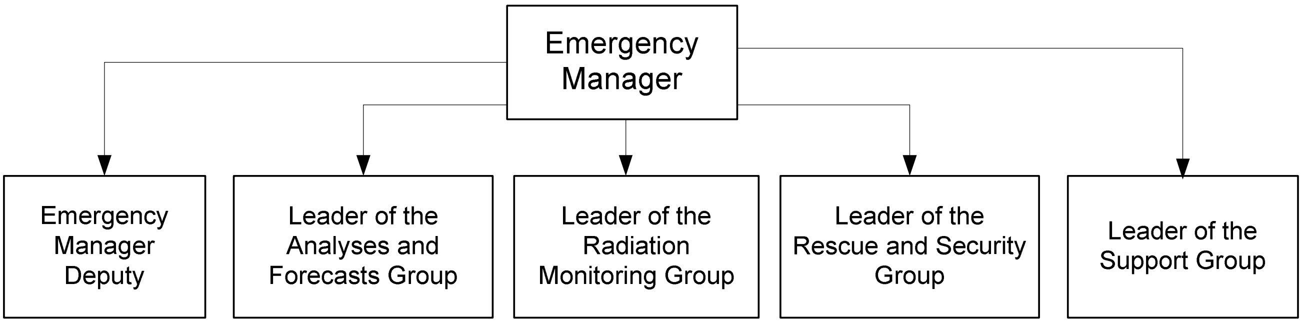
- their work places:
  - main control room;
  - control room of the open switchyard;
  - control room of the river bank pump station
- the Accident Management Centre (AMC).

Plans for assistance to the site organization

In case of physical isolation due to an external hazard (for example flooding), additional operational and maintenance personnel will be called up. A review of the Emergency plan is needed in order to consider all possible effects from a site physical isolation resulting from external hazards.

Measures to ensure optimum personnel intervention

The figure shows the Kozloduy NPP organization of the emergency response.



The management group performs the following tasks:

- gathers information about the conditions of affected facilities and of operating units;
- manages the activities on accident evaluation;
- takes decisions on:
  - personnel protection and accident management;
  - establishment of additional backup teams - if necessary;
  - shutdown or continuation of the operation of units not affected;
  - delivery of materials and spare parts for prompt repair and restoration activities;
  - request for assistance from the National Control and Coordination Headquarters (NCCHQ) and from the Ministry of Economy, Energy and Tourism;
  - initiation of restoration activities;
  - suspension of the Emergency Plan and restoration of the functional operability of affected facilities.
- prepares and disseminates information to higher-level and local authorities.

OFF-SITE TECHNICAL ASSISTANCE FOR MANAGEMENT OF ACCIDENTS

After activation of the Emergency plan, the Emergency Manager shall periodically inform about the accident progression and measures taken for accident localization and mitigation of consequences:

- the emergency centre of the Nuclear Regulatory Agency;
- the officer on duty at the Fire Safety and Public Protection Department (FSPPD) of the Ministry of Interior;
- the officer on duty at the Ministry of Economy, Energy and Tourism;
- the officers on duty at the Kozloduy and Mizia Municipalities;
- the officers on duty at the communication and information centres in the cities of Vratsa and Montana.

External forces and means, which shall be gathered to support Kozloduy NPP are determined in the National Emergency Plan for rescue and urgent recovery actions in case of disasters, accidents and catastrophes.

At "site emergency" or "general emergency", the Emergency Manager coordinates joint emergency activities with the National Control and Coordination Headquarters and its formations involved to help Kozloduy NPP. Under the leadership of the Emergency Manager are performed the joint actions between the site groups and the additional personnel within the plant area and in the preventive actions zone.

Non-affected facilities are maintained in safe conditions and accident consequences are mitigated the plant personnel following the instructions given by the NCCHQ, BNRA and MEET.

The Emergency Manager, by the help of the Leader of the support group informs the managers of the external support teams about the accident progress providing the following data:

- information about the radiation releases and the accident progress;
- routes to and areas where tasks will be performed;
- escort of the support teams to the predetermined points in the accident vicinity and orientation in the situation;
- assistance by radiation monitoring specialists;
- exchange of data to maintain continuous communication and management.

The Emergency Manager maintains continuous contacts and obtains information from the evacuation committee of Kozloduy Municipality for the evacuation of the population, in accordance with the terms and in settlements, defined in the National Emergency Plan.

The overall coordination of the activities for localization, rescue, protection and liquidation activities at beyond design basis or severe accidents in Kozloduy NPP is carried out by the NCCHQ Chair. On-site responsible is the Emergency Manager. The NCCHQ Chairman coordinates and manages the activities of the external teams and provided resources. The direct management of the external teams is carried out by their managers.

PROCEDURES, TRAINING AND EXERCISES

Personnel actions in design and beyond design basis accidents are defined in the instructions for personnel actions in emergencies. Personnel actions, provided in the instructions, shall ensure the safe state of the nuclear facilities.

Personnel actions to identify Units 5 and 6 status, to restore or compensate degraded safety functions and to prevent core damage or mitigate the consequences are defined by Symptom-Based Emergency Operating Procedures (SBEOP). Three sets of SBEOP instructions are provided for Units 5 and 6, as follows:

- SBEOP for power operation;
- SBEOP for shut down reactor with pressurized primary circuit;
- SBEOP for shut down reactor with depressurized primary circuit.

The SBEOP contain:

- procedures for diagnose of the state;
- procedures for optimal recovery;
- procedures for restoring of critical safety functions;
- procedures for accidents with damage of the barriers.

According to SBEOPs, actions are initiated after reactor scram or actuation of the safety systems. The structure and the scope of the SBEOP cover all design bases accidents and a wide list of BDBA. SBEOPs for power operation and shut-down reactor (pressurized primary circuit) are in force and are distributed to the operator's workplaces. SBEOPs for shut-down reactor and depressurized primary circuit are being verified and validated. Following operators training, the procedures will be in force for Units 5 and 6 at the beginning of 2013. These procedures include also actions in case of accident conditions in the spent fuel pool in the "shut-down reactor" and "refuelling" modes.

Units 5 and 6 staff training is performed on a full-scope simulator, which is being kept in conformity with the referent Unit 6, in accordance with the Regulatory requirements and the ANSI/ANS-3.5-1998 standards. Two types of training are being performed for the MCR operators - continuous and initial training required for the licensing.

Severe Accident Management Guidelines (SAMGs) are developed for Units 5 and 6, which follow the SBEOP format. Criteria are specified for transition from SBEOP to severe accident management guidelines. Kozloduy NPP SAMGs are verified and will be subject of internal validation. After operators training, the guidelines will be in force for Units 5 and 6 in the end of 2012. SAMGs are developed on the basis of system analysis of the processes and phenomena during severe accidents. A training course is developed and MRC operators passed theoretical SAMGs education.

In compliance with the operational licenses of Units 3 & 4, Emergency procedures have been developed and enforced in order to regulate activities of operating personnel to handle the emergency situations at spent fuel pools during the long term storage of the spent fuel.

In compliance with the operational licenses of the Spent Fuel Storage Facility an Emergency Procedure has been developed and enforced in order to regulate activities of the personnel to cope with emergency situations at the Spent Fuel Storage Facility.

For the needs of the emergency training are developed:

- programs for training in emergency planning;
- three-level training courses, first level - for common staff (staff not included in groups and teams as well as for external organizations), second level - for emergency personnel (detailed training on emergency procedures); third level - for emergency personnel on positions included in the Emergency plan - to train the emergency procedures, instructions, methodology, etc.

Training is documented in accordance with the established in the Kozloduy NPP personnel qualification system. The training, the emergency drills and general emergency training exercises are conducted in accordance with a schedule, approved by the Executive Director and in compliance with a program, which is developed and approved in advance. Scenarios are developed for emergency training and used to perform training of emergency teams. The Kozloduy NPP objective of emergency training activities is to test and maintain staff preparedness to respond adequately to emergencies.

POSSIBILITY TO USE THE EXISTING EQUIPMENT

MEASURES THAT ENSURE THE USE OF MOBILE DEVICES

The mobile diesel generator is one of the design modernization measures of Units 5 and 6 of Kozloduy NPP, designated to enhance safety and aims to ensure emergency power supply to the "reliable power supply busses" in case of loss of AC power. A procedure is prepared for transportation and connecting the mobile diesel generator to the busses in the premises of the emergency feed water pumps. The success criterion is: the time from the loss of AC power supply until the starting of the pump shall be no longer than 2 hours. Fulfilment of this criterion is confirmed by emergency trainings, provided that destruction of the infrastructure as result from external influences is not considered.

The total stock of fuel and oil for the mobile diesel generator ensures its continuous nominal power operation for a period of more than 21 hours and 40 minutes. For power supply of only the emergency feed water pump this stock is sufficient for 60 hours.

Support and management of supplies

The available fuel and oil inventory ensure:

- at operation of two emergency DGs (one per each unit) - the total emergency DGs fuel and oil reserve is sufficient for more than 38 days;
- the discharge time of batteries at nominal load is more than 10 hours;
- the total inventory of fuel and oil for the additional DGs ensure continuous operation of each one of them for more than 4 days;
- the total inventory of fuel and oil for the emergency DGs of Units 3 and 4 ensure their continuous operation for 4 days;
- the total inventory of fuel and oil for the complementary emergency feed water system ensure continuous operation of the system for more than 5 days;
- the total inventory of fuel and oil for the emergency DG of the spent fuel storage facility ensure its continuous operation for 72 hours (3 days);
- the safety of the dry spent fuel storage facility does not depend on the availability of power supply and water.

The available at Kozloduy NPP Units 5 and 6 water volumes used for decay heat removal by the secondary circuit are:

- tanks of the emergency feed water system (TX) – 1300 t total volume;
- tank with emergency volume of demineralised water (UA) – 1000 t;
- tanks with feed water (deaerators) – 370 t.

Water amount required for primary circuit cooling down to ^{o}C, which allow start-up of the residual heat removal system does not exceed 724 t (conservative scenario for cooling with two steam generators). Therefore the available water volume is 3.75 times more than the needed.

If due to dry SGs the secondary heat removal is not possible, the coolant release from the primary circuit through the Pressurizer safety valves could be compensated with borated water, injected by the following systems:

- high pressure boron injection system (TQ4) - 3x15=45 t;
- medium pressure boron injection system (TQ3) - 3x15=45 t;
- tank of the low pressure boron injection system and of the containment spray system – 570 t;
- hydro accumulators - 4x50=200 t;
- tanks with concentrated boron solution (TB10B01,02) - 200 t;
- tanks with boron solution (TB30B01,02) - 250 т.

If the residual heat of the reactor core is 18 MW (18 hours after the reactor shut-down), the above mentioned volume of boron solution will be enough for about 51 hours. The fact that the injected boron solution remains in the containment in form of steam or condensate is not considered.

Additional amount of demineralised water is available as follows:

- tanks for demineralised water (UA21,22,BO1): 1800 t;
- tanks for clean condensate in the reactor building (TB40B01,02): 960 t;
- tanks for condensate in the auxiliary building (0TR90B01,02): 280 t

The amount of the stored dry boric acid is 4 t.

The total volume of stored boron solution for injection in the primary circuit of Units 3 and 4 is 1000 m3;

The total volume of demineralised water is:

- for Units 3 and 4 - 3400 m3;
- for spent fuel storage facility - 500 m3 in Auxiliary building 2.

Management of radioactive releases

Plant design provides for localizing systems, ensuring fulfilment of the established criteria for radioactive discharges into the environment. For implementation of localizing functions, in the containment structure are installed systems and means for monitoring of containment medium parameters, devices for isolation of the containment structure and devices for reduction of the concentration of radioactive fission substances, hydrogen and other substances that could be released into the containment atmosphere during and after design basis and severe accidents. For implementation of these safety functions the following systems are installed:

- leaktight enclosure system;
- containment spray system;
- pressure reduction filtering system;
- hydrogen recombination system.

In the scope of Modernization Programme, the following measures related to leaktight enclosure system have been implemented:

- improvement of the containment test procedure;
- qualification of cable channels and planning of replacement;
- installation of filtering ventilation;
- development and implementation of radiation monitoring system for severe accidents.

Communication and information systems (on-site and off-site)

- **Safety Parameters Display System (SPDS)**

In implementation of its functions, the SPDS continuously measures the safety important technological parameters and by calculating provides information on the Critical Safety Functions. This information is presented at the Main control room and at the Accident Management Centre.

- **Radiation monitoring systems**

The Radiation monitoring systems provide information in the dose control boards, where is displayed and archived the information about:

- the dose rate and the concentration of radioactive gases and aerosols in the operating and restricted access compartments and in different technological fluids in the Reactor building and in the Auxiliary building;
- quantities of gas-aerosol and liquid radioactive releases.

This information is presented in the Accident Management Centre. In accordance with the recommendations of EUROATOM 2004 the system is upgraded.

- **Automated information system for off-site radiation monitoring**

- The system consists of 2 basic stations and 8 control stations, in which the equivalent dose rate of the gamma radiation and the surface concentration of I-131 is measured. The basic stations are located on the sites of EP-1 and EP-2 (one station per EP). Two of the control stations are located on the NPP territory, and the rest in the preventive actions zone (within radius of 1.8 km from the NPP, at 45º one from the other).
- 5 water stations, in which the specific volume activity of the waste process waters is measured.

The system is integrated in the National Automated System for continuous monitoring of the radiation gamma background of the Ministry of Environment and Water, thus providing conditions for early notification in case of a radiation accident. The information is presented in the Accident Management Centre.

- **Automated information system for on-site radiation monitoring**

The automated information system for on-site radiation monitoring provides information for the gamma background levels in fourteen points around Kozloduy NPP site. The information is presented in the Accident Management Centre.

- **Meteorological monitoring system**

The meteorological monitoring system provides information about Kozloduy NPP region, which is necessary for making forecasts for the radioactive transfer and for the dose exposure in the emergency planning area. The system is integrated with the System for meteorological monitoring and the data from the system are submitted to the national institutions.

- **Environmental and Kozloduy NPP site monitoring**

Field measurements are conducted on the KNPP site and within the areas of preventive and emergency protective actions by the help of:

- three cross-country vehicles;
- mobile lab.

Laboratory assays of samples collected from the environment and the KNPP site are performed at the Environmental monitoring labs. Sample pre-treatment, radiochemical isolation, concentration and subsequent radiometric and spectrometric measurements are also performed there in conformity with the applicable methodologies. The information is presented in the Accident Management Centre.

- **AMC Information System**

The AMC Information System is a complex of technical and software tools for support (ensuring information exchange) of the emergency management team and the staff at the Accident Management Centre. The AMC Information System receives input data from the KNPP SPDS, from the on-line radiation monitoring systems and from the weather monitoring system. The generated output data is used to assess facilities status, radioactive releases and public exposure, which is needed to support decision making and to implement protective actions.

- **Alarm and communication facilities**

A modern alarm system is available at Kozloduy NPP site, the objective of which is to ensure high quality and reliable announcement on-site of KNPP and the towns within the 12-km area in case of activation of the Emergency plan. If necessary, all available information communication tools, telephone, radio communication and loudspeaker systems are used to inform the personnel, management and the public.

FACTORS THAT CAN HINDER ACCIDENT MANAGEMENT AND EVALUATION OF UNFORESEEN CIRCUMSTANCES

Significant damage to infrastructure or flooding around the plant, which may prevent site access

Assessments of "Earthquakes" in the range of seismic impacts $0{,}26 < PGA \leq 0{,}36$ g, (significantly above the design basis of 0,2 g) show that serious damages and destructions are expected in seismically unqualified structures and facilities on site. At this level of site seismic impact, it is likely that all administrative buildings, designed upon general industry standards, will be severely damaged and will be unusable (Administrative Building, Engineering laboratory complex, Medical service). Seismically unqualified technological overhead roads are likely to be damaged too. Bridges over the cold channel are likely to be damaged, which can cut the direct road connecting EP-1 and EP-2.

Similar damages are expected also in buildings and infrastructure around the site. As a result of beyond design basis seismic impact it is very likely that the hospital and the fire fighting service in the city will not function properly. These secondary effects of the combined impact of an earthquake and a subsequent flooding should be considered when planning emergency activities. Respectively, evacuation routes, transport of fuels and materials should be diversified, as well as access of operating personnel.

At seismic accelerations in the range of $0{,}26 < PGA \leq 0{,}36$ g, the upper ventilation stack of Auxiliary Building-2 will be destroyed for sure. As a result, the upper part of the chimney (about 50 m) can partially affect the surrounding infrastructure (roads) that would limit access of emergency teams or heavy machinery to the Spent Fuel Storage Facility. Nevertheless, in the considered range of seismic accelerations, the Spent Fuel Storage Facility will maintain its functions for safe storage of spent fuel.

The possible earthquake adverse effects on the national infrastructure and plant ability to maintain the safety functions are described under Topic 2 of this report.

Analyses of "External flooding" show that even the entire volume of the "Shishmanov val" dam is released, the water level in the valley around the plant will not be higher than elevation

+29.00, so there is no danger of flooding at the site and direct impact on the safety functions. When assessing the response, possible flooding of parts of Kozloduy town and the possible difficulties in access to the plant should be considered.

All scenarios of combination of beyond design basis earthquake and a flooding lead to loss of the ShPS pumps due to flooding. Their loss leads to the loss of water supply to the spray pools of Units 5 and 6, i.e. the time to provide ultimate heat sink will be limited.

More important weak points, found by the analyses of flooding with Maximum Water Level = 32,93m, are as follows:

- Interruption of the power production and switch over to diesel generator power supply – this is caused by possible loss of some of the High Voltage Lines, connecting Kozloduy NPP with the National Grid;
- Loss of cooling water flow in the cold channel – loss of River Bank Pump Station and loss of access to the station;
- loss of make-up water to the spray pools – loss of Shaft Pump Stations;
- flooding of part of the town of Kozloduy and access to the NPP from Kozloduy, using only the bypass road;
- flooding of part of underground communication tunnels, placed below elevation 32,93m.

Loss of communication equipment/systems

In case of blackout, the time up to recovery of the communication systems power supply is as follows:

- the availability of the systems, supplied by UPS is up to 8 hours;
- the availability of the systems, supplied by Diesel Generator-1 and Diesel Generator-2 in AMC is more than 4 days.

High radioactive dose rate, radioactive contamination and destruction of some equipment on the site

The actions and measures, described in the Emergency plan are performed depending on the emergency condition in Kozloduy NPP. The actions and measures are specified in details based on additional information about the radioactive release and based on the criteria for intervention in the early phase of the accident.

Application of specific protective measures is ordered by the Emergency Manager in the initial and in the subsequent messages. All reasonable efforts shall be made to maintain the annual effective doses for the members of the emergency teams and individuals involved in the intervention below 100 mSv. When a emergency personnel receives the annual effective dose of 100 mSv, it is replaced by other member of the emergency team. In emergencies, when implementation of lifesaving activities is required, the limit of 100 mSv may be exceeded

The designs of the Main and Emergency control rooms and the Accident management centre ensure their habitability during radiation or nuclear accidents.

Impact on the accessibility and habitability of MCR and ECR

- **Units 3 and 4**

Control and monitoring of technological processes is performed by two Main control rooms (one for each unit). A divided layout of the Main control rooms is adopted in the Technical design which ensures:

- high fire safety of the control rooms;
- high reliability in unit operations;
- better tracing of cables.

There are two Emergency control rooms provided by the design, one for each unit, which could be used to shut-down the units in case of an emergency at the Main control rooms.

The following equipment is controlled through MCR: working transformers for Unit consumers 15,75/6,3 kV, 6 kV, circuit breakers for back-up power supply of 6 kV busses, Unit working transformers and Unit stand-by transformers 6/0,4 kV and elements of the reliable power supply of the Units. The following communication systems are provided in MCR:

- two-direction loudspeaker connection of the duty operator and the operating staff;
- command loudspeaker and signalization in the main production premises on the territory of the power plant.

Conditioning systems for maintenance of the necessary conditions for uninterrupted work of the operators have been installed in MCR. This is combined with the arrangement of MCR and forms the so-called “working” area of the operators in MCR. To ensure habitability of MCR in case of accident with radioactivity release, there is installed emergency system which would maintain positive pressure in MCR and incorporates particle and aerosol (iodine) filters.

On the ducts of the existing ventilation systems to MCR are installed cut-off valves, which are closed automatically in case of fire, which might impact the atmosphere in MCR. This prevents the diffusion of smoke into the MCR. Separate air-conditioning system is provided for ECR to ensure the operation of the equipment, sensitive to high-temperature conditions.

Provision of the necessary ventilation and conditioning systems has been also carefully reviewed during the design of the new safety systems – Additional system for feed water supply to SG and Fire pump station 2 whereas the problem was solved during the construction of the respective new buildings in 1997-1999.

- **Units 5 and 6**

Reactor facility, reactor status and process systems are controlled from MCR in normal operating modes and in emergency conditions. The MCR is situated in a separate room in the reactor building, outside the containment in a clean area and is categorized as seismic class 1. The MCR is located at a lower level below the reactor pile. Design bases accidents involving loss of coolant do not affect the MCR. The studies of the beyond design basis seismic impacts show that the civil structure of the MCR and the adjacent rooms preserve their integrity. The studied beyond design combined seismic and external flooding impacts show that the MCR preserves its functionality. The studied beyond design impacts from external flooding show no affect of the MCR.

The ECR is designed to bring the reactor in a safe sub critical cold condition and to maintain that state without any restrictions, to actuate the safety systems and receive information about the reactor status. The ECR is located at level -4.20 in the reactor building. The ECR is seismically qualified as Category 1. Design basis accidents with loss of coolant do not affect ECR. The studies of the beyond design basis seismic impacts show that the civil structure of the ECR and the adjacent rooms preserve their integrity. The studied combined beyond design seismic and external flooding impacts show that it is possible to have the ECR flooded.

- **SFSF - accessibility and habitability**

In case of complete dry out of the fuel pools, the dose rate in the rooms of SFSF (including the control room) will reach values requiring the corresponding levels of actions.

- **DSFSF - accessibility and habitability**

The studies within the earthquake analysis found that a cask buried under debris which may have been a result of extreme external initial events as earthquake, would increase its temperature. In case of 100% burial with debris, the conservative assumption calculations show that the maximum temperature of the shell can be exceeded after more than 2 days.

Considering the roof structure, it can be expected that the realistic level of burial shall be below 50%. That increases the time available to take counter measures to more than 7 days. Even in the worst scenario of loss of heat removal accident, there is sufficient time, available to take adequate counter measures, i.e. to remove the debris and restore the natural ventilation.

Impact on different buildings and rooms

During the analyses of earthquake, flooding and the combination of earthquake and flooding, it wasn't found any difficulties with the access to the MCR. During the analyses of the beyond design basis combination of earthquake and flooding, it was found scenario with possible flooding of ECR and surrounding areas, which will make access of staff to ECR of Units 5 and 6 difficult.

The functioning of the Accident management centre at seismic impacts (lower than SSE), will be determined by secondary seismic effects, such as destruction of surface structures which limit the access of staff to the Accident management centre. This problem has been considered in the design and it is provided an emergency way for access to the Accident management centre.

Measures for accident management in case of external hazards (earthquakes, flooding)

- **Units 3 and 4**

In accordance with the results from the earthquake assessment, fuel damage cannot be avoided for PGA over 0,36g, i.e. with accelerations of the input impact for which is expected liquefying of the sands underneath Fire protection station-2 and Circulation Pump Station 2. Therefore, during the assessment is reviewed an earthquake within the range $0,26 < PGA \leq 0,36$, which defines the spectrum of beyond design basis earthquakes where the seismically induced failures of SSCs do not lead to fuel damage.

It is assessed the level of earthquake, which leads to loss of the containment integrity i.e., the integrity of the containment construction of Units 3 and 4 has been assessed and the following conclusion has been made: The most probable mechanism for loss of leak tightness of the system of leaktight premises of Units 3 and 4 is via demolition from cutting of the wall at axis 19 up to level +10,10m. The value of the seismic acceleration at which is expected malfunction of the leaktight premises system is Am = 1.25 g. This value is more than 6 times higher than RLE and it is practically improbable, taking into account the actual seismic-tectonic environment of the Kozloduy NPP site and the region around it.

In relation to the initial design bases which define MSK = 0,1 g for nuclear facilities, the margin is 0,26g or 260%, i.e. the units can resist with no fuel damage an earthquake that is 3,6 times higher than the MSK of the original design.

In accordance with the results from the flooding margins assessment, it has been established that from all civil structures in which there is placed equipment, related to implementation of the safety functions for Units 3 and 4 of Kozloduy NPP, only the building of

Additional SG feedwater system is in danger of flooding during maximal water level. Level 0,00 of the building is positioned at elevation 35,60. Analysis shows that with Danube River level over 31,10 m it is possible that the basement of the building of will be flooded (due to the presence of siphons at the level -4,50 = 31,10m). The pumps of the Additional SG feedwater system are located at elevation -3.00m level, which predetermines that they will be impacted at water level over +32,50m

- **Units 5 and 6**

The design of Kozloduy NPP Units 5 and 6 is robust against impact of external hazards. The reactor and the main primary equipment are located in a reinforced concrete leak-tight structure, designed to retain the radioactive products, resulting from accident inside and that is seismically qualified for 0,2 g. The main systems, the safety systems components and the safety important systems are also located into buildings that are seismically qualified for 0,2g. The studied beyond design basis seismic impacts show that for seismic impacts of up to 0,36 g, the systems, with which the accident can be managed are available. The studied combined beyond design bases seismic and external flooding impacts show, that safety functions at Units 5 and 6 are performed by the help of the equipment that remains intact. The studied beyond design bases external flooding impacts show that systems and equipment, necessary to perform the safety functions, are not impacted.

The staff shall undertake measures, complying with the Unit emergency procedures to shutdown the reactor and to maintain it in a safe state. The internal and the external emergency plans shall be activated together with the emergency procedures.

- **SFSF**

According to the earthquake assessment, it was established that the spent fuel storage facility can perform its functions at seismic acceleration within the range of 0.12 – 0.39g. According to the earthquake assessment, it was established that the spent fuel storage facility can perform its functions at seismic acceleration within the range of 0.12 – 0.39g. In this particular situation, the extension of the time for safe fuel storage, shall depend on the possibility to clear out the debris and restore the natural ventilation.

- **DSFSF**

DSFSF shall continue to perform its functions for safe storage of spent fuel in the conditions of seismic acceleration up-to 0,31 g. The extension of the time for safe fuel storage shall depend on the possibility to clear out the debris and to restore the natural ventilation. This is shown in the seismic analysis.

Loss of power supply

- **Units 3 and 4**

In accordance with the assessment of the results in case of Loss of power supply and Loss of ultimate heat sink, it has been found that the power supply of the fuel cooling systems in SFP-3 and SFP-4 is provided by different physically separated sources (emergency diesel generators – 3 for each unit, emergency diesel generators of the Additional SG feedwater system, mobile DG). With low value of the residual heat in the spent fuel pools, the available time till the beginning of the fuel assemblies uncovering in case of full loss of cooling is nearly one week for SFP-3 and more than 9 days for SFP-4.

- **Units 5 and 6**

The impacts of blackout at “Kozloduy” NPP Units 5, 6 were studied within the assessment of loss of power supply and loss of ultimate heat sink. Several options of successive loss of power supply sources were studied. In principle, the availability of the accident management equipment is decreased, but the design provides sufficient emergency power supply sources, which, when actuated, will restore the equipment that is necessary for the management of the accident. The emergency procedures list the remedial actions to be taken by the operators.

- **SFSF**

The analysis of postulated initial events in result of blackout at spent fuel storage facility show that the spent fuel, stored in the pools, shall not be uncovered.

- **DSFSF**

The complete loss of power supply is irrelevant to the safety of the Dry spent fuel storage facility. Due to the existing passive system for decay heat removal, the safe operating mode of the storage facility is independent from the power supply. That can be seen from the analyses of loss of power supply and loss of ultimate heat sink.

Potential failure of measuring instruments

- **Units 3 and 4**

At the present moment all measurement channels related to reactor protection have been qualified for the relevant seismic conditions and environmental conditions. Precise digital equipment is used for formation of the signals. Uninterrupted power supply devices provide separate power supply for these channels, which ensures independence of the electrical power supply of the channels.

A qualification programme for the remainder of the safety related equipment has been implemented, including check of equipment aging, seismic and environment conditions during accidents with loss of coolant. A qualification programme for the remainder of the safety related equipment has been implemented, including check of equipment aging, seismic and environment conditions during accidents with loss of coolant. Based on the qualification results the remainder of the safety related detectors was replaced.

Computerized systems were additionally implemented for aiding the actions of the operators, such as:

- computerized systems for support of the operator and for recording the process parameters during normal operation and in case of accident;
- system for monitoring of the safety related parameters, based on own qualified detectors;
- new digital systems for fire detection and for fire alert, which would allow the operator timely localization of fire;
- numerous other additional alarms from local controls outside MCR.

Failure of the stationary monitoring systems of the radiation environment and temperature and the level of the water in the SFP is possible to be compensated by portable measurement devices.

- **Units 5 and 6**

The failure of instruments was analyzed within earthquake assessment and the potential instrument failure did not result in loss of data due to the triple redundancy of the measuring channels.

The Units 5 and 6 are equipped with Post accident monitoring systems, which are seismically qualified and the measuring channels have triple redundancy.

- **SFSF**

Failures of the plant monitoring and radiation monitoring systems and the pool water temperature and level monitoring systems can be compensated by the help of portable measuring devices.

- **DSFSF**

Failures of the plant monitoring and radiation monitoring systems and the cask temperature systems in the cask storage hall can be compensated by the help of portable measuring devices.

Potential impact from other neighbouring installations on site

- **Units 3 and 4**

The design allows impact from the neighbouring unit due to the location of the spent fuel pools of Units 3 and 4 in a common premise in the central hall of the reactor building. Other common rooms are provided in the design (common for both Units):

- dose monitoring control room;
- auxiliary building control room.

In case of accident at Units 5 and 6 and spent fuel storage facility the Units 3 and 4 staff acts in accordance with the Emergency plan of Kozloduy NPP.

- **Units 5 and 6**

In case of accident at Units 3 and 4 and Spent fuel storage facility the Units 5 and 6 staff acts in accordance with the Emergency plan of Kozloduy NPP.

- **SFSF**

The earthquake assessment shows that the ventilation stack-2 has the required seismic stability. At RLE earthquakes is not expected SFSF buildings or emergency diesel generator building be destroyed or have difficulties in accessing them. In case of an accident occurring on Units 3 and 4 or Units 5 and 6, the SFSF staff shall follow the Emergency Plan of Kozloduy NPP.

- **DSFSF**

In case of an accident occurring on Units 3 and 4, Units 5 and 6 and in the Dry Spent Fuel Storage Facility, the staff shall follow Emergency plan of Kozloduy NPP.

MEASURES TO IMPROVE ACCIDENT MANAGEMENT CAPABILITIES

Units 3 and 4

- **Measures to improve the sustainability of Units 3 and 4, derived from the analysis of the combination of beyond design basis earthquake and flooding**

Regarding the performance of safety functions, the flooding of the Additional SG feedwater system building leads only to decrease of the number of the systems, which perform the same safety functions if the fuel is located in the reactor.

- **Measures to improve sustainability against loss of power supply**

Power supply to systems for fuel cooling in SFP-3 and SFP-4 is provided from different physically separated sources (emergency diesel generators - three per one unit, emergency diesel generators of the Additional SG feedwater system, mobile DG). At low value of decay heat of the fuel stored in the pools, the time available before start of fuel uncovering is approximately 48 days for SFP-3 and 68 days for SFP-4 assuming total loss of cooling. Therefore, no further measures are needed to strengthen the sustainability of SFP-3 and SFP-4.

- **Measures to improve the resistance against loss of ultimate heat sink**

At low value of decay heat of the fuel stored in the pools, the time available before start of fuel uncovering is approximately 48 days for SFP-3 and 68 days for SFP-4 assuming total loss of cooling.

Units 5 and 6

The periodic safety review, performed in 2008, has identified the following measures to enhance the safety, which are under implementation:

- putting in force the SAMGs according to the developed program (measure D-2-3).
- putting in force SBEOPs for shut-down reactor and pressurized primary circuit and SBEOPs for shut-down reactor and unsealed primary circuit (measure D-2-1) and (measure D-2-2).

SFSF

Additional measures to enhance the safety of SFSF in case of loss of power supply are.

- to provide mobile diesel generator for spent fuel storage facility (measure A-1-1);
- to install autonomous cooling system for spent fuel storage facility compartments with autonomous power supply (measure C-2-4).

DSFSF

The measures in the internal and external emergency plans are sufficient.

BNRA confirms the need to implement the proposed corrective measures and considers necessary to carry out the following additional corrective actions with regard to the possible combination of earthquake and flooding events, with subsequent loss of power supply and ultimate heat sink:

- updating of the internal and external emergency plans (measure D-1-1) considering the following aspects:
  - difficult access to ECR of Units 5 and 6;
  - possible draining of the sections of SFP with subsequent increase in the dose rate to the levels of intervention;
  - provide alternative routes for evacuation, transport of fuels and materials, necessary to the plant, and access of operational staff.
- construction of a new Accident management centre outside the NPP site to eliminate possible problems, associated with difficult access of the staff to the existing Accident management centre, as a result of secondary seismic impacts. (measure D-1-2).

MAINTAINING THE INTEGRITY OF UNITS 5 AND 6 CONTAINMENT FOLLOWING SERIOUS FUEL DAMAGE

EXCLUDING THE POSSIBILITY OF FUEL DAMAGE/MELTING AT HIGH PRESSURE

Design features

A strategy for reducing the pressure in the reactor vessel has been developed within the Severe accident management guidelines. The main engineering features for pressure reduction at accident progress to the severe phase are primary circuit safety valves and primary circuit emergency gas removal system. As an additional option for primary pressure decrease are used valves on reactor coolant pumps sealing water drain lines. To ensure practical capability for the use of the primary circuit emergency gas removal system in a severe accident phase, a modification has been implemented ensuring redundant power supply of respective valves from batteries.

Operational features

In the event of accident conditions the operators of Units 5 and 6 start to use the SBEOP. This would happen a few hours before the accident reaches the most severe phase with fuel damage. Successful implementation of the actions set out in these emergency procedures will ultimately prevent fuel damage and will reduce the pressure in the reactor vessel.

MANAGEMENT OF THE RISKS DUE TO GENERETION OF HYDROGEN IH TNE CONTAINMENT

Design features

Units 5 and 6 are provided with containment hydrogen reduction system which consists of 8 passive auto catalytic recombiners, located in the containment. They are designed to burn hydrogen generated during the accident. The system is designed with capacity to cope with hydrogen generated at design basis accident with maximum loss of primary coolant. Further analyses of the hydrogen reduction system show that it is able to reduce the hydrogen generated during the internal phase of the severe accident to acceptable levels not reaching explosive concentrations.

Operational features

The SAMGs and the emergency procedures describe actions for monitoring, evaluation and prediction of hydrogen concentrations in the containment. Described are recommendations for the control of containment spray system operation depending on the hydrogen concentration.

PREVENTION OF CONTAINMENT OVERPRESSURE

Design features

The design of Units 5 and 6 provides containment spray systems for heat removal from the containment and for iodine binding in the steam-air mixture at loss of coolant accidents. The operation of this system results in containment pressure decrease to safe values. The containment spray system is classified as safety system. It is actuated automatically at containment overpressure above the setpoint.

For pressure control in severe accident conditions in Units 5 and 6 additional filtration system is installed on each Unit to reduce the containment pressure. The system operation is based on passive principle. At containment pressure increase to the design value, breaks the membrane on pipeline to the tank, filled with filtering solution. The gas medium from the containment structure passes through the filtering solution and is discharged by means of throttle system to the ventilation stacks of Units 5 and 6.

Operational and organizational features

During normal operation in the containment structure is maintained under pressure. Overpressure protection features are available. In emergency conditions, the active protections are switched on automatically depending on the actuation setpoints and controlled in accordance with the guidance, provided in the emergency operating procedures.

PREVENTION OF MELT THROUGH

Possible design features for retention of the corium in the reactor vessel

Possibility of external cooling of the reactor has been studied. It was found that in some of the options of severe accident development the vessel damage could be prevented.

SAMGs describe actions to recover coolant supply to the reactor. In the event that during the internal phase of the severe accident, the operators fail to supply enough coolant to the core, there is a possibility to cool the corium and retain them within the reactor vessel

As a tool for coolant supply to the primary circuit could be used the available channels of the safety systems – medium pressure emergency injection system and low pressure emergency injection system, and the primary circuit make-up system (TK).

Design features for corium cooling in the containment structure after vessel damage

The cooling of the corium during the ex-vessel phase of the accident is possible by restoring of the boron injection to the primary circuit. Such actions are described in SAMGs. For this purpose could be used: any restored safety system – medium pressure boron injection system (TQ-3), low pressure boron injection system (TQ-2); the primary circuit make-up system (TK).

PROTECTION OF THE CONTAINMENT STRUCTURE INTEGRITY

Design features

The active equipment, which protects the integrity of the containment and needs restoration of the power supply are the components of the containment spray systems: pumps and valves. They are powered by electric busses - category II.

Operational features

The procedures and the operational documentation, provided at MCR and ECR describe the power supply sources of each component. The steps for power supply switch-over are clearly explained.

INSTRUMENTATION REQUIRED TO MAINTAIN CONTAINMENT INTEGRITY

Units 5 and 6 have information systems to support operators in emergency conditions - SPDS for monitoring of safety functions and PAMS. In the framework SBEOP development and designing of PAMS the available measurement channels are systematically examined. Appropriate channels required for accident management are selected. The necessary measuring channels with extended measurement range are installed designed to withstand severe accident conditions and included in the scope of PAMS.

The means for control of the main systems for accident management are located in the MCR and the ECR and are available to the operators. The emergency procedures describe specific actions and indicate the necessary instruments for monitoring. The Units 5 and 6 are not provided with system for direct monitoring of water vapours and oxygen in the containment structure, but such a system will be installed.

ADDITIONAL MEASURES TO MAINTAIN CONTAINMENT INTEGRITY AFTER SIGNIFICANT FUEL DAMAGE

Corrective actions are under realisation, identified in the project for SAMG development for Units 5 and 6 and confirmed during the Units 5 and 6 periodical safety assessment in 2008:

- installation of temperature sensor with wide range for monitoring of the reactor vessel temperature, whish will provide information, needed for implementation of measures according to SAMGs (measure D-3-4);
- closure of ionization chambers channels, located in the walls of the reactor vessel cavity, where the containment structure is supposed to be bypassed at a severe accident (measure D-3-3).

As result of the assessment of the available technical and operational features for protection of the containment integrity, the following measures for improvement are proposed:

- installation of measuring channels for monitoring and evaluating the concentration of water vapours and oxygen within the containment of Units 5 and 6 of Kozloduy NPP, to provide the necessary information for severe accident management (measure D-3-2);
- installation of additional hydrogen recombiners in the containment structure, witch will cover the ex-vessel phase of the severe accident and fuel damage in the spent fuel pool (measure D-3-1);
- to study the possibilities for corium localisation in case of severe accident (measure D-3-5).

MEASURES FOR MANAGEMENT OF ACCIDENTS WITH RADIOACTIVITY RELEASE

RADIOACTIVITY RELEASES IN CASE OF CONTAINMENT INTEGRITY LOSS AT UNITS 5 AND 6

Design features

WWER-1000/V320 type reactor containment containing the reactor and the primary circuit consists of a cylinder with a dome on top. The structure is built of pre-stressed concrete with a thin steel lining inside. The volume of the containment shell is large.

The characteristics related to the unit safety are analyzed in terms of risks of severe accidents, including direct heating of the containment shell in probabilistic scenarios with core melt at high pressure, explosion of hydrogen, fuel/coolant interactions and steam explosion outside the reactor vessel, possibility of the reactor vessel external cooling and containment shell bypassing. Probabilistic/deterministic assessment indicates that (i) direct heating of the containment shell is not a significant threat to the containment shell of WWER-1000/V320 and (ii) the integrity of the containment shell is under serious threat in case of corium flow through the penetrations of the base plate in scenario with possibility of the reactor vessel external cooling.

MCR and ECR of WWER-1000 are located at a lower level in the reactor building, i.e. below the containment shell structure. The base plate of the containment shell, which would be affected by the corium in the ex-vessel phase of the accident has been lifted, and under it are located compartments containing safety related pumps and equipment. These compartments may become inaccessible. MCR can also become uninhabitable. Corium penetration in the base plate of the containment shell is not immediate threat after such postulated accident, due to structural characteristics of the shaft (thickness of the base is 3.194 m, the thickness of the base plate of the shaft is 3.6 m.). There is a much more likely scenario where the corium outside the reactor vessel could bypass the base plate flowing through penetrations of the ionization chambers channels to the compartments below it. Now at Units 5 and 6 is implemented project for elimination of this scenario.

In the unit design are provided localizing systems, ensuring fulfilment of the established criteria for limiting discharges of radioactive substances into the environment. For the implementation of localizing functions in the containment structure are installed systems and means for monitoring of containment medium parameter, devices for isolation of the containment structure and devices to reduce the concentration of radioactive fission substances, hydrogen and other substances that could be released into the containment atmosphere during and after design basis and severe accidents. For implementation of these safety functions the following systems are installed:

- leaktight enclosure system;
- containment spray system;
- pressure reduction filtering system;
- hydrogen recombination system.

In the scope of Modernization Programme the following measures related to leaktight enclosure system have been implemented:

- improvement of the containment test procedure;
- qualification of cable channels and planning of their replacement;
- Installation of passive filtering ventilation;
- Development and implementation of radiation monitoring system for severe accidents.

Operational features

The organizational and engineering features in case of radioactive releases after loss of integrity of the containment structure of Units 5 and 6 are covered by the Emergency Plan of Kozloduy NPP. This includes the work of MCR operational staff following the SBEOP and SAMGs simultaneously with coordinated actions according to the National Emergency Plan, where are defined external resources and means provided to NPP.

ACCIDENT MANAGEMENT AFTER UNCOVERING OF THE FUEL IN THE SPENT FUEL POOLS

Hydrogen control

Measures for hydrogen control in the long-term storage of spent fuel in SFP 3 and 4 (more than 4 years after removal of fuel from the reactor) are not provided in the design.

SFPs of Units 5 and 6 are located inside the containment structure. Hydrogen generated at assumed damage will spread in the containment structure and will be recombined by the Passive autocatalytic recombiners. It is necessary to consider any further release of fission products in the containment and hydrogen generation, which could arise from occurrence associated with fuel damage in the SFP.

The analysis in case of total blackout in SFSF shows that it is possible accumulation of hydrogen due to the switching-off of the ventilation systems. Minimum air flow of 17,5 m^3/h is sufficient to ensure hydrogen concentration above the surface of the pools not exceeding 0.4% by volume.

Provision of adequate radiation protection

The implementation of the protective measures, provided in the Emergency plan for Units 3 and 4 provide adequate protection against radiation. Analysis of earthquakes, flooding and combination of beyond design basis earthquakes and flooding, loss of power supply and loss of ultimate heat sink showed no loss of SSCs, including the ventilation systems.

For Units 5 and 6, the radioactive substances that could be released during the accident in SFP will remain in the containment.

The implementation of protective measures provided in the emergency plan for SFSF, provides adequate protection against radiation.

Limitation of discharges after serious damage of the fuel in the SFP

Stress tests analyses show that hypothetically only partial, mechanical and no serious damage to the fuel in the SFP-3 and SFP-4 are possible. SFP-3 and SFP-4 are located in the reactor hall outside the sealed rooms of the primary circuit and the fuel damage leads to discharge of radioactive substances in the environment with containment bypassing. This makes the strategies for maintaining negative pressure in the SG compartment senseless.

The radioactive substances that could be released in the accident in SFP-5 and SFP-6 will remain in the containment structure. The emergency instruction addresses initiating events in SFP and describes actions to remove the personnel from the containment and to close the containment, if such accident occurred.

Regarding the SFSF, if one section for spent fuel storage was drained, the release of aerosols and noble gases can not be limited. To prevent damage of fuel elements there are necessary conditions for effective natural circulation of air through the compartment.

Instrumentation necessary for SFP condition monitoring and accident management

Units 3 and 4 have the following systems:

- System for monitoring of the radiation environment over SFP.
- SFP temperature and water level monitoring system.
- Leak monitoring system.

The accident does not affect automation.

Instrumentation necessary to monitor the condition of the fuel in the SFP-5 and SFP-6 is located in MCR. Light and sound signals occur at pool level decrease to control limits.

SFSF has the following systems:

- system for radiation monitoring of the fuel storage compartments and spent fuel storage facility building;
- monitoring system for temperature and water levels in the compartments.
- leakage monitoring system.

Control room accessibility and habitability

MCR-3 and MCR-4 accessibility and habitability are not affected during this accident.

MCR-5 and MCR-6 accessibility and habitability are not affected during accident in SFP.

At total drying of compartments the SFSF, control room is not accessible.

MANAGEMENT OF THE RADIOACTIVE DISCHARGES FROM DRY SPENT FUEL STORAGE FACILITY

Beyond design basis accidents such as earthquake and flooding do not lead to release of radioactive substances or to reduction of the protective shielding ensured by containers in DSFSF.

MEASURES TO IMPROVE LIMITATION OF RADIOACTIVE DISCHARGES

Units 3 and 4

The analyses of stress tests show large safety margins of Units 3 and 4

Units 5 and 6

Most of the measures to reduce discharges of radioactive substances are directly related to the measures provided for maintaining the integrity of the containment structure of Units 5 and 6. General measures to reduce the discharges and to protect the integrity of the containment structure are as follows:

- implementation of the project for closure of ionization chambers channels, located in the walls of the reactor vessel cavity. The measure is defined in the project for SAMGs for Units 5 and 6 development and is confirmed during the periodic safety review in 2008 (measure D-3-3);
- installation of measuring channels for monitoring and evaluating the concentration of water vapours and oxygen within the containment of Units 5 and 6 of Kozloduy NPP, to provide the necessary information for severe accident management (measure D-3-2);
- to study the possibilities for corium localisation in case of severe accident (measure D-3-5);
- installation of optimal number of hydrogen recombiners in the containment structure, witch will cover the ex-vessel phase of the severe accident and fuel damage in the spent fuel pool (measure D-3-1), considering:
  - the hydrogen, generated during the ex-vessel phase of the severe accident;
  - the results of the study of the possibilities for corium localisation in case of severe accident;
  - additionally generated hydrogen in case of fuel damage in SFP.

SFSF

There are no measures related to enhance the safety in SFSF.

DSFSF

BDBA like earthquake and flooding do not lead to release of radioactivity in the environment.

CONCLUSION

The provided information for management of severe accidents in Kozloduy NPP shows that the following aims and tasks are performed:

- it is kept continuous emergency preparedness of the personnel;
- defined are the actions for accident management, for restoration of the equipment, facility or activity, including during combination of accidents and other emergencies (such as explosion, fire, flooding and earthquake) and mitigation of their consequences;
- there are defined the necessary measures to protect personnel, society and environment, aimed at preventing serious deterministic effects and reduce the risk of stochastic effects to the minimum reasonably achievable minimum.

There are adopted procedures and instructions for allocation of responsibility, effective communication with national and local structures and for technical assistance from outside of Kozloduy NPP.

Finally, the organization for emergency planning, the capacity of the plant to operate in emergency conditions, and the current operational and technical measures confirm the readiness of Kozloduy NPP to management severe accidents. This is confirmed during the periodic BNRA inspections regarding the operator organization to manage severe accidents. These checks include emergency procedures, internal emergency plan, as well as emergency drills. The last inspection regarding the emergency preparedness of the operator is carried out in October 2011

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TOPIC 4 – NATIONAL ORGANIZATIONS

REGULATORY BODY

The primary law in the field of nuclear facilities safety is the Act on the Safe Use of Nuclear Energy (ASUNE), effective from July 2002. ASUNE regulates public relations, related to governmental regulation of safety use of nuclear power and ionizing radiation, safety management of radioactive waste and spent nuclear fuel, as well the rights and obligations of persons, performing these activities to ensure nuclear safety and radiation protection. ASUNE complies with latest trends in the field of nuclear legislation, including the legislative practice in the EU countries. During the ASUNE development were taken into account recommendations of IAEA experts who assess the project. According to the ASUNE, BNRA is politically and financially independent regulatory body.

According to ASUNE, State regulation over the safe use of nuclear power and ionizing radiation, safe management of radioactive waste and spent nuclear fuel is performed by the BNRA Chairman, who is independent specialized body of the executive power. Regulatory functions performed by BNRA in service to society, determine the organization's mission, namely: “Protection of human life, society, future generations and the environment from harmful effects of ionizing radiation”. In order to achieve its mission, Nuclear Regulatory Agency applies the internationally accepted principles for nuclear safety and radiation protection, striving to improve continuously its effectiveness, using internationally accepted best regulatory practices.

Authority and responsibilities of BNRA are stated basically in article 5 of the ASUNE. ASUNE sets as basic BNRA functions licensing activities, implementation of regulatory control, safety assessments and analyzes, regulatory requirements elaboration, maintenance of emergency preparedness and international co-operation of Bulgaria within its competency. In addition, ASUNE clarifies that the BNRA Chairman shall have other authorities conferred upon him by legislation.

According to the Rules of Procedure, BNRA has 114 statutory positions and has a legal opportunity to appoint employees on a contract (up to 10%). About March 2012, the basic BNRA human potential is 98 employees real staff. Almost all employees are university graduated, have Master degree and professional experience of many years in the field of regulation, design, construction and operation of nuclear facilities and sites with sources of ionizing radiation. The conducted analysis shows that in recent years is difficult to hire new personnel, so the office can not fill all available positions. The difficulty of hiring new employees is determined by the fact that because of the enormous responsibilities to society for the candidates are set higher requirements for individual skills, qualifications and experience.

The analyzes show the difficulties of the institution in transmitting knowledge from more experienced employees to newcomers. This is due to the process of generational change, started several years ago. As the launch of major infrastructure projects increase the workload experienced inspectors and experts, insufficient time remains for passing on knowledge and skills to newcomers. However, it should be noted that 34% of the positions are occupied by employees to age 40, which allows continuity of gained knowledge and professional experience.

Looking to the future development of the organization, the priority remains to building and maintaining of competence, which shall provide effective and efficient implementation of regulatory functions. Special attention should be paid to the training of newly hired employees, specialized training in nuclear safety and general administration to meet the expectations of the society and stakeholders.

Analyses show that up to now BNRA successfully handle the complicated task of ensuring the timely information to the media and the public about everything that happens in the field of nuclear safety. The aim of BNRA is to transmit the right information and messages and to help its correct understanding by media and the public. In addition, it should be noted that BNRA regularly organizes training seminars for journalists, in which traditionally participate representatives of all national media, as well experts in public relations from agencies concerned. An example of the BNRA openness is the publishing on the website of all reported events from nuclear facilities (in Bulgarian and English).

TECHNICAL SUPPORT ORGANISATIONS

Despite the fact that it has its own Department for review and assessment of safety, BNRA has developed and maintains well-structured, full and effective system for technical support. BNRA has signed framework agreements for cooperation and expert support with more than 20 Bulgarian engineering companies and research organizations who have demonstrated competence in the field of safety of facilities and activities, covering the lifecycle of nuclear facilities.

At the beginning of each calendar year, all TSOs are required to update their documentation package, including the profile and competence. Based on periodically collected data, competencies and capabilities of TSOs are analyzed and regulatory challenges planned. BNRA assists TSOs in training in new areas of professional competence, which could support the Regulator.

In some cases BNRA asks for assistance other (foreign) expert organizations, as well as takes advantage of the great expert abilities of the IAEA. BNRA supports all reasonable activities of co-operation between regional and international experts organizations for evaluation and analysis.

MINISTRY OF ECONOMY, ENERGY AND TOURISM

Ministry of Economy, Energy and Tourism (MEET) implements the state policy on energy promotion and implementation of energy policy. The Ministry develops and (after approving from the Council of Ministers) implements the national strategy for energy development and the national strategy for spent fuel and radioactive waste management.

The control functions of the MEET in sub-section "nuclear energy" are specified by the Rules of Procedure of the Ministry, including the control of state companies for electricity generation and decommissioning of nuclear facilities and radioactive waste management. Directorate "Reliability of energy supply" is part of the specialized administration of MEET. Department:

- supports the implementation of state policy on radioactive waste management, management of spent nuclear fuel and decommissioning of nuclear facilities;
- organizes and coordinates activities in preparation of a proposal to build a national repository for storing and / or disposal of radioactive waste according to ASUNE;
- prepares, coordinates and monitors strategic plans for decommissioning of nuclear facilities;
- monitors and coordinates the implementation of measures arising from obligations under international agreements, and activities for implementation of programs to improve safety and reliability, construction and decommissioning of nuclear facilities.

MINISTRY OF INTERIOR

The principles, objectives, activities, structure and management of the Ministry of Interior (MI) are regulated by the Law of the Ministry of Interior. Ministry of Interior provides security of nuclear facilities and related with them sites identified as particularly important in terms of their physical protection. The arrangements for ensuring the physical protection of nuclear facilities, nuclear materials and radioactive substances during operation, storage and transport are governed by an ordinance adopted by the Council of Ministers on a motion by the Minister of Interior, Minister of Defence, BNRA Chairman and State Agency "National Security", where a leading role have the Ministry of Interior and BNRA.

According to ASUNE, certain nuclear facilities as well the sites that are technologically related with them or serve them, can be identified as particularly important in terms of physical protection by resolution of the Council of Ministers on a motion of the Minister of Interior, BNRA Chairman and State Agency "National Security" Chairman. The security of particularly important facilities is provided by the Ministry of Interior.

With the recent amendments and supplements to the Law of Ministry of Interior, in a separate Directorate General of the Ministry are united fire safety and disaster protection. Through the General Directorate "Fire safety and public protection" Ministry of Interior shall coordinate the protection of population and national economy in disasters and accidents, including the conduct of risk assessment, preventive measures, rescue and emergency restoration work and providing international assistance. Structure and activities of the Directorate are determined by the Implementing Regulations of the Law of Ministry of Interior.

Analyses show that the integration of fire safety and civil protection in a common structure with common management provides effective use of available resources and equipment. Analysts expect a significant improvement in the organization for help and rehabilitation of affected regions, resource and technical support of teams and improving performance in decision-making and response.

Information about national level of the organization for protection of the lives and health, environment and property during disasters is given under Topic 5 " Emergency Response" of this Report.

MINISTRY OF HEALTH

Ministry of Health (MH) implements the state policy of protecting health of people and establishes obligatory health standards, requirements and rules on all matters of hygiene, radiation protection and epidemiology. Through its organizations the Ministry carries out specialized functions in the field of health protection during the use of nuclear energy and ionizing radiation. These specialized organizations are the National centre of radiobiology and radiation protection, and departments "Radiation control" of the Regional inspectorates for protection and control of public health. In emergency situations ministry gives advices on taking protective action to reduce harmful effects on human health..

MINISTRY OF ENVIRONMENT AND WATER

Ministry of Environment and Water (MEW) directs, coordinates and controls the development and implementation of state policy on environmental protection, conservation and use of water and earth. The Ministry manages the National system for monitoring of the environment and is competent to decide on environmental impact assessment reports.

Ministry of Defence and Ministry of Transport Information Technology and Communications also carry out specific functions and tasks in the field of nuclear energy.

COORDINATION AND INTERACTION

According to Article 5 of ASUNE, the BNRA Chairman is responsible and carries out the coordination between agencies in terms of nuclear safety and radiation protection. In matters of coordination of the departments' actions under normal conditions, the BNRA Chairman shall develop and provide to the Council of Ministers appropriate distribution of tasks and responsibilities. The decision of the Council of Ministers is binding for all departments. In emergency (nuclear and radiological emergencies in or outside the country), National Emergency Plan has been developed and adopted by the Council of Ministers. The Emergency Plan is described under Topic 5 " Emergency Response" of this Report.

Representing an independent regulatory authority in the executive power system, the BNRA Chairman shall report to the Prime Minister through the Deputy Prime Minister and Minister of Finance. In addition, the BNRA Chairman shall inform the National Assembly on matters of nuclear safety and radiation protection by participating in meetings of parliament and parliamentary committees.

Analysis of the organizations and their interaction showed that Bulgaria has the necessary institutions for the formation and implementation of national policy on nuclear safety, for the implementation of state regulation and control, as well for emergency response. Responsibilities and functions are clearly defined and distributed among various agencies and other interested organizations.

LEGISLATIVE BASE

In the BNRA policy statement is declared that "Nuclear Regulatory Agency shall update the regulatory requirements in accordance with the development of international standards and European legislation and shall develop regulatory guidelines in areas where this is necessary." In pursuance of this policy, BNRA prepared amendments and supplements of the ASUNE, effective from October 2010. Amendments of ASUNE account new EU legislation, new or modified IAEA documents, as well the experience of the practical application of the law.

Detailed requirements for nuclear safety and radiation protection are specified in secondary legislation for application of the ASUNE (more than 20 regulations), that are listed and described in Appendix 2. When the changes in ASUNE became effective, Nuclear Regulatory Agency developed and implemented a program for review and revision of all regulations. In the process of the regulatory requirements review were taken seriously the lessons of the nuclear accident at Fukushima Daiichi. The jurisprudence analysis shows that primary attention should be paid to several regulations, and the most important of them are the Regulation on Conditions and Procedure for Establishing of Special Status Areas and the Regulation on Ensuring the Safety of NPPS.

The intentions of BNRA are to review again regulatory requirements, when new IAEA documents, reflecting lessons learned from the nuclear accident at Fukushima Daiichi are published.

Nuclear Regulatory Agency continues to develop of regulatory manuals, which are periodically reviewed and updated. In the process of periodic review and updating, guideline will be recognizing of lessons learned and the new documents of IAEA and the European Commission.

TOPIC 5 – EMERGENCY PREPAREDNESS AND RESPONSE

NATIONAL ORGANIZATION

The emergency preparedness and response and post-accident management (off-site) in the Republic of Bulgaria is part of the existing country systems for disaster protection. Disaster protection is done at three levels:

- national level;
- territorial (local) level - including regional and municipal levels;
- On-site.

The National level includes governmental organizations, as MI, MH, MEW, MD (Armed Forces), BNRA, other organizations with responsibilities in an emergency. Territorial level includes areas (28 in total) and municipalities (264 in total), according to division of the country and regional structures of the executive.

According to the Law on Disaster Protection and Act on the Safe Use of Nuclear Energy, the disaster protection is based on on-site level. The operators develop internal emergency plans. Disaster protection includes mechanisms for request (providing) assistance at international level.

The main legislative act, regulating the protection of the population is the Law on Disaster Protection. Under this law, "disaster" is defined as "an event or series of events caused by natural hazards, accidents, emergencies or other extraordinary circumstances, which affect the life, health, property or environment in amounts that require a measures or involvement of special forces and the use of special resources". This definition includes the case of nuclear and radiological emergencies. The activities in emergency preparedness, response and post-accident management are carried out in taking into account the specific conditions that are created in nuclear and radiological emergencies.

Based on analysis of possible disasters, the Minister of Interior, jointly with relevant departments, develops a National Plan for Disaster Protection. The External (National) Emergency Plan for protection against nuclear and radiological emergency is a part of this national plan and is adopted by the Council of Ministers. The External emergency plan fixes the emergency planning zones, the specific duties of competence, cooperation and measures to protect the population in an emergency and the procedures to render (request) international assistance. Each of the involved organizations develops their own internal departmental emergency plans.

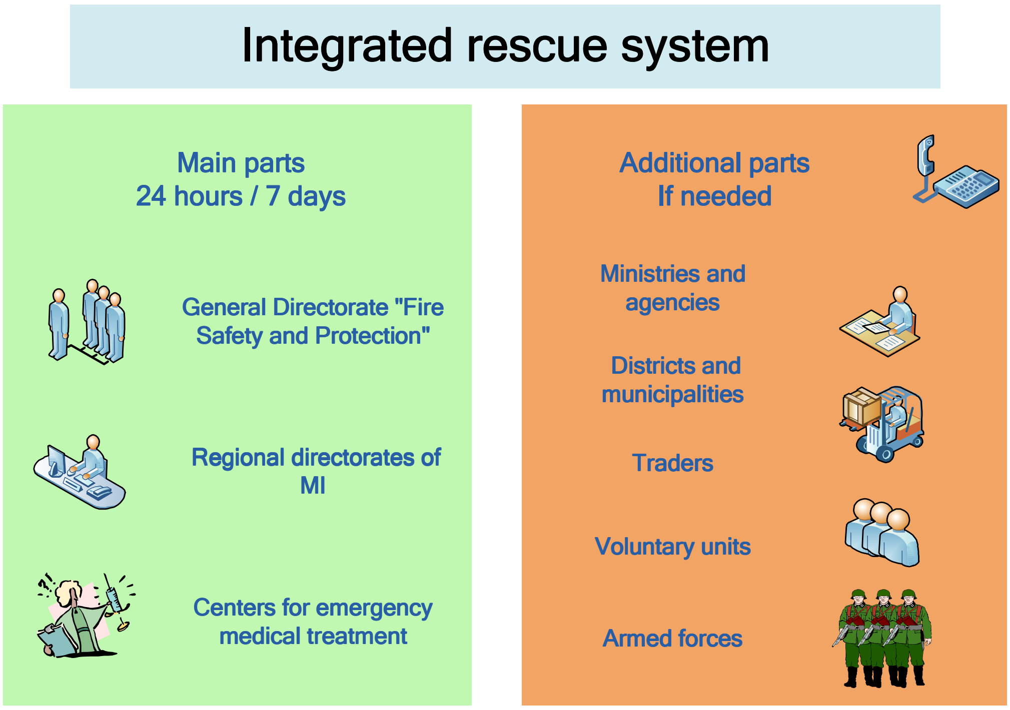
The nuclear facility shall develop internal (on-site) emergency plan, that is based on the maximum possible radiation effects on personnel, population and environment. The On-site emergency plan identifies the measures to minimize and mitigate the consequences of an accident, the functional responsibilities of the personnel for actions during an emergency situation and the interaction with the executive bodies in accordance with the External emergency plan. The Internal emergency plan is coordinated with all existing plans for physical protection, protection in case of flooding, earthquakes and other events.

An integrated rescue system is established for disaster protection, which includes:

- ministries and agencies;
- districts and municipalities;
- companies and sole traders;
- centres for medical treatment and other health facilities;

– non-profit entities, including voluntary units;
– armed forces.

The integrated rescue system consists of main teams and support teams. The main teams are the General Directorate FSPP of MI and its regional directorates, regional directorates of MI and the centres for emergency medical treatment. These units provide a continuous readiness to receive messages in the event of disasters, their evaluation and immediate action to mitigate and protect the population. Additional components of integrated rescue system provide assistance upon request in accordance with specific plans for disaster protection.



Coordination of the forces of the integrated rescue system on national level is carried out by operational centres of the General Directorate FSPP and at the territorial level by the regional directorates. In case of urgent actions (rescue and emergency recovery activities) in the area of the disaster, the coordination between the forces of the integrated rescue system is carried out by the on site manager. The area of the disaster is defined as "a place of intervention." Manager of the protective actions at the "place of intervention" is the head of the territorial directorate FSPP or a person authorized by him.

The management of the integrated rescue system is carried out by the NCCHQ. In case of nuclear or radiological emergency the National Headquarters for Control and Coordination is headed by the Minister of Interior and includes senior management from all relevant ministries and departments. NCCHQ gather in a specially designated place in the building of the General Directorate FSPP. Headquarters decide to implement protective measures which shall be approved by the Prime Minister.

At each of the listed above organizations, emergency team is organized according to the departmental emergency plans. The functions of these teams are described in the External emergency plan. Continuous communication and exchange of information and data is maintained between them and the Headquarters. Each emergency team prepares proposals for protective measures in accordance with its competence and sends them to NCCHQ, which takes the final decision.

The functions of the key players in emergency response to nuclear or radiological accidents can be summarized as follows:

- MI – manages activities, related to emergency response support to the NCCHQ, apply measures to protect the population and environment;
- BNRA collects, process and analyzes information about the accident and advises the NCCHQ for taking protective measures. BNRA provides NCCHQ with information and data about accident progression and the actions taken by the operator. In addition, BNRA informs the international organizations and provides information to the population, legal persons and public organizations;
- MH advises NCCHQ on the implementation of health standards to protect individuals in cases of emergency;
- MEW performs radio-ecological monitoring and provides the data to NCCHQ;
- Ministry of Agriculture and Food monitors the radioactivity in agricultural products and advises on the use and handling of food, feed, soil and other agricultural products and use of land in areas affected by the accident;
- MD, assisted by the Army, helps to overcome the consequences of the accident, when so requested by the NCCHQ;
- The National Institute of Meteorology and Hydrology predicts the atmospheric processes and phenomena to determine the distribution and deposition of radioactive substances and exchanges data and forecasts for weather and radiation conditions with other countries and international organizations.

Specific responsibilities for providing information to the population and communication channels for emergency teams are assigned to the Bulgarian National Radio and Bulgarian National Television. All legal entities are obliged to cooperate fully by providing equipment and supplies.

MI supports the national systems for informing the population in case of disaster (transmission of sound signals and messages to people in an emergency). In case of accidents, the operator shall immediately notify the affected population and give advice on the application precautionary measures. The NCCHQ informs the public about the development of the accident, its characteristics and necessary protective measures. The information includes:

- tips on personal hygiene and decontamination;
- limiting the consumption of certain food products;
- treatment and storage of food products to prevent their contamination;
- sheltering;
- organization of distribution and use of personal protective equipment and medicines;
- organization of a possible evacuation;
- information about assistance from emergency personnel and comply with their orders.

In accordance with the regional External emergency plan, the regional directorates establish checkpoints on the boundary of the area for urgent protective measures. At these points shall be performed decontamination of vehicles, evacuating people and animals; decontamination of equipment, participated in the rescue; sanitizing of the evacuated population. Upon request, MD organizes additional checkpoints. The representatives of MH assist the irradiated individuals, determine the radiation exposure and measure whole body activity. The representatives of MAF perform radiation monitoring of animals and plants.

The External emergency plan defines procedures for evacuation of the population, animals, material and cultural values. Primary and back-up areas to accommodate the evacuated population are defined at average distance 70-80 km from the NPP. Determined is a list of livestock, subject to evacuation, and places for their accommodation. MEET and the Bulgarian Red Cross provide clothing for the evacuated population.

The External emergency plan deals with issues and actions after the accident: return to normal work and life, including radiological assessment; benchmarking and effective mechanisms for decision making; management of contaminated materials; migration, communication and information, rehabilitation, compensation and more.

Clearing and collection of radioactively contaminated materials, equipment and radioactive waste shall be conducted by the State enterprise "Radioactive Waste" and specialized units of the regional directorates - Montana, Vratsa, Pleven and Veliko Tarnovo. Ministry of Transport and Communications organizes the transport of containers with radioactive waste to the sites for processing.

ACTIVITIES OF THE OPERATOR

The Kozloduy NPP emergency plan (internal emergency plan) is the main guiding document for actions inside the plant in case of emergency. The latest revision of the internal emergency plan of Kozloduy NPP was issued in 2007. It establishes the necessary organization to maintain emergency preparedness of the personnel and conduct of localizing, rescue and other emergency protective measures. The criteria for activating the Emergency plan are updated.

With regard to natural phenomena, integral parts of the plan are actions in case of:

- emergency low water of the Danube River;
- presence of oil stains on the Danube River;
- earthquakes, fires and other natural disasters;
- emergencies in existing hydro-technical structures;
- icing of power lines.

In Kozloduy NPP are built and maintained emergency and technical equipment, systems and tools. The operational management of the facilities is done by the operating shifts 24 hours a day, 7 days a week, headed by the Shift supervisor. The Shift supervisor is responsible for initiation of immediate actions in case of emergency, and other natural disasters and for first aid for injured employees.

It is maintained continuous emergency duty, ensuring the organization of the emergency teams that are formed by the plant personnel. The specific duties of the participants in the Emergency plan are described in separate instructions and procedures.

The structure of emergency organization includes the following groups and commands:

MANAGEMENT GROUP

The group is managed by the Emergency Manager and is activated in all emergency situations. Until the arrival and assembly of the management group, its functions are performed by the shift personnel leaded by the Shift supervisor. The main tasks of the management group are to obtain information about the state of the damaged and the operating Units; to manage the activities for accident assessment; to prepare decisions to take measures for limiting and localizing the consequences; protection of the personnel and population; preparation of orders of the Emergency Manager to stop or continue the operation of other Units.

TEAM 1

The team is formed by operational staff on duty and reserve shift. The main responsibilities of the team are: operation of the facilities at Kozloduy NPP under current operational documents; monitoring of the safety functions; initial assessment of the accident and determination of the status; activation of the Emergency plan; management of the actions according to the Emergency plan up to the formation of emergency structures; communication and information of personnel, population and the competent authorities at local and national level; organization of immediate emergency measures to protect the staff; management of the accident; individual dose control of the personnel; conducting urgent recovery activities.

TEAM 2

The team is leaded by radiation monitoring supervisor. The main responsibilities of the team are: radiation monitoring, documenting of results and timely reporting to the Emergency Manager; analyzing data from the special radiation monitoring system; assessment of the radioactive source term; forecasting of radiation effects in the early and middle stage of the accident; preparing proposals for protective measures for the staff; organizing and controlling activities with planned higher exposure of the emergency personnel; monitoring of the implementation of measures for individual protection of the personnel; putting fences, marking and signs of radiation hazard; assessment of the need to conduct decontamination work.

GROUP FOR ANALYSES AND FORECASTS

This group is built for work during the incident as an advisory body to the Emergency Manager. It has no right to decide on management of personnel and other emergency units. The main responsibilities of the group are: obtaining information and monitor the condition of the facilities; making periodic classification of the emergency situation in the course of the accident; performance of the necessary engineering analyzes; preparation and proposal of measures for management of the accident; providing the necessary support to the staff of Team 1; consultation with external support organizations.

GROUP FOR TECHNICAL AND INFORMATION SUPPORT TO THE ACCIDENT MANAGEMENT CENTRE

The main responsibilities of the group are: provision of connections, ensuring reliable operation of the information systems in the Accident management centre; maintaining the necessary conditions for the emergency teams, providing first aid to the personnel from the emergency teams.

The structure for emergency response includes the following services related to the implementation of the Emergency plan:

- Regional Office for Fire Safety and Public Protection;
- Specialized police unit for physical protection;
- Health Service;
- Auto transport.

OPERATOR MEASURES TO IMPROVE EMERGENCY PLANNING

After the Fukushima accident the following measures are planned:

- Updating the External and Internal emergency plans (measure D-1-1);
- Analysis and evaluation of the functioning of the Accident management centre at seismic impacts, associated with destruction of surface structures (difficult access of the staff to the Accident management centre); reliability of underground channels through which pass the communications to the Accident management centre; ensure

the integrity of the underground construction of Accident management centre (part of the measure D-1-1);
- Evaluation of possible damage to the regional road infrastructure around the plant under extreme external impacts and reliable routes to provide access of personnel, equipment and supplies (part of the measure D-1-1);
- Construction of new Accident management centre outside the NPP site (measure D-1-2).

ACTIVITIES OF THE REGULATOR

As part of the agency is created department "Emergency Planning and Preparedness," which supports the functioning of the BNRA Emergency centre, and is provided with necessary facilities and technical means. The department performs the tasks of "National contact point" under the Convention on Early Notification of a Nuclear Accident, Convention on Assistance in Case of a Nuclear Accident or Radiological Emergency and ECURIE.

The measures and actions to support the emergency preparedness and response of the BNRA employees in case of nuclear or radiation accident in NPP, in cross-border transfer of radioactive substances, illegal traffic or accident involving radioactive sources and contamination by radioactive substances in the country are defined in the BNRA internal emergency plan.

In the BNRA is created an emergency team to support the emergency preparedness and response in case of nuclear and radiation accidents. The emergency team is formed by BNRA inspectors and technical staff. The emergency team is designed for continuous shift work. Its composition is updated annually by order of the BNRA Chairman. The duties of the members of the Emergency team are described in the Emergency plan.

The emergency centre is equipped with modern communications and technical resources: satellite communications (phone and fax) to the BNRA inspectors at the site of Kozloduy NPP; direct phone channel with General Directorate FSPP (and with its territorial structures and Kozloduy NPP); telephone and fax, and email links with national institutions, Kozloduy NPP, sites with sources of ionizing radiation, the IAEA, the EU and emergency centres in other countries; mobile phones to receive emergency messages. The centre is equipped with a diesel generator to provide emergency power supply.

In the BNRA Emergency centre operates one of the emergency stations of the National Automated Systems for Continuous Monitoring of Gamma Radiation - background (BULRaMo), which acts as early warning system. This allows the BNRA to monitor in real-time the background radiation. The emergency centre is equipped with software to calculate the doses in nuclear or radiological emergency with release of radioactive substances into the environment (RODOS, ESTE, EPADose etc.). There are supported direct channels with NIMH to obtain meteorological data, used in the programs RODOS and ESTE.

In the BNRA Emergency centre were installed systems ECURIE (European Community Urgent Radiological Information Exchange) and EURDEP (EUropean Radiological Data Exchange Platform). ECURIE is 24 h operating emergency notification system for exchange of information in the EU in case of nuclear accident or radiological emergency. In accordance with Council Decision 87/600/Euratom Bulgaria has installed a system for information exchange with EU countries and the EC. The system is used for reporting the status of the accident, the weather conditions, the protection measures taken and others. EURDEP is system for exchange of data about radiation monitoring of the environment with EU in real time. In accordance with

Recommendation 2000/473/Euratom, the countries send daily information, and in case of emergency, the data transmission continues with increased frequency.

REGULATORY REVIEW OF EMERGENCY PREPAREDNESS

The Emergency preparedness is a continuous process, requiring a permanent improvement and enhancement. In this context, the emergency plans are checked annually, the results are analyzed and if necessary the plans are updated. The basis for evaluation and approval of emergency plans (internal and external) are analysis of beyond design basis and severe accidents, including verification of compliance with dose limits and criteria for application of protective measures, which are developed by the licensee and accepted (approved) by the regulatory body.

The Regulatory body monitors and performs annual inspections at nuclear facilities and sites, using sources of ionizing radiation. The inspections are based on pre-established plan. Thus the implementation of the requirements for emergency preparedness is checked at various stages of activity.

In November 2011 was performed inspection to establish the status and level of emergency planning and maintenance of emergency preparedness in Kozloduy NPP. In view of the accident in Japan, during the inspection was paid particular attention to:

- initial assessment of the accident - an assessment of discharges to the environment, information to the workers and the population;
- implementation of protective measures - areas for implementation, monitoring, intervention levels and actions to implement protective measures;
- informing the population - preliminary information, notice and periodic testing of the systems.

OTHER DEPARTMENTS

Following the accident at Fukushima Daiichi NPP, MEW analyzed the performance of the National Automated Systems for Continuous Monitoring of Gamma Radiation - background (BULRaMo). The analysis shows the need for its upgrading. It is planned replacement of servers, workstations and their associated components and installation of new modern operating systems that will improve and simplify the work with the system. The renovation includes moving from the unit Gy/h to Sv/h (Ambient equivalent dose), which will directly show human exposure, without having to perform additional calculations. It is also planned implementation of more advanced interface for data visualization facilitated by adding choices and visualization of historical data. Implementation is planned by the end of 2014.

In the National Centre of Radiobiology and Radiation Protection at the MH is installed radiation monitoring systems and the data are published in real time on the website of the National Centre of Radiobiology and Radiation Protection and in the BNRA.

DRILLS AND EXERCISES

The national legislation requires and regulates the performance of periodic drills and exercises at the departmental, national and international level to review the preparedness and response for nuclear or radiological emergency. BNRA participates in the trainings with different topics and character. Under the bilateral program between BNRA and Kozloduy NPP in 2011 were conducted 11 exercises for using the software to predict the dose in case of nuclear accident. As a result of these trainings were formulated several suggestions for improvement of the communication between BNRA and Kozloduy NPP in case of accident, and suggestions for improvement of internal communications and emergency organization within BNRA - across departments and directorates, which have obligations in case of accident. For 2012 are planned 6 trainings, scheduled to involve in them MI and MH

BNRA participates in national computer-simulated exercise to deal with various disasters (flooding, earthquake, terrorist attack with a dirty bomb, etc.).

BNRA participates in the training of the series "ConvEx", organized by IAEA for international information exchange in case of nuclear or radiological accident and in the international training "ECURIE", organized by the EU. BNRA is involved in training of series INEX of EU.

PLANNED MEASURES AT NATIONAL LEVEL

The National Program for Protection in Case of Disasters was updated in 2011. A number of specific topics were planned for improvement and development, most important of which are given in the list of planned measures.

The planned measures at national level include:

- Review and update of the National (External) Emergency Plan – a working group (inter-departmental) was created. By end of October the working group will prepare a proposal to modify the plan;
- Analysis of existing and development of missing procedures, instructions and methods for action of the emergency teams according to the National Emergency Plan;
- Updating and maintaining database of current volunteer teams to work in an emergency;
- Updating of system BULRaMo

In addition, it should be noted that the analysis indicates a need to improve the activities for informing and preparation of the population for emergency. Under discussion is the creation of specialized methodological teams in the schools.

CONCLUSIONS OF REGULATORY AUTHORITY

The external impacts, leading to the nuclear accident in Japan, namely the tsunami resulting from the earthquake are not possible for the site of Kozloduy NPP. The accident, however, gives the reason for performance by the regulator and the operator of an extraordinary review of emergency planning, maintenance of emergency preparedness and response to emergencies. Based on the results of the review were outlined several measures at national level and at operator's level to improve the emergency preparedness.

BNRA appreciates the efforts of the operator to improve the emergency planning, the maintenance of the emergency preparedness and the response to emergencies. The rating of the regulator in relation to the performance of the operator is high.

TOPIC 6 – INTERNATIONAL COOPERATION

Republic of Bulgaria follows harmonized international policy in the field of safety, based on approach reducing the risk of harm, both in terms of its own population and territory, as well beyond the borders.

National nuclear infrastructure has been built consistently over the years, based on fundamental conventions to which the country has acceded - Convention on Nuclear Safety (CNS, ratified in 1995), Joint Convention on the Safety of Spent Fuel Management and on the Safety Management of Radioactive Waste (Joint Convention, ratified in 2000), Convention on Early Notification of a Nuclear Accident (ratified in 1997), Convention on Assistance in Case of a Nuclear accident or Radiological Emergency (ratified in 1986), Vienna Convention on Civil Liability for Nuclear Damage (ratified in 1994), Convention on the Physical Protection of Nuclear Material (ratified in 1984) and Convention amendment from 2005 (ratified in 2006).

The state organized implementation of obligations under these Conventions distributing them in various special laws. By the Act on the Safe Use of Nuclear Energy (ASUNE) international cooperation of the Republic of Bulgaria in the field of safety is entrusted to the BNRA Chairman. He coordinates the preparation of national reports and implementation of the obligations under the Conventions and serves as a central authority and point of contact for notification of an accident. In addition to conventions, national legislation reflects Bulgarian and other international documents such as EU legislation.

CONVENTIONS

Republic of Bulgaria is party to the key conventions (listed above) on safety with depositary the General Director of IAEA. In the field of environment saving Bulgaria is a party to the Convention on the Assessment of Environmental Impact in a Trans boundary Context (Espoo), in force since 1997 and to the Convention on Access to Information, Public Participation in the process of decision taking and access to Justice in environmental Matters (Aarhus), in force since 2004

In recent years, Bulgaria, monitors the process of supplementing or amending of international instruments concerning safety and analyzes international experience in their application or take specific measures on accession. The last international instrument ratified is Convention on the Physical Protection of Nuclear Material in its amendment of 2005. Amended Convention was ratified by law in February 2006.

In the light of nuclear accident at Fukushima Daiichi, Bulgaria encourages countries that have not ratified the Convention to accelerate the relevant procedures for accession. Also, the Republic of Bulgaria supports the analysis and review of international conventions and treaties, as a logical step for the development of public relations affected by the accident.

BILATERAL COOPERATION

BILATERAL AGREEMENTS

Along with the conventions, another mechanism for conjunction with the international community is that the agreements on a bilateral or multilateral basis offer. This mechanism is very popular and appropriate to maintain cooperation relations with neighbouring or nearby countries.

Republic of Bulgaria has signed several cooperation agreements with almost all neighbouring countries and Russia (on the field of nuclear materials transport), as well with some non-European countries like the U.S. (for regulatory cooperation).

In the variety of agreements, a significant place take these, related to cooperation for assistance in the event of a nuclear accident and for early notification of a nuclear accident. These agreements were signed, mainly on an intergovernmental basis. Agreements on cooperation in emergency preparedness were concluded with Bulgaria's neighbouring countries - Romania, Turkey and Greece. In 2010 was signed and agreement on an inter institutional basis (between regulatory authorities) with Macedonia for cooperation on radiation protection, which covers the case of an accident or emergency involving radioactive materials transported across the border between the two countries.

In 2011, after the accident at Fukushima Daiichi, Bulgaria has taken steps to analyze the existing cooperation agreements on a bilateral basis with neighbouring or nearby countries, as well as the preparation and conclusion of bilateral agreements if these agreements are missing. As a result, calls for the signing of an intergovernmental agreement were led with Serbia. The draft agreement was prepared and is under review and discussion. Calls for signing the agreement on cooperation between regulatory authorities of Bulgaria and the Russian Federation are implemented. The analysis of bilateral agreements continues. If the analysis identifies the need for additional measures to improve communication between the countries, the agreements shall be amended accordingly.

It should be noted, that as a full EU member, for Bulgaria are in force all agreements of the Union in this area.

PROJECTS WITH INTERNATIONAL PARTICIPATION

In recent years cooperation between Bulgaria and the international community was performed by application and development of certain projects, related to both operational and regulatory work.

Norway

At the end of April 2011 was realized two-year project "Safe Nuclear Energy - Regional Program for Excellence" which is part of the Agreement between Bulgaria and Norway to implement the program of cooperation for economic growth and sustainable development in Bulgaria. The project covered the areas of emergency preparedness and safety culture and was implemented with the active participation of the IAEA.

In the scope of the project, pursuing Part "Emergency preparedness and response" were carried out training courses on the following topics:

- Developing, implementing and evaluating of training to deal with nuclear or radiological emergency;
- Actions of first reacting people (rescuers) during nuclear or radiological emergency.

In the scope of the project was carried out a joint Bulgarian-Romanian training of acting in an accident during transportation of spent nuclear fuel on the Danube. The aim of the training was to examine the interactions and operation procedures for informing government institutions, including response in case of incident involving ship. The training was observed by experts from Norway, Russia and representatives of IAEA, Interpol and other international organizations, who praised the organization and activities of the structures on both sides. Assessment of threat in case of transportation of spent fuel on the Danube was made as a part of the project.

Immediately after the accident at the NPP Fukushima Daiichi, at the request of the BNRA, in the emergency centre of BNRA were installed System to display the parameters important to safety (SPDS) and System for monitoring of critical parameters (PAMS) at Units 5 and 6 of Kozloduy NPP. Systems provide obtaining of data about work parameters of the 5 and Unit 6 of Kozloduy NPP and their visualization in real time for to support the BNRA experts in assessing the conditions of the reactors. Obtaining this information in the emergency centre will improve the interaction between the operator and BNRA and will shorten the time for decision making in critical situations.

As a result of successful project implementation and with support of the international community, through the help of the Norwegian Government, the IAEA, and the partners from Romania and Interpol, the Republic of Bulgaria achieved the following:

- the qualifications of experts in various institutions was improved;
- the interaction between the operator and the regulator was improved;
- the interaction between Bulgaria and Romania in case of accidents was improved;
- were set the elements for improving of emergency plans;
- the training programs for action in case of emergency were improved;
- the possibilities of the country to respond to transportation accidents was improved;
- the interaction between Bulgaria and the IAEA, including the communications and exchange of information in emergency was improved;
- an independent assessment of a country's ability to provide international assistance according to RANET system of IAEA was made.

There are intentions to continue the cooperation between Bulgaria and Norway till 2014, including in training programs for personnel engaged in activities on liquidation of consequences of a radiological accidents and on matters related to the management of severe accidents.

Databases of international organizations

Exchange of information between Bulgaria and the international community, including neighbouring countries, is implemented, in addition to mentioned mechanisms, also through the specialized electronic systems of international organizations. These are the common system of the IAEA for information exchange in an emergency situation (USIE) (the official system of the International Atomic Energy Agency for information exchange in incidents and emergencies), the International Nuclear Information System and systems of the European Union for the early exchange of information in the event of a radiological emergency ECURIE (European Community Urgent Radiation Information Exchange) and for exchange of radiation data (EURDEP).

INTERNATIONAL ORGANIZATIONS

Republic of Bulgaria is a member of the IAEA and the EU and has adopted an approach for engagement with the process of decision making by international organizations, using contribution to the mechanisms for establishment and development of international documents, their incorporation (when this stems from the status of these documents) and execution. Moreover, the country participates through its experts in various workshops, seminars and training at international level, supports own representatives in the Permanent Representations in Vienna to UN, OSCE and other international organizations as well the EU in Brussels.

Another mechanism for cooperation with international organizations is the State's participation in international projects related to assistance in the form of training, seminars, funding. Republic of Bulgaria uses the mechanisms for cooperation and assistance within the regular program and technical cooperation program of the IAEA. Declaring intention to strengthen its nuclear and regulatory capacity, the state through its experts, participate in initiatives in areas such as operations, safety and security, emergency preparedness, radioactive waste management and transportation of nuclear materials.

As a result of the 54th meeting of the Board of Governors of the Moscow Centre of WANO on 22.12.2011, a decision has been taken to expand the association's activity, creation of Representative offices on the site of each participating plant, and to increase WANO staff of Moscow Centre. This action plan and appropriate budget for 2012 is adopted and approved on 01/24/2012. The participating plants should consider the possibility to set up local representative offices on their sites and to nominate their employees to participate in competitions in Moscow for both permanent representatives at the association and at the office site.

The European Union (through EBRD) assist Bulgaria in meeting the commitments in the decommissioning of Units 1-4 of Kozloduy NPP, by providing training of experts involved in the decommissioning and experts involved in regulatory aspects of the activity.

INTERNATIONAL WORKING GROUPS

Republic of Bulgaria participates, through its representatives in working groups and committees, operating at international level. Such forums are groups of IAEA, EU, OECD, WANO, etc.

Under the IAEA national experts take part in formats, such as group to support information system for the full cycle of nuclear fuel, the group for training of regulator’s staff, the group of national contact points for nuclear and radiological emergency notification, the technical group for fuel behaviour and technology, as well in Committee on Nuclear Safety Standards (NUSSC), Radiation Safety Standards Committee (RASSC), Transport Safety Standards Committee (TRANSSC) and Radioactive Waste Safety Standards Committee (WASSC).

The European Nuclear Regulators Group (ENSREG) Bulgaria is represented by the President of BNRA. The country participates in Scientific and Technical Committee for the EURATOM Treaty, the European platform for qualifying of personnel using sources of ionizing radiation, the working groups on transport. National representatives participate in groups involved in the Association of European Nuclear Regulatory Authorities (WENRA)

Being member of WANO the operator - Kozloduy NPP participates in the following programs:

- program for peer review;
- program for exchange of operational experience;
- program for vocational and technical development;
- program for maintenance and exchange.

INTERNATIONAL PEER REVIEWS

Lessons learned from operating experience of a single country and its ability to maintain an acceptable level of safety, including using a mechanism to overcome or reduce the occurrence of unwanted effects, certainly would contribute to improving safety in other countries. Periodic self-assessment and accompanying peer reviews are a form of international cooperation aimed at achieving this goal. Republic of Bulgaria acknowledged the willingness to participate and to accept peer reviews of its territory. Traditionally it has been host to such forms of cooperation under operational and under the regulatory practices.

National legislation being based on international, including European documents is open and encourages periodic self-assessments and peer reviews. For example, the Act on the Safe Use of Nuclear Energy (ASUNE) requires at least once in 10 years BNRA to arrange self-assessment of national legislative infrastructure of safety, and to propose an international peer reviews. This text does not exclude self-assessment and adoption of international missions for shorter periods of time.

By invitation of the Bulgarian Government in 2013 in Bulgaria shall be hold new peer review of regulatory practices - IRRS. The mission will also address issues in the light of experience from the accident at NPP Fukushima Daiichi.

In March 2012 the Moscow Centre of WANO held mission in Kozloduy for technical support on "Preparing for the OSART mission" in the areas of operation, repair, security engineering, chemistry and emergency preparedness. The OSART mission of the IAEA will be held in November 2012.

The results of the international peer reviews shall be disclosed as required according to the principles of transparency and publicity about the activities of state institutions, including according to the principle of regulatory independence.

THE EXCHANGE OF OPERATING EXPERIENCE

The main tools for sharing of operational experience are mainly in cooperation with corresponding bodies of the IAEA, EU, OECD, WANO and bilaterally. Following the accident in Fukushima, several meetings were held with participation of the Bulgarian regulator and operator. The most important of them are:

- meeting with the Commissioner for Energy of European Commission Mr. Oettinger in connection with the accident in Belgium;
- Westinghouse seminar for stress tests in Belgium;
- meeting of WANO managing directors in Spain;
- Vienna Energy Forum, Ministerial Meeting in green industry and the Ministerial Conference on Nuclear Safety in Austria;
- Regional Seminar of WANO Moscow Centre on conducting "stress tests" of NPP with participation of operators of reactors built by Russian projects in Russia;
- workshop between representatives of the Temelin NPP and Kozloduy NPP on matters relating to the conduct of "stress tests" in the European Union, Czech Republic;
- meeting on the topic: "Stress tests of NPP with an overview of the seismic", Russia;
- workshop on the topic "Stress tests of NPP with an overview of the seismic", Romania;
- forum "Fukushima", USA.

IAEA STANDARDS

The implementation of safety standards of the IAEA is undoubtedly one of the guarantees to maintain an acceptable level of safety. In Bulgaria a significant part of the safety standards of IAEA have been incorporated into national legislation. When developing the regulations and when reviewing periodically the regulatory requirements they obligatory shall be reviewed and compared with the requirements and safety directions of the IAEA.

At the same time standard practice and approach in the licensing process is BNRA to require from the applicant, (respectively licensee), to substantiate the safety also by following the appropriate standard of the IAEA, so as to create belief in the BNRA that the applicant is capable to maintain level of safety, acceptable to international standards.

All new IAEA standards are analyzed by both - the regulator and the operator, the international practice on the standard is reviewed, is incorporated as appropriate and is applied as a touchstone of the place of the national safety infrastructure to world one.

Republic of Bulgaria reacts any perceives all good practices, arising out of or related to the implementation of recommended documents of the international community and address these practices to national legislation. For example, national legislation requires when the operator notifies the BNRA about events occurred at nuclear facilities, to submit an estimate of the event according to the INES scale, followed by analysis of the event and determining its final level for to determine its importance to safety. Although the scale is used primarily for purpose of informing the public about the importance of events, national legislation has adopted the INES concept as its national concept and directed the relevant requirements as part of the relationship between regulator and operator.

List of Abbreviations

AMC	Accident management centre
ASUNE	Act on the Safe Use of Nuclear Energy
BNRA	Bulgarian Nuclear Regulatory Agency
BPS	River Bank Pump Station
CSF	Critical Safety Function
DG	Diesel Generator
DSFSF	Dry Spent Fuel Storage Facility
EC	European Commission
ECCS	Emergency Core Cooling Systems
ECR	Emergency Control Room
EDG	Emergency Diesel Generator
ENSREG	European Nuclear Safety Regulators Group
EP	Electrical Production
EU	European Union
FSPP	Fire Safety and Public Protection
I&C	Instrumentation and Control
IAEA	International Atomic Energy Agency
INES	International Nuclear and Radiological Events Scale
IRS	Integrated Rescue System
MAF	Ministry of Agriculture and Food
MCR	Main Control Room
MD	Ministry of Defence
MEET	Ministry of Economy, Energy and Tourism
MEW	Ministry of Environment and Water
MH	Ministry of Health
MI	Ministry of Interior
NIMH	National Institute of Meteorology and Hydrology
NPP	Nuclear Power Plant
PGA	Peak (maximum) Ground Acceleration
PSA	Probabilistic Safety Assessment
RLE	Review Level Earthquake
SAMG	Severe Accident Management Guideline
SAR	Safety Analysis Report

SBEOP	Symptom-based emergency operating procedures
SFP	Spent Fuel Pool
SFSF	Spent Fuel Storage Facility
SG	Steam Generator
SL1	Seismic level 1 - maximal acceleration with recurrence period of 100 years
SL2	Seismic level 2 - maximal acceleration with recurrence period of 10 000 years
SSC	Structures, Systems and Components
SSEL	Safe Shutdown Equipment List
SV	Safety Valves
UPS	Uninterruptible power supply
WENRA	Western European Nuclear Regulators' Association

ATTACHMENTS

Appendix 1,
to Topics 1-6 of the Report

Measure			Activities of the Operator			Activities of the Regulator [2]		
ID №	NF/O[1]	Description	Progress	Plan/Stage	Result	Progress	Plan/Stage	Conclusion
TOPIC 1 - EXTERNAL IMPACTS								
A1		**Earthquakes - Ensuring of alternative possibilities for residual heat removal**						
A-1-1	Units 5,6 SFSF	Provision of a mobile diesel generator for each nuclear facility on site, the existing mobile DG shall remain in reserve	Implementation	December 2013	No	Planned	Change permission	Yes
A-1-2	Units 5,6	Research and investigation of the possibilities for alternative ways of residual heat removal in case of loss of essential components service water system, using the Additional system for SG feedwater supply of Units 3 and 4 for Units 5 and 6	Implementation	March 2013	No	Planned	Change permission	Yes
A-1-3	Units 5,6	Securing in shutdown mode the availability of at least one tank of the SGs Emergency Feedwater System in order to provide for the use of the SGs as alternative for residual heat removal	Implemented	N/A	Yes	Planned	Change permission	Yes
B1		**Flooding - Improvement of the readiness for actions in case of flooding s**						
B-1-1	NPP	Development of an emergency procedure for personnel actions in case of damage of "Iron Gate 1" and "Iron Gate 2" dams	Implementation	November 2012	No	Planned	Change permission, training	Yes
B2		**Flooding - Measures for prevention and mitigation of consequences of floodings**						
B-2-1	BPS	Investigation of the possibilities for protection of BPS 2 and 3 equipment in case of external flooding with maximal level 32,93 m	Implementation	October 2012	No	N/A	N/A	Yes
B-2-2	Units 5,6	Development of measures to prevent water intake in the plant sewage network in case of valley flooding	Implementation	October 2013	No	N/A	N/A	Yes
B-2-3	Units 5,6	Modernization of the sewage network and drain pump system	Implementation	October 2013	No	N/A	N/A	Yes

Measure			Activities of the Operator			Activities of the Regulator [2]		
ID №	NF/O[1]	Description	Progress	Plan/Stage	Result	Progress	Plan/Stage	Conclusion
TOPIC 2 - DESIGN ISSUES								
C1		**Measures for improvement of the robustness at loss of power supply**						
C-1-1	Units 5,6	Delivery of 2 new mobile DGs Provision of recharging of one of the accumulator batteries of the safety systems by a mobile DG	Implementation	December 2013	No	Planned	Change permission	Yes
C2		**Measures for improvement of the robustness at loss of ultimate heat sink**						
C-2-1	NPP	Study the conditions, efficiency and availability of emergency water supply from the Shishamnov Val dam.	Implementation	May 2012	No	N/A	N/A	Yes
C-2-2	Units 5,6	Ensure power supply of the systems for SFP cooling or filling by mobile DG.	Implementation	December 2013	No	Planned	Change permission	Yes
C-2-3	Units 5,6	Analyse the necessity and possibility for power supply of the valves at the pipelines, connecting the hydroaccumulators to the primary circuit from the batteries to ensure possibility for coolant supply to primary circuit in cold state of the reactor and failure of DGs.	Implementation	December 2013	No	Planned	Change permission	Yes
C-2-4	SFSF	Analyse the possibility to install autonomous cooling system in SFSF, which has independent power supply.	Planned	December 2013	No	Planned	Change permission	Yes
TOPIC 3 - MANAGEMENT OF SEVERE ACCIDENTS								
D1		**Measures to improve the NPP organization for accident management**						
D-1-1	NPP	Updating of the internal and external emergency plans considering the effects of physical isolation due to external hazards: - difficult access to ECR of Units 5 and 6; - possible draining of the sections of SFP with subsequent increase in the dose rate; - provide alternative routes for evacuation, transport of fuels and materials, necessary to the plant, and access of operational staff.	Implementation	July 2012	No	Planned	Change permission	Yes
D-1-2	NPP	Construction of a new Accident management centre outside the NPP	Planned	December 2015	No	N/A	N/A	Yes

Measure			Activities of the Operator			Activities of the Regulator [2]		
ID №	NF/O[1]	Description	Progress	Plan/Stage	Result	Progress	Plan/Stage	Conclusion
D2		**Measures to improve the possibilities for management of severe accidents**						
D-2-1	Units 5,6	Putting in force symptom oriented emergency procedures for shut-down reactor and sealed primary circuit.	Implemented	February 2012	Yes	Implemented	Approved	Yes
D-2-2	Units 5,6	Putting in force symptom oriented emergency procedures for shut-down reactor and unsealed primary circuit.	Implementation	February 2013	No	Implemented	Approved	Yes
D-2-3	Units 5,6	Putting in force the SAMGs according to the developed program	Implementation	November 2012	No	Implemented	Approved	Yes
D-2-4	Units 5,6	Develop technical means for direct injection of water to the reactor core, SG, SFP and the containment by mobile fire protection equipment in case of accidents.	Planned	December 2013	No	Planned	Change permission	Yes
D-2-5	SFSF	Develop technical means for direct injection of water to the compartments of SFSF by mobile fire protection equipment in case of accidents.	Planned	September 2013	No	Planned	Change permission	Yes
D3		**Measures for reducing the releases of radioactivity**						
D-3-1	Units 5,6	Installation of additional hydrogen recombiners in the containment	Implementation	December 2013	No	Planned	Change permission	Yes
D-3-2	Units 5,6	Installation of measuring channels for monitoring and evaluating the concentration of water vapours and oxygen within the containment	Implementation	June 2014	No	Planned	Change permission	Yes
D-3-3	Units 5,6	Implementation of the project for closure of ionization chambers channels, located in the walls of the reactor vessel cavity	Implementation	December 2014	No	Planned	Change permission	Yes
D-3-4	Units 5,6	Installation of temperature sensor with wide range for monitoring of the reactor vessel temperature	Implementation	December 2012	No	Implemented	Licence requirement	Yes
D-3-5	Units 5,6	Study the possibilities for corium localisation in case of severe accident	Planned	December 2017	No	N/A	N/A	Yes
		TOPIC 4 – NATIONAL ORGANIZATIONS						
N1		**Regulatory requirements**						

Measure			Activities of the Operator			Activities of the Regulator [2]		
ID №	NF/O[1]	Description	Progress	Plan/Stage	Result	Progress	Plan/Stage	Conclusion
N-1-1	NRA	Taking into account the lessons from the accident at the NPP Fukushima Daiichi in the performance of the program for review of the regulations	N/A	N/A	N/A	Implementation	December 2013	N/A
N-1-2	NRA	Review of the existing regulatory requirements against the new documents of IAEA, considering the lessons from the accident	N/A	N/A	N/A	Planned	Permanent	N/A
N-1-3	NRA	Active participation of Bulgarian experts in the reviews of the IAEA standards	N/A	N/A	N/A	Planned	Permanent	N/A
N-1-4	NRA	Taking into account the lessons learned and the new documents of IAEA and the European Commission in the process of periodic review and updating of the regulatory guidelines	N/A	N/A	N/A	Planned	December 2014	N/A
N2		**Regulatory practice**						
N-2-1	NRA	Review of NRA actions, related to IRRS mission of IAEA				Planned	June 2013	No
TOPIC 5 – EMERGENCY PREPAREDNESS AND RESPONSE 3								
E1		**National level**						
E-1-1	MI	Revision and updating of the National (External) Emergency Plan	N/A	N/A	N/A	Implementation	June 2013	N/A
E-1-2	MI	Analysis of the existing and development of missing procedures, instructions and methods for action of the emergency teams according to the National Emergency Plan	N/A	N/A	N/A	Implementation	June 2014	N/A
E-1-3	MI	Updating and maintaining a database of existing voluntary teams to work in an emergency	N/A	N/A	N/A	Planned	December 2012	N/A
E-1-4	MEW	Renovation of the National Automated System for Continuous Monitoring of radiation - BULRaMo	N/A	N/A	N/A	Planned	December 2014	N/A
E2		**Regulatory level**						
E-2-1	NRA	Installation of Safety Parameters Display System in the NRA Emergency Centre and installation of system for monitoring of critical parameters of Units 5 and 6 of Kozloduy NPP, that provide visualization of the parameters and obtain the parameters of the blocks in real time	N/A	N/A	N/A	Implemented	May 2011	Yes

Measure			Activities of the Operator			Activities of the Regulator [2]		
ID №	NF/O[1]	Description	Progress	Plan/Stage	Result	Progress	Plan/Stage	Conclusion
		TOPIC 6 – INTERNATIONAL COOPERATION						
M1		**Bilateral cooperation**						
M-1-1	NRA	Analysis of the existing agreements for bilateral cooperation with neighbouring or nearby states	N/A	N/A	N/A	Implementation	June 2013	No
M-1-2	NRA	Preparation and signing of bilateral agreements when such agreements lack	N/A	N/A	N/A	Planned	December 2014	No
M-1-3	NRA	Modification of the existing agreements, in case of need for additional measures to improve the communication between the states	N/A	N/A	N/A	Planned	December 2014	No
M2		**International organizations**						
M-2-1	NPP	Create a local WANO office of the Kozloduy NPP site	N/A	N/A	N/A	Planned	December 2013	No
M-2-2	NPP	Nomination Kozloduy NPP employers for the WANO in Moscow	N/A	N/A	N/A	Planned	December 2013	No

[1] – Nuclear facilities or organizations;

[2] – All measures of the Operator are agreed by NRA, as the performance of some of them needs permission to make changes after the submission of a specific technical solution;

[3] – The Emergency planning measures the operator are described in topics 1-3.

Appendix 2,
To Topic 4 of the Report

LIST OF SECONDARY LEGISLATION

- **Rules of Procedure of the Nuclear Regulatory Agency**

BNRA Rules of Procedure determine the structure, activity, organization of work, functions and number of personnel of the Agency and its administrative units. According to the Rules of Procedure, the BNRA Chairman is a primary administrator of budgetary credits since 01 January 2003.

- **Regulation on the procedure for issuing licenses and permits for safe use of nuclear energy**

The regulation cover all matters related to the procedures for issuing, amending, renewing, revoking and controlling the licenses and permits, as required by the ASUNE. The overall regulation structure takes into consideration the specific types of nuclear facilities, as well as practices and sites with sources of ionising radiation. The scope and contents of required documents are specified in respect to measures required for providing nuclear safety, radiation protection and physical protection. Grade approach is applied, as based on the lower risk for the public and the environment, less documents are required for certain activities with sources.

- **Regulation on the conditions and procedure for transfer of radioactive waste to the State Enterprise "Radioactive Waste"**

Radioactive waste generators shall transfer the RAW to the State Enterprise, which is responsible for the safe management of the radioactive waste after the transfer.

The regulation specify the conditions and procedure (including timeframe) for transfer of the RAW to the State enterprise "Radioactive Waste", as well as the radioactive waste not eligible for transfer. Specific procedures are defined for transfer of radioactive waste from past practices, radioactive waste with unknown ownership, or RAW which had been imported to the country and cannot be returned back. At the moment of its transfer to the State Enterprise the radioactive waste becomes state property.

- **Regulation on ensuring the safety of nuclear power plants**

The regulation specify the main criteria and rules for the safety of nuclear power plants, based on the defence in-depth concept.

Subject to regulation are the organizational measures and technical requirements for providing of safety during site selection, design, construction, commissioning and operation of nuclear power plants. The regulation contains detailed requirements on the establishment of the design basis and performance of safety assessments, the site characteristics, and the safety requirements for the nuclear power plant and its systems.

The regulation is developed based on the IAEA safety standards and takes due account of the reference levels for harmonization of the safety requirements for nuclear power plans, defined by the West European Nuclear Regulators Association (WENRA).

- **Regulation on ensuring the safety of research nuclear installations**

The regulation specifies the main criteria and rules for the safety of research nuclear reactors and stands. Subject to regulation are the organizational measures and technical requirements for providing of the safety during site selection, design, construction, commissioning and operation of research nuclear installations. The regulation contains detailed requirements related to the design basis and safety evaluations, the site characteristics and the safety requirements for the research nuclear installations.

– **Regulation on radiation protection for practices with sources of ionising radiation**

The regulation defines the basic requirements and rules for radiation protection during activities with sources of ionising radiation and the conditions and procedures for accounting of sources of ionising radiation. The regulation puts in place requirements for radiation monitoring during activities with sources. The regulation specifies technical and organizational rules for conformity with the established Bulgarian Basic Norms for Radiation Protection.

– **Regulation on the conditions and procedure for notification of the BNRA about events in nuclear facilities and in sites with sources of ionising radiation**

The regulation defines the obligations of the licensee or the permit holder to establish a system for collection, recording, investigation, analysis and assessment of events and for implementation of corrective measures.

Requirements for events information use are also defined, including for analysis of operational experience, assessment of events safety significance, as well as the procedure and terms for providing the public with the information in respect to events safety significance.

– **Regulation of the conditions and procedure for exempting small quantities of nuclear material from the Vienna convention on civil liability for nuclear damage**

According to the Vienna convention for civil liability for nuclear damage, the operator of a nuclear facility is liable for any nuclear damage and is obliged to maintain an insurance or other financial guarantee, covering this liability.

Every contracting country has the right to exempt small quantities of nuclear material from the application of the convention, up to the maximum quantities defined by the IAEA Board of Governors. According to Article 135 of the ASUNE, the authority to accept a Regulation on the conditions and procedure for exempting small quantities of nuclear material from the application of the Vienna convention was delegated to the Council of Ministers.

The regulation was developed in conformity with the decision of the IAEA Board of Governors dated 14-15 September 1978 for establishing the maximum limits for exempting small quantities of nuclear material from the application of the Vienna convention and with the IAEA safety standards for transport of nuclear materials.

– **Regulation on safety of spent nuclear fuel management**

According to the ASUNE provisions, the regulation defines in detail the matters related to the basic criteria and rules for providing nuclear safety and radiation protection in the management of spent nuclear fuel, as well as the specific organizational measures and technical requirements for providing the safety during site selection, design, construction, commissioning and operation of spent fuel management facilities.

Matters related to the technical safety, fire safety, physical protection, and emergency planning and preparedness of the spent fuel management facilities are defined in the regulation, to the extent that follows from the defence-in-depth concept.

– **Regulation on the safe management of radioactive waste**

The Regulation defines the safety requirements, norms and rules for site selection, design, construction, commissioning and operation of facilities for radioactive waste management.

The regulation also defines the obligations of the entities carrying out radioactive waste management activities. The entities which as a result of their activities generate radioactive waste are responsible for its safe management from the RAW generation till its transferred to the State enterprise “Radioactive waste” or until its release from regulatory control.

- **Regulation of the conditions and procedure for acquiring professional qualification and for the procedure for issuing licenses for specialized training and individual licenses for use of nuclear energy**

The regulation defines the conditions and procedure for acquiring professional qualification for activities in nuclear facilities and facilities with sources of ionising radiation, the positions for which individual licenses are required, the procedure for issuing licenses for specialized training and individual licenses, as well as the conditions and procedure for carrying out exams for obtaining the license.

- **Regulation on emergency planning and emergency preparedness in case of nuclear or radiological emergencies**

In accordance with ASUNE provisions, the regulation defines the conditions and procedure for developing emergency plans and the obligations of the persons who apply them.

The actions and measures for mitigation and elimination of the consequences from a nuclear or radiation accident are also defined, as well as the decision taking criteria for intervention and the means of public communication. Subject of regulation is also the maintenance and control of the emergency preparedness and the interactions between the executive authorities and the licensees or permit holders.

- **Regulation for the provision of physical protection of nuclear facilities, nuclear material and radioactive substances**

According to the ASUNE and the Convention on Physical Protection of Nuclear Material, the Regulation specify the requirements related to the physical protection of nuclear facilities, as well as to the use, storage and transport of nuclear materials and radioactive substances.

The Regulation take into account the specifics of the different kinds of nuclear facilities, nuclear materials and radioactive substances, which demand different levels of physical protection, depending on the category of nuclear materials and radioactive substances and the degree of risk (graded approach).

- **Regulation on the basic norms for radiation protection**

The regulation reflects the requirements of the 96/29/EURATOM Directive, setting the basic standards for protecting the health of personnel and the public from the adverse impact of ionising radiation. The basic principles of radiation protection are established, and dose limits for the personnel and the public are set. In accordance with Directive provisions, the concept of clearance of radioactive material resulting from authorised practices, as well as concept of limitation of exposure are introduced.

The Regulation sets the requirements for monitoring of the working places and of the individual exposure, as well as the requirements for recording of monitoring results. The requirements of Directive 90/641/EURATOM in respect to external workers in the controlled areas are also introduced.

In relation to the Bulgarian membership in the European Union, the Regulation introduces the basic principles and requirements for radiation protection of medical exposure, taking into consideration Directive 84/466/EURATOM.

– **Regulation on the conditions and procedure for establishing of special-statutory areas around nuclear facilities and facilities with sources of ionising radiation**

In the regulation, the criteria to determine the size and boundaries of area with special status, the procedure to establish the areas are specified, as well as the responsibilities of the competent state authorities, according to the law. According to the ASUNE, the regulation sets restrictions for licensee activities in the special status areas, including the requirements for radiation monitoring of the public and the environment. Criteria of compensations for imposed restrictions over the use of private real estate are defined.

– **Regulation on the conditions and procedure for collecting and providing information and keeping records of the activities subject to safeguards, according to the Non-Proliferation Treaty**

According to the ASUNE, Article 126, the Regulation specifies the conditions and procedure for collecting and submitting the information and keeping records of the activities subject to the Agreement between Bulgaria and the IAEA for application of the safeguards in respect to the Non-Proliferation Treaty and the Additional Protocol. According to the ASUNE provisions, entities that carry out activities subject to the Agreement and the Additional Protocol shall develop and apply internal rules and procedures for registration and control of the type, quantity, location and movement of the nuclear material and its shipment. They shall present to the BNRA Chairman all the information required to comply with the obligations of the Republic of Bulgaria under the agreement, and shall grant sites access to the IAEA inspectors, EC inspectors and the accompanying BNRA inspectors.

– **Regulation on the safety of nuclear facilities decommissioning**

The regulation provides that the safe decommissioning of nuclear facilities shall include preliminary and interim panning, adoption of a concept, and developing of a decommissioning plan. Safety shall be justified for each stage of the decommissioning activities.

The Regulation defines the basic safety requirements for decommissioning; for maintenance of safety related systems and equipment; for equipment decontamination and dismantling; for radiation protection; and for radioactive waste management. It is required that with the completion of each decommissioning stage of the nuclear facility, licensee shall prepare and submit to the Regulator an updated SAR for the respective stage.

– **Regulation on the procedure for paying the fees under the ASUNE**

The Regulation determines the procedure for paying the fees for applications review and for issuing of licenses and permits, in accordance with the ASUNE provisions.

– **Tariff for the fees collected by the BNRA under the ASUNE**

The tariff determines the amount of the fees to be collected by the BNRA for applications review and for issuing of licenses and permits, in accordance with the ASUNE provisions. The amount of initial and annual license fees, as well as the fees for issuing of permits are determined, depending on the complexity and the range of the regulatory control, and of the specifics of the relevant activity, which is subject to state regulation, in accordance with the ASUNE provisions.

– **Regulation on the procedure for assessment, collection, spending and control of the financial resources and definition of contributions to the “Nuclear facilities decommissioning” Fund**

The regulation determines the procedure for assessment, collection, spending and control of the financial resources and definition of contributions to the “Nuclear facilities decommissioning” Fond under the auspices of the Minister of Energy and Energy Resources.

The Fund is managed in a manner to assure implementation of the annual program of the permit holder for decommissioning of a nuclear facility. The revenues of the Fund are collected mainly from contributions from nuclear facility operators and national budget resources, allocated annually pursuant to the National Budget Act for the relevant year.

- **Regulation on the procedure for assessment, collection, spending and control of the financial resources and definition of contributions to the "Radioactive waste" Fund**

The regulation determines the procedure for assessment, collection, spending and control of the financial resources and definition of contributions to the "Radioactive waste" Fund under the auspices of the Minister of Energy and Energy Resources. The Fund is managed in a manner to assure implementation of the activities for radioactive waste management. Fund revenues are collected mainly from contributions from legal and physical entities generating radioactive waste at waste transfer to the State Enterprise "Radioactive waste", as well as from the State budget, allocated annually pursuant to the National Budget Act for the relevant year.

- **Regulation on the conditions and procedure of transport of radioactive material**

The regulation delineates the conditions and order for ensuring the radiation protection and safety during transport of nuclear material, radioactive waste and other radioactive substances on the territory of the Republic of Bulgaria. It also introduces into the national legislation the requirements of the international treaties for transport of dangerous goods category 7. Regulation provisions are in accordance also with the IAEA requirements for safe transport of radioactive substances - TS-R-1. The regulation introduces the requirements of the European legislation in the field of radiation protection during transport of radioactive waste determined by a Council Directive 92/3/EURATOM on the supervision and control of shipments of radioactive waste between Member States and into and out of the Community as well as in case of import or export from the Community.

Appendix 3,
to Topic 5 of the Report

EMERGENCY TECHNICAL FACILITIES, SYSTEMS AND MEANS TO ENSURE THE EMERGENCY PREPAREDMNESS IN KOZLODUY NPP

1. Emergency Management Centre– designed to ensure the appropriate working conditions for the emergency management team and the duty teams during an emergency. EMC is established, according to the design, at the site of Units 1-4. The Centre is equipped with: different system for internal and external communications (autonomous digital phone network of 100 posts, short and ultra-short wave radio stations), including with regional and state authorities; backup power supply by two diesel generators; autonomous filtering ventilation system using iodine and aerosol filters for working conditions of total isolation; system for control and maintenance of the microclimate parameters; separate water supply system with backup service water and deactivation reagents; medical facility for emergency medical care; and protective clothing and instruments warehouse.

Access control regime with a possibility for deactivation is established. EMC is equipped with: technological, radiological and meteorological monitoring; program and technical means for assessment, forecast and visualization of the conditions. Working premises are equipped with the necessary technical and operating documentation. The EMC has its own medical facility, foods store and water reservoirs.

2. Announcing system in the emergency planning zones – Kozloduy NPP site, in the precautionary UPAZ and the 12 km sub-zone of the UPAZ. Announcing system was completely renovated in 2009, with 28 announcing points; power supply racks with computerized control and interface with the internal phone system; radio announcers and personal computers and panels for remote control from the working place for USS NPP-1; USS NPP-2 and EMC.

3. EMC Access control point for the emergency staff using build in monitors for control of surface contamination, showers and sinks for decontamination. Radiation control of premises is carried out using mobile devices, including for control of aerosol content in the air. Individual dose monitoring of the personnel is done by TLD and digital dosimeters.

4. Meteorological monitoring system (MMS) with 3 meteorological stations and air-logical sampling system using balloon and radio-sampling devices, connected through a radio-channel with the NCMH and MEW.

5. Automated Information System for External Radiological Monitoring (AISERM), measuring gamma background and iodine concentration, equipped with 10 stations and integrated with the national system BULRaMo. This system includes also 5 water stations to control liquid discharges, which was recently upgraded.

6. Automated Information System for Site Radiological Monitoring (AISSRM) including 14 points with visualization panels of gamma background and temperature. Displays and gamma detectors have been replaced.

7. EMC Information System – local computer network with 13 stations, video screens, printers, UPS and specialized software for information management in accidents or drills, being upgraded in the last years. Hardware has been completely replaced in 2008and 2009. The computer program for forecast of radiological consequences and protective actions in the early

accident phase has been updated and additionally 1 station of the RODOS system was installed. The indications have been ensured at the panels of AISERM, AISSRM, MMS, program for control of fuel positions - Smart Fuel; program for calculation of isotopes accumulation and residual heat – Scale; program for control of the water level of the Danube River and the dikes; and control of Containment ropes stressing.

8. Emergency packages with Individual Protective Means (IPM) – containing respirators, face masks, respiration filters for radioactive environment, gloves, iodine tablets. They are located in specific cabinets in all large administrative and operating buildings, including for all external contractors located inside the 3 km zone.