EUROPEAN STRESS TESTS

Kozloduy NPP

Final Report on the Implementation of the Updated National Action Plan of Republic of Bulgaria

following the accident at the Fukushima NPP

Nuclear Regulatory Agency

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FINAL REPORT

IMPLEMENTATION ON THE UPDATED

NATIONAL ACTION PLAN OF REPUBLIC OF BULGARIA

following the accident at the Fukushima NPP

INTRODUCTION

Immediately after the severe nuclear accident at the Fukushima Daiichi Nuclear Power Plant (NPP), caused by a major earthquake and the following large tsunami wave in March 2011, the Bulgarian Government took urgent actions to reassess the preparedness of Kozloduy NPP to respond to extraordinary situations and emergencies. Following the directions of the Bulgarian Nuclear Regulatory Agency (BNRA) and in compliance with the actions recommended by the World Association of Nuclear Operators (WANO), the Nuclear Power Plant developed and implemented by the middle of June 2011, a "Programme for Review and Assessment of the Preparedness of Kozloduy NPP to Manage and Mitigate the Consequences of Beyond Design Basis Accidents, External and Internal Events". A large number of additional inspections of the operability and assessment of the technical status of safety important structures, systems, and components (SSCs), the availability and applicability of instructions and procedures, and preparedness of the personnel to respond to extraordinary situations were carried out within the frames of the Programme.

- ***Stress-tests of Kozloduy NPP***

Following the Fukushima Daiichi NPP accident, the European Council requested the European Commission (EC) and the European Nuclear Safety Regulators Group (ENSREG) for a safety review of all NPPs in EU countries on the basis of a comprehensive and transparent risk assessment (stress tests). In May 2011, the ENSREG and the EC adopted a Declaration and EU Stress Test Specifications, defining the stress test as a targeted reassessment of the safety margins of the European nuclear power plants in case of external initiating events.

The purpose of these stress tests was to perform a targeted reassessment of the safety margins of nuclear facilities under extreme external events, loss of safety functions and severe accidents. In compliance with the EC and BNRA requirements, in 2011 Kozloduy NPP carried out stress tests for the nuclear facilities on the NPP site. At the end of 2011, the BNRA presented the Bulgarian National Report on the Stress Tests of Kozloduy NPP to ENSREG. In the period from February to March 2012, all national reports of the EC countries operators of nuclear facilities were subjected to reviews, discussions and peer reviews by ENSREG.

- ***National Action Plan of the Republic of Bulgaria after the stress test (December 2012)***

In 2012, ENSREG and the EC requested that each Member State should develop a National Action Plan (NAcP) as a follow-up of the stress tests, that takes into account the national planned measures, general ENSREG recommendations and the decisions taken at the extraordinary meeting (EOM) of the Convention on Nuclear Safety (CNS), held in August 2012, at the International Atomic Energy Agency (IAEA), Vienna.

The National Action Plan (NAcP) of the Republic of Bulgaria (December 2012) contains systematic information on the extent of the implementation of the recommendations of ENSREG, and the planned additional measures resulting from the peer review by ENSREG and the related WANO Programme after the accident at the Fukyshima Daichi NPP. The National Action Plan is structured in accordance with the recommendations of ENSREG.

The measures in the National Action Plan are established at two levels – the Kozloduy NPP site level and institutional level.

The Operating Organisation shall report to BNRA its obligations under the implementation of the NAcP measures at the Kozloduy NPP site level, and shall develop and maintain an up-to-date programme for implementation of the relevant measures. For each measure a time schedule with deadlines, milestones (analyses and safety assessments, justifications, decisions and authorisations of regulatory bodies, feasibility studies, preparation of detailed designs, equipment supply, construction works, etc.) and coordinator shall be defined. The proposals for design changes or modifications shall be supported by engineering and/or financial justification.

The implementation of each NAcP action at NPP site level shall be reported by the Operating Organization in a summary report. After the final implementation of all measures, the Operating Organization prepares a complete report on the NAcP implementation at that level.

The measures at institutional level are adopted by a Governmental Decree of 2 May 2012. These measures were reported according to the periodic review process for the implementation of the CNS obligations, as the Government approved the corresponding reports. During the implementation of the measures at institutional level, the BNRA, in the frames of its competence, ensured the coordination with Ministries, Institutions and Organizations in Bulgaria.

A total of 63 measures and activities were envisaged in the National Action Plan of December 2012.

MAIN CHANGES IN THE NACP SINCE THE FIRST EDITION OF THE PLAN IN 2012

- ***National Progress Report on the implementation of the NAcP of the Republic of Bulgaria (January 2014)***

In April 2013, a workshop was held in Brussels to peer review the contents and status of implementation of the measures in the NAcPs of the EC Member States. As a result of this review conclusions were made on the implementation of the NAcP of each country and some general recommendations were identified. At the end of 2013, ENSREG requested the Member States to present until the end of January 2014 national progress reports on the status of the NAcPs and the implementation of the general recommendations of the workshop of April 2013. For this purpose, at the end of 2013, Kozloduy NPP presented a summarized progress report of the NAcP measures and an updated plant Programme for implementation of the Stress Tests Recommendations. The updated Programme reflects the current status of the measures up to the end of December 2013 and specifies 10 new measures for implementation of design solutions or conduct of further investigations resulted from already completed measures, comprising analysis or studies.

- ***The National Action Plan of the Republic of Bulgaria (revision January 2014)***

In January 2014, the BNRA updated the status of the National Action Plan and issued a new revision. It contains 10 new measures for implementation or conducting new analyses resulted from already completed measures from Part I and Part III of the NAcP of December 2012, related to completed researches or studies. The activities and measures envisaged in this part are at the site level. The NAcP includes also a new Attachment 4 which specifies in tabular form the new measures. The same table also indicates the interface with the previous measure, the status of implementation and deadline for completion. A total of 73 measures and activities were included in the NAcP of January 2014.

- ***Updated National Action Plan (December 2014)***

During the ENSREG workshop for peer review of the NAcP, held in April 2013, it was decided to organize a second workshop in 2015. The main objective of the second workshop was to use a similar process of peer review of the progress of the implementation of the national action plans, as well as to exchange technical information on the measures and activities

included in the NAcPs. For the second workshop of ENSREG in 2015, each country had to have prepared an Updated NAcP by the end of December 2014, which would reflect the changes that had occurred since the initial approval of the NAcP, as well as the present status of the planned measures and their implementation. For this purpose, BNRA prepared and published the Updated NAcP, which icontained 4 new measures. A total of 77 measures and activities have been included in the Updated NAcP.

- ***Updated National Action Plan (revision December 2018)***

In December 2018, the BNRA updated the status of the Plan. In this revision was added one new measure related with the development of procedure for actions of the emergency teams during the simultaneous accidents in different units/installations at the site. A total of 78 measures and activities have been included in the Updated NAcP.

- ***Updated National Action Plan (revision March 2020)***

In March 2020 the Updated National Action Plan was updated. In the plan is presented the current status of implementation of the remaining 5 measures.

- ***Updated National Action Plan (revision December 2021)***

In December 2021 the UNAcP was updated. In the plan is presented the current status of implementation of the remaining 3 measures.

- ***Final Report on the Implementation of the Updated National Action Plan***

This current report is the updated and final version of the implementation of all measures addressing in the National Action Plan. The 78 measures included in the plan have been implemented.

PART I – INFORMATION ABOUT THE ACTIVITIES AT THE KOZLODUY NPP SITE LEVEL

The text bellow describes activities and measures (reference issues) regarding each topic, performed in fulfilment ofthe general recommendations and proposals of ENSREG resulting from the stress tests peer reviews.

TOPIC 1 – EXTERNAL INITIATING EVENTS (EARTHQUAKE, FLOODING, EXTREME METEOROLOGICAL IMPACTS)

The National Report analyzes the seismic stability of structures, systems and components (SSCs) of Kozloduy NPP important to safety that are considered in the accident scenarios. The limit values are identified of the seismic accelerations that each nuclear facility on-site can withstand without the occurrence of severe fuel damage and release of radioactive substances to the environment. The seismic stability analysis demonstrates that the SSCs of the Kozloduy NPP are capable of ensuring the plant safety in case of seismic impacts, considerably exceeding the current design basis.

Within the stress tests scope, the maximum water level for the site (MWL), and the duration were assessed in combination with other adverse events. The analysis of the results confirms that the Kozloduy NPP site is not floodable.

The systems and components important to safety are not directly affected by extreme meteorological impacts. The studies within the stress tests scope demonstrate that the considered civil structures have the load capacity needed to withstand increased loads caused by extreme meteorological impacts.

1. SUMMARY OF ENSREG RECOMMENDATIONS AND SUGGESTIONS

1.1. Risks (Hazards) Frequency of Occurrence

The current seismic characteristics of the Kozloduy NPP site were re-assessed in the period 1990-1992. Reassessment was completed against the IAEA safety standards. By means of comparative analysis and additional investigations they were found to comply with the requirements of the current IAEA document Safety Standards Series No. SSG-9: Seismic Hazards in Site Evaluation for Nuclear Installations, 2010. The re-evaluation is valid for all nuclear facilities. A definition is provided for the so called RLE (Review Level Earthquake). The following seismic levels are defined with the help of probabilistic and deterministic methods:

- Operational Basis Earthquake (OBE) (also SL1) of PGA 0.10 g, with return period of 100 years;
- Design Basis Earthquake (DBE) (also SL2, Safe-shutdown Earthquake) of PGA 0.20 g, with return period of 10 000 years.

According to the Bulgarian regulations, the maximum water level (MWL) on the site is evaluated for possible maximum flood in case of river overflow with annual frequency of 1E-4 events, in combination with high tide resulting from damage of the Hydro-power Facilities Zhelezni Vrata 1 and 2, and flood surge caused by wind. The analysis was developed on the basis of the current routine hydrological study of the Danube in 2010.

The extreme winds for the region of the site are evaluated at 1E-4 frequency of occurrence and at 1E-6 for tornado.

The current assessments of natural hazards are included in the periodic safety analysis for all nuclear facilities on the site.

1.2. Earthquake Secondary Effects

The report presents and analyses the results from possible earthquake secondary effects such as floods or fires, considered in the Kozloduy NPP Seismic Probabilistic Safety Assessment (PSA). The most conservative scenario is analyzed for a catastrophic wave caused by a sudden and complete damage of the Hydro-power Facilities Zhelezni Vrata 1 & 2, resulting from a beyond design basis earthquake in combination with maximum water level of the Danube, maximum precipitation in the region, and the maximum water level on the site, namely MWL=32.93 m (elevation 0.00 on KNPP site corresponds to elevation +35.00 as per the Baltic Altitude System). That scenario is also considered for assessment of safety margins in case of floods. The National Report also considers water levels of lower probability (1E-5 to 1E-7) with the above combinations, the result being that the maximum level of the water will not exceed the level of 33.42 m with a probability of occurrence of 1E-7/year. The analysis of the results confirms that the Kozloduy NPP site is not floodable.

The scheduled measure in the National Report to enhance the plant robustness in case of external flooding, to avoid secondary effects of beyond design basis flood of external sites is implemented (Measure B-1-1 in *Attachment 1*).

1.3. Protected Volume Approach

Our off-site flooding analysis used the “protected volume” approach to demonstrate the protection from flooding of the buildings, rooms and places important to safety. Potentially endangered rooms and equipment are identified and possible measures for plant robustness enhancement are planned against external flood of MWL=32.93 m, in order to avoid secondary effects of floods (measures B-2-1, B-2-2 and B-2-3 in *Attachment 1*).

1.4. Early Warning

The Danube high levels and the water quantity trends are indicated by the readings of the implemented Automated System for Water Level and Hydraulic Regime Monitoring (AQUA). The system automatically monitors water levels and water volumes in the two canals, and the level and temperature of the Danube river water. Daily data are electronically transmitted by the Danube Study Agency in Ruse.

An on-site automated meteorological monitoring system is built at the Kozloduy NPP.

Preventive actions rrocedures are developed to be implemented by the staff in case of notification of, as follows: extreme weather conditions, emergency low level of the Danube, freezing of the water along the River Bank Pump Station (BPS), low temperatures that can result in pump grids freezing in the Circulation Pump Stations 2-4.

A measure is implemented to enhance the plant robustness in case of external flooding, to avoid any secondary effects of it (Measure B-1-1 in *Attachment 1*).

1.5. Seismic Monitoring

The Kozloduy NPP site seismic monitoring is performed by the following independent systems:

- The seismic monitoring and control system which registers and records seismic events above certain threshold (0.01g); the system detectors are installed on Unit 6, and there are annunciators for registered events on the information panels of the Main Control Room (MCR) 5 and 6;
- Accelerograph system for seismic monitoring of equipment and structures consisting of 10 accelerographs arrayed separately in the free field and at identified places of the

civil structures. The system registers and records seismic events above a given threshold (0.01 g);

- Equipment for industrial seismic protection intended to cause automatic reactor shutdown in case of a registered seismic acceleration movement of the base plate exceeding 0.05 g;
- Local seismological network consisting of three peripheral seismic stations situated around the Kozloduy NPP site which perform on-line seismic monitoring of the plant surroundings. The local seismic network (LSN) provides reliable registration and localization of seismic events on the territory of the country and surrounding regions that may affect the Kozloduy NPP safe operation.

Written procedures are developed for each activity in compliance with the quality assurance system. The activities are performed by qualified personnel.

An Emergency Response Procedure for the unit shift operator actions in case of an earthquake and a plan for the actions of the staff during and after an earthquake are developed. An Earthquake Event Emergency Procedure is developed describing response in case of an earthquake.

1.6. Qualified Walkdowns

The Department of Hydrotechnical Facilities and Civil Structures is a part of the plant organisational structure. This Department carries out the seismic monitoring of the facilities, provides for the cadastral servicing of the company territory, controls status and development of engineering and civil sites through specialized surveillance and measurement, post- maintenance or post-modification testing, development and/or provision of corrective measures for the sites, and change control. Geodetic monitoring of the hydrotechnical facility deformations, civil structures, and process equipment is carried out, and the implementation and control of cadastral activities on the territory of the Kozloduy NPP.

1.7. Assessment of Flood Safety Margins

The assessment of margins in case of external flooding is based on the individual margins of all buildings and facilities that are directly related to the safety of the plant. The margin of a given building is identified according to its lowest point, from where theoretically flooding can occur in a room that accommodate systems, structures and components for bringing the facility in safe condition.

The MWL, its duration, and the sequence of direct flooding of facilities in the valley are identified. The MWL of 32.93 m is well below the 0.00 level of the NPP site which corresponds to the level of +35.00 m as per the Baltic Altitude System. This confirms that the selected site is not floodable. An expected secondary effect of the valley flooding can be flooding of some premises via the sewer system. The flooding margin is identified for such premises that house safety important equipment in critical proximity.

No buildings or facilities are found to directly impact the safety functions of the plant when flooded. Nevertheless, measures have been planned and implemented to enhance the plant stability against secondary effects from off-site flooding with MWL = 32.93 m (measures B-1-1, B-2-1, B-2-2, B-2-3 and B-3-1 in *Attachment 1*).

1.8. Safety Margins for External Impacts

The equipment important to safety and included in the emergency scenarios is analysed for seismic stability, and parameters are defined to describe its provisional probability of failure (fragility curves). All ranges of seismic impacts are analysed consecutively, defining for every

range the safety important SSCs that are expected to fail. The limit values of the seismic accelerations are identified that each nuclear facility on-site can withstand without the occurrence of severe fuel damage and release of radioactive substances to the environment.

The analysis of the beyond design basis earthquake is conservative enough and provides assurance in the capability of the KNPP systems, structures and components as to ensure the plant safety for the maximum potential seismic impacts on the site.

The margin of Units 5 and 6 according to the analyses conducted is 0.13 g or 65% as compared against RLE (PGA =0.2 g).

Despite the significant margins in terms of seismic stability of the equipment important to safety, measures for potential improvements are implemented for Units 5 and 6 (measures A-1-1, A-1-2, A-1-3 in *Attachment 1*).

The Spent Fuel Storage Facility (SFSF) margin is 0.16 g as a minimum or 80% compared against RLE (PGA=0.2 g).

No measures to enhance the seismic stability of the SFSF are proposed.

As regards the flooding margin, the defined MWL of 32.93 m is well below the 0.00 level of the NPP site, which corresponds to the level of +35.00 m as per the Baltic Altitude System. The estimated maximum water level values at lower probability (1E-5 to 1E-7) show that the water level will not exceed 33.42 m. This confirms the selected site is not floodable. Nevertheless, the measures undertaken to improve the plant robustness to extreme flooding are described in section 1.7.

The assessment performed for region specific meteorological impacts (such as extreme winds, tornado, snow pack and icing, extreme temperatures, and extreme precipitation) and analyses of the technical condition of the structures, organisational and technical measures performed to ensure the power supply of the site consumers and nuclear fuel cooling have shown that the systems important to safety are in compliance with the design requirements, and the available instructions and procedures are applicable to the actions of the personnel in extreme situations. Additional analyses have been performed of the extreme weather conditions and combinations thereof on the KNPP site (measure E-1 in *Attachment 3*).

TOPIC 2 - LOSS OF SAFETY SYSTEMS

The reassessment of the safety margins in case of loss of safety functions that could lead to severe accidents is based on safety analysis performed applying deterministic approach. The results of the analysis of the postulated initiating events with loss of power supply and loss of ultimate heat sink show the strong robustness of the Kozloduy NPP nuclear facilities and adequate time period available for implementation of additional recovery actions, if necessary.

1. SUMMARY OF ENSREG RECOMMENDATIONS AND SUGGESTIONS

1.1. Alternate Cooling and Heat Sink

As it is stated in the National Report, the following alternative cooling means and ultimate heat sinks in case of loss of the main ultimate heat sink and the connection with it have been provided at the Kozloduy NPP site:

- Emergency bank pumping station, providing independent water supply (with its own Diesel Generator (DG)) in an emergency volume of the inlet channel through two independent steel pipelines;
- Emergency water volume in the inlet channel pumped out with motor-driven pumps or diesel-pumps of the service water system to fill in the spay ponds;

– Six shaft pump stations which are powered by the DG of the emergency pump station and are sufficient to supply the spray ponds;
– Closed cooling loop through the spray ponds to the atmosphere;
– Passive Steam Generator (SG) make up by demineralised water and heat sink to the atmosphere through the secondary side steam dump.

Number of measures related to investigation of the possibilities and the implementation of various plans for decay heat removal from the nuclear facilities on-site have been implemented in order to provide additional safety margins (C-2-1, C-2-2, C-2-3, C-2-4, A-1-2, A-1-3, D-2-4 and D-2-5 in *Attachment 1 and* FD-2-4-1, FD-2-4-2, FD-2-4-3 и FD-2-5-1 in *Attachment 4*).

1.2. AC Power Supplies

The design provisions for offsite power supply of Kozloduy NPP include 3 independent connections with the national grid of Bulgaria and neighbouring countries throughout 13 transit electric lines of 400 kV, 220 kV and 110 kV.

The existing Restoration Plan of the National Grid after Severe Accidents ensures the prioritized restoration of the plant power supply from three different channels, including power supply from the Hydro Power Plants (HPP) with a possibility for black start and from other national grids (Romania, Serbia) whereas the restoration time varies from 15 minutes to 4 hours.

The following levels of protection in case of loss of off-site AC power supply have been provided in the design of Units 5 and 6:

– 3 emergency diesel generators for each unit (one for each safety system train);
– Additional diesel generator for each unit ;
– Mobile diesel generator (MDG) on site;

In order to ensure additional safety margin, additionally two MDGs for units 5 and 6 have been delivered (measure A-1-1 in *Attachment 1*).

1.3. DC Power Supplies

According to the design, 3 batteries are provided per each unit (one for each of the safety systems trains) and three batteries for the normal operation systems. The design for DC power supply has been modernized thus ensuring the redistribution of loads, as well as permanent monitoring of the condition of the equipment and extended availability time. Based on real test performed it was proven that the discharge time of the safety systems batteries is over 10 hours.

In order to ensure additional safety margins, a measure has been implemented to make provisions to supply one safety system battery per unit by a mobile DG (measure C-1-1 in *Attachment 1 and* FA-1-1-2 in *Attachment 4*).

1.4. Operational and Preparatory Actions

Arrangements, procedures, control and responsibilities have been established at the Kozloduy NPP as to provide the required survival resources of fuel, oil and consumables to ensure the continuous operation (beyond 10 days and nights) at full load of all on-site back-up power supply sources.

The requirements for continuous operation of the DG and diesel pumps in emergency mode have been specified in the Technical Design of the particular nuclear facility and the auxiliary on-site facility, in the Safety Analysis Reports and/or the Technical Specifications. In compliance with the Operational Limits and Conditions of the nuclear facilities, the required emergency reserves of boron acid, reagents, chemical agents for the chemical and radiochemical laboratories, boron concentrations and demineralised water shall be maintained.

The operational and organizational activities on providing consumables are assessed as sufficient and there is no necessity of applying additional measures.

1.5. Instrumentation and Monitoring

Within the period 1998-2008 the Kozloduy NPP implemented a huge modernization programme at units 5 and 6, whereas one of the programme objectives was to provide qualified, triple redundant channels for measurement and control of the significant parameters for accident management beyond the design basis in the reactor and in Spent Fuel Pool (SFP) including the implementation of Safety Parameter Display System (SPDS) and Post-Accident Monitoring System (PAMS). For this purpose during the development of the symptom-based emergency operating procedures (SBEOP) and the Severe Accidents Management Guidelines (SAMG) systematic analyses of the available measurement channels were performed. Widerange temperature detectors have been installed for monitoring the temperature of the reactor vessel (measure D-3-4 in *Attachment 1*). Apart from that, the operational radiation monitoring systems and the environmental radiation monitoring systems have been modernized in the framework of the Modernization Programme of Units 5 and 6, and qualified wide range redundant continuous measurement channels have been provided.

I&C for the main systems for accident management are located both at the MCR and at the Emergency Control Room (ECR) and are available to the operators. The emergency procedures include specific actions and specify required control instrumentation. In the course of the stress tests performed, it was concluded that units 5 and 6 do not have available system for direct monitoring of steam and oxygen within the containment, and such system has been installed (measure D-3-2 in *Attachment 1).*

1.6. Shutdown Improvements

In order to enhance safety in a shutdown state a number of analyses have been performed and SBEOPs have been developed and implemented for a reactor shutdown states with closed reactor (measure D-2-1 in *Attachment 1*) and with open reactor (measure D-2-2 in *Attachment 1*).

Considering the results of the stress tests performed at the Kozloduy NPP, it is provided power supply for the motors of valves connecting the pipelines of the hydro-accumulators by batteries to ensure the possibility of primary circuit make-up in cold condition (measure C-2-3 in *Attachment 1*). Availability of at least one tank of the SG emergency feed water system at units 5 and 6 in a shutdown unit state has been provided (measure A-1-3 in *Attachment 1*).

1.7. Reactor Coolant Pump Seals

The design, construction, and manufacturing of the Reactor Coolant Pumps (RCP) seals for WWER-1000 reactor units allow maintaining the tightness of the reactor coolant pressure boundary in case of loss of power supply. Their robustness for at least 24 hours at high temperature and without cooling media has been experimentally verified by the manufacturer and has been assessed as sufficient.

1.8. Ventilation

As a result of a review performed on the accident management equipment, the operability of the control systems to perform their functions in the conditions of a continuous blackout has been confirmed with no necessity of ventilation of the respective premises.

1.9. Main Control Room (MCR) and Emergency Control Room (ECR)

The designs of the MCR, ECR and emergency response centre (ERC) provide operability and habitability for the personnel during nuclear and radiation emergency including station

blackout (SBO). Analyses have been performed to identify the possibility of degradation of the work environment due to the high level of radioactive contamination (in certain areas) and failure of on-site equipment and its potential impact on the access and habitability of the MCR and the auxiliary control panels (measure D-2-8 in *Attachment 1* and measures FD-2-8-1, FD-2-8-2, FD-2-8-3, FD-2-8-4 in *Attachment 4*).

Two autonomous DGs have been installed in the ERC and, thus, the emergency response centre is independent in the event of total loss of on-site or off-site power supply. In the event of moderate seismic impacts (below DBE of the plant), the functionality of the ERC depends upon secondary seismic effects, whereas the degradation of the above-ground structures hinders the access of the personnel to the ERC. This issue is considered in the design and there is an independent emergency underground access to the ERC premises. There is also a measure in the Report for the construction of a new off-site ERC which has been implemented (measure D-1-2 in *Attachment 1*).

1.10. Spent Fuel Pool (SFP)

The spent fuel pools at the Kozloduy NPP units 5 and 6 are located in concrete buildings which are part of the containment. In this regard, they are reliably protected from external impacts. The design characteristics of the SFP exclude modes related to occurrence of criticality or drainage of the pools. Emergency operating procedures (SBEOPs) have been introduced in case of emergency conditions in the SFP, which include strategies with the use of alternative sources for fuel cooling. The monitoring devices in the SFP have an indication displayed in the MCR and the ECR including alarm signals, whereas their power supply is ensured by a battery.

In order to provide an additional safety margin, a measure has been implemented to ensure power supply for the heat removal systems or the SFP filling from a mobile DG (measure C-2-2 in *Attachment 1*).

1.11. Separation and Independence

Design solutions based on both active and passive principle of operation are used in the design of the systems and equipment important to safety.

The specific technical solutions applied in the design of the safety systems are: multi-channel structure (redundancy), physical separation and diversity. The combination of these solutions ensures the robustness of the safety systems to common cause failures, i.e. the total loss of the ability of safety systems to perform their function.

Moreover, the Kozloduy NPP design specifies a number of means to ensure alternative (independent) implementation of the safety functions avoiding the dependence of the support and auxiliary function systems (e.g. alternative cooling sources and methods).

1.12. Flow Path and Access Availability

Electric power supply sources and operational inventories of working media and cooling water ensure autonomy of safety systems for more than 72 hours. Based on real test performed, it was identified that the batteries discharge time is over 10 hours. In order to ensure additional safety margins, a measure has been implemented to establish power supply allowing charging of one of the batteries of the safety systems by a mobile DG (measure C-1-1, *Attachment 1* and measure FA-1-1-2, *Attachment 4*).

The emergency procedures clearly define the valves positions in case of loss of all AC power supply sources. The access of personnel to the equipment and control panels is realized through emergency exits operating on mechanical principle.

1.13. Mobile Devices

As it is specified in the National Report on the stress tests performed, there is one MDG set on a platform at the Kozloduy NPP site. The platform transportation to the electrical board of the SG Alternative Feed Water System is performed with a tractor. The actions of the operating personnel in the event of a loss of power supply are specified in the emergency procedure, the SBEOP for actions in case of a full station blackout and the procedure on the transportation and actuation of the MDG to the premises busbars. The established success criterion is that the pump actuation occurs in less than 2 hours after the initiation of the alarm signal for total loss of power supply. The criterion is verified during the emergency drills performed.

In order to ensure safety margins, two new MDGs have been delivereded on the site (measure A-1-1 in *Attachment 1*).

1.14. Bunker/Hardened Systems

As it is stated in item 1.13 above, Mobile devices, one MDG were available on the Kozloduy NPP site and procurement of two new MDGs is fulfiled (measure A-1-1 in *Attachment 1*) in order to provide additional level of protection in the event of beyond design basis accidents and possibility for their simultaneous use at units 5 and 6. Options for power supply for key systems by the new MDGs have been provided:

- power supply for charging of one battery of a safety system train of each unit (measure C-1-1 in *Attachment 1* and FA-1-1-2 in *Attachment 4*);
- electrical boards for power supply of the SG Alternative Feedwater System of both units by the MDG;
- power supply of SFP cooling system (measure C-2-2 in *Attachment 1*).

The selection and establishment of sites for MDGs location, in view of their robustness to wide range of extreme events, has been done as part of measure FA-1-1-4.

1.15. Multiple Accident

The accident management systems for the nuclear facilities at the Kozloduy site have been designed and implemented separately for each facility and there is no sharing of systems or human resources. ERC is located at the Kozloduy NPP site and is equipped with both emergency procedures for each nuclear facility on site, as well as with common emergency response instructions. In order to improve the response preparedness and the interfaces with the off-site organizations, measure D-1-1 in *Attachment 1* has been imlemented.

The survival emergency resources of fuel, oil and consumables are sufficient to ensure the continuous operation (over 10 days and nights) at full load of all on-site emergency power supply sources.

1.16. Equipment Inspection and Training Programs

Additional equipment for beyond design basis accidents management is available at the plant site, such as a MDG, mobile diesel pumps, and fire-extinguishing techniques. The maintenance and periodic inspections of this equipment are regulated in specific programmes and schedules for their performance. The technical and operating maintenance is performed by trained and qualified personnel.

1.17. Further Studies to Address Uncertainties

- *SFP integrity*

The spent fuel pools represent a reinforced concrete structure with inner metal coating and are located within the containment. This ensures the robustness against all external impacts and

tightness in case of boiling. With implementation of measure D-2-6 the scope of severe accident management guidelines was extended for the SFP and for shutdown reactor states. Technical means are provideded (an additional pipeline to supply SFP) to ensure back up from an external source (measure FD-2-4-1, *Attachment 1*).

- *Functionality of the control equipment during SBO*

The WWER-1000 design solutions ensure a stable natural circulation without operator actions in case of station blackout (SBO) until the coolant in the horizontal SGs is spent. The systems and components, performing overpressure protection functions at primary and secondary side and in the containment, are powered by batteries or operate on a passive principle. In order to ensure additional safety margins and increase the availability of the control valve in the event of total loss of power supply, measures A-1-1, C-1-1, C-2-3 in *Attachment 1* have been fulfiled.

TOPIC 3 - SEVERE ACCIDENTS MANAGEMENT

The results from the severe accidents management review show that the applicable actions for recovery of the control over the nuclear facilities are regulated, including in combination of an accident and other extraordinary situations. The measures related to the severe accidents management, planned to be fulfilled after 2010 are verification, validation and implementation of SAMGs, preventing early bypassing of the containment and updating and extending the PSA - level 2 scope.

The programmes for completing those actions have been implemented.

1. SUMMARY OF ENSREG RECOMMENDATIONS AND SUGGESTIONS

1.1. WENRA Reference Levels

- *Hydrogen mitigation in the containment*

Within the Modernization Programme, passive autocatalytic recombiners (PAR) have been installed in the containment of units 5 and 6, for hydrogen risk management in case of design basis accidents. An additional analysis was made, which shows, that their capacity is sufficient also for controlling the hydrogen from the in-vessel phase of a severe accident.

In order to cover the whole severe accident evolution, an additional PARs were instaled in the containments of the Kozloduy NPP Units 5 and 6 (measure D-3-1 in *Attachment 1*).

- *Hydrogen monitoring system*

Within the Modernization Programme, measuring devices were installed in the containment of units 5 and 6 for measuring the hydrogen concentration. The analyses related to the design of the post-accident monitoring system (PAMS), as well as the analysis performed under PHARE Project BG.01.10.01: “Phenomena Investigation and Development of SAMGs, in Accordance with the European Requirements”, justified the possibilities to use the available hydrogen measuring devices in severe accident conditions.

Measure D-3-2 for installing measurement devices for water steams and oxygen concentration within the containment space has been implemented.

- *Reliable depressurization of the reactor coolant system*

In the design of the Kozloduy NPP WWER-1000 reactors have technical provisions for reactor coolant system depressurization to avoid high pressure melt ejection, which are available in SBO conditions. The required operator’s actions are described in the emergency instructions.

- *Containment overpressure protection*

Within the Modernization Programme (2002-2008), in conformity with the recommendations of the document "Safety Issues and their Ranking for WWER-1000 Model 320 Nuclear Power Plants", IAEA-EBP-WWER-05, March 1996, in 2006 at the units 5 and 6 pressure reduction filtering systems were installed, which act in passive way, in order to control the pressure under severe accident conditions.

- *Molten core stabilization*

There are prevention strategies in place for those phenomena developed in SAMGs. Wide-range temperature sensors have been installed for monitoring the temperature of the reactor vessel (measure D-3-4 in *Attachment 1*). A project was implemented for plugging the most vulnerable pathways for spreading of melted core outside the containment and preventing containment bypass (measure D-3-3 in *Attachment 1*).

1.2. SAM Hardware Provision

Specific SSCs have been additionally designed for severe accident management and prevention the containment failure, such as passive filter venting system for containment depressurization, SGs alternative feedwater system, PAR, located in the containment. These provisions have proved their capability to perform their functions in severe accident conditions.

1.3. Review SAM Provision Following Severe External Events

As a result of the review made of the available provisions for severe accident management it was concluded that there are adequate response measures in such conditions. The nuclear facilities have sufficient independence and recourse, which allow undertaking necessary actions in these conditions. Despite all this, measures to enhance the facilities resistance have been implemented (measures A-1-1, A-1-2, A-1-3, A-3-1 and D-3-3 in *Attachment 1*).

1.4. Enhancement of Severe Accident Management Guidelines (SAMGs)

The SAMGs in Kozloduy NPP are unit-based and each nuclear facility on the site is capable to react independently to the symptoms in case of severe accident. The planned measure for issuing SAMGs for use was implemented – SAMGs for units 5 and 6 were issued for use, as well as SAMGs for the ERC (measure D-2-3 in *Attachment 1*).

The on-site and off-site emergency plan of Kozloduy NPP was reviewed and updated, with a view to taking into account possible effects from physical isolation, caused by external hazards (measure D-1-1 in *Attachment 1*).

1.5. SAMGs validation

According to Kozloduy NPP internal procedures, the process of SAMGs development involves their validation (measure D-2-3-3 in *Attachment 1*). The validation was performed on the basis of completed analyses of representative scenarios of severe accidents. The entrance conditions for SAMGs are validated using a full-scope simulator (FSS). The transfers from SBEOP to SAMGs are validated at the FSS, while a practical application of the described actions and strategies are validated by a team of independent experts following the "table top" method.

1.6. SAM exercises

Emergency planning training program and training courses are developed for three staff levels.

The following exercises and drills are carried out:

– Full-scope emergency exercise with the emergency structural units;

– Separate emergency drills with the individual working groups and teams of the emergency structural units;
– Functional tests of the notification and communication means performed by the maintenance and servicing structural units.

The emergency drills and the full-scope emergency exercises are carried out according to an approved schedule and a preliminary developed and approved syllabus. The scenarios developed for full-scope emergency exercises cover the local and national emergency structural units, verifying the interaction procedures with regard to the accident management, notification, announcing and protection of the public. SAMGs, as a set of instructions for operator's actions in case of severe accidents are part of Kozloduy NPP Emergency plan. During full-scope emergency exercise, the operating staff drills the emergency situation on a simulator, an assessment is made of the applicability of the strategies for exercising impact on the facility which is subject to severe accident, as well as the operative decision-making strategies by the emergency response supervising team in the ERC.

Analyses and reports are prepared for the implementation of all types of exercises and drills.

1.7. SAM Training

A full scope simulator (FSS) is used for operators training. Two types of training are carried out – initial licensing training and periodical training.

The periodical training of the operators is performed according to a preliminary approved schedule, twice a year, for 5 days each time. The training is delivered by licensed instructors.

The FSS scenarios cover "emergency conditions" from the whole range of postulated initiating events. The practical exercises continue until reaching of controlled safe state (success), and/or core damage (failure). The range of topics is selected in such a way, as to cover operators' actions with the available equipment at the units, as well as the available emergency procedures. The teams are trained to work according to SBEOPs, to make transition to SAMGs and to bring in action the Emergency Plan.

A lecturing course on severe accidents management guidelines is also delivered.

1.8. Extension of SAMGs to All Plant States

SAMGs cover power operation, low power and shutdown pressurized reactor (measure D-2-3 in *Attachment 1*).

The states corresponding to depressurized primary circuit with open reactor are covered by the SBEOPs (measure D-2-2 in *Attachment 1*). SBEOPs are also implemented for response actions under "emergency conditions" in the SFP. The actions and strategies described in those procedures are applicable also under conditions of severe fuel damage. Measure D-2-6 which extends the scope of SAMGs for the SFP and shutdown and unsealed reactor states is implemented.

1.9. Improved Communication

Diverse, multi-channel and backed up information systems are established on the site:

– Safety Parameter Display System (SPDS) at the MCR, ERC, integrated with an emergency centre at BNRA;
– Operational radiation monitoring systems (dosimeter monitoring panels, ERC);
– Automated information systems for off-site radiation monitoring (MCR, ERC, integrated with the National automated systems for permanent monitoring of the radiation gamma background of the Ministry of Environment and Water);

- Automated information system for radiation monitoring on the industrial site (dosimeter monitoring panels, ERC);
- Meteorological monitoring system (dosimeter monitoring panels, ERC, national system for meteorological monitoring, emergency centre with the BNRA);
- Environment and Kozloduy NPP site monitoring - on-line field measurements in the areas for preventive and urgent protective measures with three off-road vehicles and a mobile laboratory. The information is communicated directly to the ERC;
- Information system in the ERC - a complex of hardware and software means for assessment of the facilities' condition, radioactive releases and radiation exposure of the population, which are necessary for making a decision and applying protective measures. The information system obtains input data from the SPDS, the automated radiation monitoring systems of NPP and the meteorological monitoring system. Information sharing between the ERC and the BNRA is provided for;
- Notification means and means of communication - backed up, independent and diversified as regards the principle of operation, contemporary communication and notification means.

The interface between the individual users is maintained through radio systems, optical connection, GPS communication, telephone and paging system and satellite connection.

1.10. Presence of hydrogen in unexpected places

In the conditions of a severe accident hydrogen could be generated in the reactor core and the Spent Fuel Pools (SFP). Both are located in the containment.

In severe accident conditions the containment is isolated and there is no possibility for hydrogen migration outside it. Additional recombiners have been installed (measure D-3-1 in *Attachment 1*) to control the hydrogen generated in the ex-vessel phase and during fuel melt in the SFP.

1.11. Large Volumes of Contaminated Water

The question was discussed during the peer review and it was proposed to examine conceptual solutions for potential treatment of large volumes contaminated water. Measure D-3-6 in *Attachment 1* provides study in this area.

1.12. Radiation Protection

Kozloduy NPP on-site emergency plan provides for the required resources for protection of the personnel that is engaged with the accident management. They are available on site, being serviced and kept in repair by the responsible organizational units.

The design solutions for the MCR, ECR and ERC ensure operability and habitability for the staff in conditions of nuclear and radiation accident, including in SBO. All control rooms and the ERC are provided with a continuous backed up radiation monitoring, 120% redundancy with individual emergency kits for the operators, the emergency personnel of the plant and the team on duty of the fire brigade and the police. A separate shelter is foreseen for the emergency personnel, equipped with an autonomous DG and a ventilation system.

An additional analyses of the possibility for deterioration of the working conditions due to the high radioactive contamination level (in certain areas) and damage of equipment on the site and potential impact on the access and usability of the MCR and ECR is implemented (measure D-2-8 in *Attachment 1* and FD-2-8-1, FD-2-8-2, FD-2-8-3, FD-2-8-4 in *Attachment 4*).

1.13. On-Site Emergency Centre

The Emergency Response Centre (ERC) ensures operability and habitability for the staff in conditions of nuclear and radiation accident, including SBO. There are 2 autonomous DGs installed in the ERC, which makes the emergency centre independent under SBO conditions, and ensures the ventilation of the rooms. ERC is supplied with resources for continuous functioning, communication and information systems to the nuclear facilities on the site, as well as to external organizations at municipal and national level.

At seismic impacts the ERC functioning is determined by secondary seismic effects, while destruction of surface structures would impede the personnel access to the ERC from the main entrance. This problem was taken into account in the design and an emergency independent access to the ERC rooms is foreseen. Despite this, off-site ERC has been build (measure D-1-2 in *Attachment 1*).

1.14. Support to Local Operators

The organization of the emergency planning in the country foresees, upon request by the operator, provision of external expert and hardware support in case of an accident. Measure EO-2-7 foresees additional provision of expert support from the Regional Crisis Centre in Moscow.

1.15. Level 2 Probabilistic Safety Assessments

In 2001 a level 2 PSA was developed for Kozloduy NPP units 5 and 6, which reflects the configuration of the plant before the Modernization Programme in 2002. During the implementation of the Modernization Programme (2002-2008), passive autocatalytic recombiners and a passive containment filter venting system were installed; the in-vessel phase and the ex-vessel phase of severe accident evolution were examined. The PSA level 2 is currently being updated. The update will reflect the implemented design modifications. The insights will be used to determine specific modes and scenarios depending on their severity as regards the consequences.

1.16. Severe Accident Studies

- *The availability of safety functions required for SAM under different circumstances*

The phenomena related to severe accidents for the Kozloduy NPP units 5 and 6 have been studied within an international project - PHARE Project BG.01.10.01 “Phenomena Investigation and Development of SAMGs, in Accordance with the European Requirements”. On the basis of the project analyses results, the accident management strategies have been determined (hydrogen recombination, containment filter venting, reactor vessel failure, core melt localization and retention within the containment), and SAMGs for units 5 and 6 have been developed and issued for use (measure D-2-3). With implementation of measure D-2-6 the SAMGs scope is extended for the SFP and for specific states of the reactors (shutdown and unsealed reactor).

- *Accident timing, including core melt, reactor pressure vessel (RPV) failure, basement melt-through, SFP fuel uncovery, etc.*

Within PHARE Project BG.01.10.01: “Phenomena Investigation and Development of SAMG, in Accordance with the European Requirements”, an analysis was made of the phenomena related to the core melting, reactor vessel degradation, melted core spill over the containment basement, and the threats associated with these processes.

Within the stress tests the time window between boiling and fuel uncovery in the SFP was analyzed. Measure D-2-6 in *Attachment 1* provides an additional examination of the emergency consequences with fuel melting in the SFP.

- *PSA analysis, including all plant states and external events for PSA levels 1 and 2*

As of 2010 an updated PSA level 1 study is available at Kozloduy NPP, which reflects the units' state following the completion of the measures from the Modernization Program (2001-2008). Level 1 PSA relates to all units states (full power, low power and shutdown state) and covers all internal events (flooding, fire, missiles), and as relates to the external events - it covers only the seismic impacts. Level 2 PSA study has been developed, which reflects the measures from the completed modernization of the units;.

Additional analyses using probabilistic methods to study combinations of extreme meteorological conditions according to the IAEA methodology were implemented (measure E-1 in *Attachment 3)*.

- *Radiological conditions on the site and associated provisions necessary to ensure MCR and ECR habitability as well as the feasibility of accident management measures in severe accident conditions, multi-unit accidents, containment venting, etc.*

The existing design provides for radiation protection of operational staff in MCR and ECR. As a result of the stress tests, it is foreseen and implemented an additional analysis of potential degradation of performance due to the high level of contamination (MCR and ECR) and the equipment damage at the site, including the impact on the accessibility and usability of MCR and ECR (measure D-2-8 in *Attachment 1* and measures FD-2-8-1, FD-2-8-2, FD-2-8-3, FD-2-8-4 in *Attachment 4*). Direct discharge of radioactivity at the site and in the environment is prevented with passive filter venting system.

Evaluation of the existing organizational measures and technical means for simultaneous core melt/fuel damage accidents in different units/installations at the site is implemented under measure D-2-7 in *Attachment 1* and measure FD-2-7 in *Attachment 4*.

- *Core cooling modes prior to RPV failure and of recriticality issues for partly damaged cores, with unborated water supply*

The probability for a recriticality in the reactor in case of severe accident as a result of unborated water supply is very low, in view of "inherent safety features such as geometric configurations or the use of fixed neutronabsorbing materials". The emergency procedures (SBEOPs and SAMGs) currently do not provide for supplying unborated water to the reactor.

- *Phenomena associated with cavity flooding and related steam explosion risks*

According to the existing design, the reactor cavity of the units 5 and 6 is dry. Within PHARE Project BG.01.10.01 different accident scenarios have been considered and no accident sequences were identified, which could lead to a steam explosion as a result of melted core ejections into flooded cavity.

- *Engineered solutions regarding molten corium cooling and prevention of basemat melt-through*

Within measure D-3-5 a lot of studies have been performed concerning solutions about molten corium retention during severe accidents. Kozloduy NPP participates in international projects in JRC, Petten, Netherlands and UJV Rez, Czech Republic. Consideration has been given to the both the Ex-Vessel Retention (ExVC) and the In-Vessel Retention (IVR) strategies. Activities have been performed for reducing the possibility of reaching an ex-vessel phase in case of severe accident. A hardware modification is instaled, which is related to plugging of the most vulnerable points, where basement melt-through could occur and preventing bypass of the containment. Systems for ensuring control of the reactor vessel temperature and level in the reactor in severe accidents conditions were also installed and implemented into SAMGs.

Activities related to providing direct water injection to the reactor core from an external source were implemented. Measuring channels for monitoring and evaluation the concentration of steam and oxygen in the containment have been installed.

- *Severe accident simulators appropriate for NPP staff training*

The FSS scenarios cover “emergency conditions” from the whole range of postulated initiating events. The practical exercises continue until the reactor facility is rendered to a controlled safe state (success), and/or reaching core damage (failure). The teams are trained to work according to SBEOPs, to make transition to SAMGs and to actuate the emergency plan.

PART II - INFORMATION ABOUT THE ACTIVITIES AT INSTITUTIONAL LEVEL

TOPIC 4 - NATIONAL ORGANIZATIONS

Part II of the present Action Plan addresses national conclusions and generic activities related to each issue identified by the CNS Second Extraordinary Meeting and presents respective country arrangements and planned actions.

Review and revision of nuclear Laws, Regulations and Guides

BNRA policy is to periodically review the national legislation in respect of stakeholders feedback, EU legislation and WENRA reference levels on safety harmonization, new and changing IAEA safety requirements, own feedback on the use of the requirements. In implementation of that policy, the fundamental law in the field of safety of nuclear installations – the Act on the Safe Use of Nuclear Energy (ASUNE) was reviewed and revised.

Detailed requirements for nuclear safety and radiation protection are specified in the secondary legislation for application of the ASUNE (more than 20 regulations). Following ASUNE changes, BNRA has developed and implemented a Program for review and revision of all regulations. Review and revision of regulatory requirements cover also consideration of the lessons learned from the Fukushima Daiichi accident. Implementation of this Programme is included as measure N-1-1 in *Attachment 2*.

It should be noted, that Article 5, p. 7 of the ASUNE specify that BNRA Chairman shall develop regulations on the application of the law and propose amendments and supplements, when improvement of legal framework is appropriate, taking into account operating experience, insights gained from safety analyses, and the development of science and technology. BNRA policy and intentions of are to review and revise regulatory requirements, when new IAEA documents, reflecting lessons learned from the nuclear accident at Fukushima Daiichi are published – measures N-1-2 and N-1-3 in *Attachment 2*.

Concerning comprehensive periodic safety reviews, using state-of-the-art techniques, this is already a well established practice, as the general licensing philosophy is to renew licenses on the basis of periodic safety review.

Finally, it should be mentioned that lessons learned from the Fukushima Daiichi accident and the current IAEA and WENRA documents are reflected in the periodic review of the BNRA Regulatory Guides - measure N-1-4 in *Attachment 2*.

Changes to functions and responsibilities of the regulatory authority

According to the 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 the 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, the 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.

Analyses of the BNRA independence show that it is legally, politically and financially independent, to the maximum practically possible extent. BNRA is provided with sufficient legislative power to make independent regulatory decisions, including the shut down of a facility

or license withdrawal. One of the BNRA legal responsibility and authority (ASUNE, Article 5) is to openly and transparently communicate regulatory decisions and safety information to the public and state authorities concerned. BNRA has sufficient human resources, who are highly educated and qualified, and are able to judge on the safety of regulated facilities and activities. The analyses did not identify any actions for the country to take in this respect.

Importance of inviting IRRS missions

The national legislation requires openness and transparency and the implementation of periodic self-assessments. For example, the ASUNE requires that the BNRA shall perform a self-assessment of national legislative and regulatory infrastructure and shall invite an international peer review, at least once in 10 years.

The governmental commitment for periodic international peer review is implemented through the invitation of an Integrated Regulatory Review Services (IRRS) Mission to Bulgaria, which was conducted on April 2013. Invitation of an IRRS Mission and the respective implementation of mission findings, review and verification of corrective actions effectiveness by a follow-up IRRS conducted in 2016 are included in measure N-2-1 in *Attachment 2*. The IRRS Mission results were disclosed and disseminated in line with the BNRA principles of transparency and publicity.

Review and improvements to aspects of National EP&R

The analysis of the organizations and inter-organizational interaction showed that Bulgaria has in place 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.

Topics related to periodic emergency exercises and drills, training of intervention teams, establishment of rapid intervention team to provide support to sites, international agreements, use of regional centres, as well as education of the public and the media in aspects related to emergencies are covered under topic 5.

Openness, transparency and communication improvements

BNRA uses several channels and mechanisms, as web page, media, formal letters and Annual Report to provide all necessary information to the public. Actual information about regulatory requirements, BNRA activities, opinions, decisions and news is available on the regulatory body web page. When there is a need for urgent dissemination of information, the BNRA sends press releases via e-mails, phones and faxes (available database) to journalists. BNRA periodically organizes press conferences or briefings and BNRA representatives participate in TV and radio broadcasts. Additionally, the BNRA organizes training seminars for the media, where public needs of information and its clearness are discussed.

The ASUNE requires licensees to inform the public about possible radiation risks associated with the facilities and activities. These obligations are further developed in the Regulation on Notification, according which licensees shall inform the public about deviations, incidents and accidents in nuclear facilities or sites with sources of ionising radiation, through the media, internet or in any other adequate way.

Concerning international bilateral cooperation, the BNRA has reviewed and updated its bilateral agreements under measures EO-1-1, EO-1-2, EO-1-3 and EO-1-4 in *Attachment 3*.

Post-Fukushima safety reassessments and action plans

Immediately after the Fukushima Daiichi accident, the Bulgarian Government requested urgent actions to reassess the Kozloduy NPP preparedness to respond to emergencies and respectively the BNRA specified the areas for review and verification of the conditions of SSCs, which provide protection and monitoring in extreme external events. The identified issues were included in the Initial Action Plan.

Later on, country took part in the EU stress tests as a targeted reassessment of NPP safety margins.

Human and organizational factors

Analyses show that there is governmental commitment for further development of the country human resource capacity and competence. The legislation requires assessment of human and organizational factors and safety culture and their continuous improvement.

Involvement of sub-contractors in the emergency response arrangements was assessed as part of measures EP-1-1 and EP-1-2 in *Attachment 3*.

TOPIC 5 – EMERGENCY PREPAREDNESS AND RESPONSE

At national level a Unified Rescue System is established to protect people from disasters. An integral part of this system is the emergency preparedness and response to nuclear or radiological emergencies. Disaster protection is implemented at national, regional (provincial and municipal) and on-site level and at international level through the mechanisms for request (provide) assistance.

National legislation specifies the principles, criteria and procedures for maintaining emergency preparedness and response in case of incidents and accidents with radiological consequences. The infrastructure for supporting emergency preparedness and response complies with the criteria laid down in EU legislation and the IAEA in this field.

After the accident at the NPP Fukushima Daiichi an analysis of the system for emergency preparedness and response has been performed. As a result of this analysis, update of the regulations in the field of emergency preparedness and response as well as of on-site and off-site emergency plans has been performed. After completion of the relevant activities of NAcP updates of the on-site and off-site emergency plans were implemented.

Expansion of the set of scenarios on which the off-site emergency plan is based

After the Fukushima-Daiichi NPP accident, analyses have been performed on severe accidents and the results demonstrated the need of broadening their scope including accidents which occure simultaneously on all on-site facilities in combination with natural disasters. In *Attachment 3* measures EP-1-1 and EP-1-2 were implemented.

Expanding the scope of off-site exercise programs to reflect simultaneous problems in the NPP and external infrastructure

Off-site drill programmes, based on the Off-site Emergency Plan and the scenarios included, are developed on a national level. The changes of the Off-site Emergency Plan expand the scope of the off-site drill programme, which is covered by the implementation of Measure EP-1-1 in *Attachment 3*.

Integration of mobile resources into planning and drill programs

The emergency plans at all levels (national, district, municipal and site) provide the use of mobile resources. Within the Ministry of Interior system (fire safety and civil protection departments) there are 28 mobile labs located in each of the 28 districts consistent with the territorial division of the country. The Institute for Nuclear Researches and Nuclear Energy (INRNE) has a mobile lab for measurements and analyses. The Operator also has a mobile laboratory. All mobile resources are covered by the programmes for Emergency Planning and Training, as well as in the Emergency Exercise Programmes.

Evolving need for emergency training, conducted jointly with the neighbouring countries

Republic of Bulgaria has concluded bilateral agreements with the neighbouring countries – Greece, North Macedonia, Romania, Turkey and Serbia for cooperation in the field of nuclear safety and radiation protection. Scientific visits are conducted with the aim of experience exchange with the regulators of neighbouring countries.

Exercises involving all interface points (national, regional, municipal, etc.)

For nuclear facilities annually a full scope emergency exercise, covering all interface points, has been conducted. The largest possible numbers of executive authority representatives, responsible for implementation of the off-site emergency plan, take part in that exercise andthus achieve synergies between national, regional, local and on-site emergency response structures.

Conducting of longer term exercises to reflect the challenges of extreme events

Long-term exercises are periodically conducted in Bulgaria. One of the objectives of these exercises concerning the national and district response structures with response time longer than 24 hours, is to test the capability of teams to work for long periods in extreme event conditions, as well as to test the sustainability of work when emergency response teams change shifts.

Improvement of radiation monitoring and communication system by additional diversification/redundancy

- *Radiation Monitoring*

In the Republic of Bulgaria, radiation monitoring is conducted by 5 institutions:

– The Ministry of Environment and Water (MEW) Executive Agency maintains the National Gamma Background Monitoring System (BULRaMo);
– The National Centre for Radiobiology and Radiation Protection within the Ministry of Health (MH) performs measurements of the gamma background;
– Directorate General Fire Safety and Civil Protection within the Ministry of Interior performs measurements of the gamma-background in 363 posts located on the territory of the country ;
– Kozloduy NPP performs measurements of the gamma background on the site and within the precautionary action planning zone through the Automated Information System for Off-site Radiation Monitoring (AISRM) which is joined with the BULRaMo system;
– The Institute for Nuclear Research and Nuclear Energy within the Bulgarian Academy of Sciences performs measurments at Mussala Peak (Rila Mountain), on the territory of the institute and at the site of the research reactor.

The results from the measurements are daily published on the website of each organizations mentioned and summarized on the BNRA website. The radiation monitoring

systems of these organizations are different and independent of one another and a redundancy of monitoring is ensured.

After the Fukushima accident, the operability of BULRaMo system was analyzed and the need of its upgrading was identified. Measure EP-1-4 in *Attachment 3* was fulfiled as a result of this analysis.

- *Communications*

Republic of Bulgaria has a field experience in using communications during emergency exercises, including in response to real emergencies. According to the national legislation, communications are provided by the Ministry of Transport and Communications (MTC). The Ministry of Interior uses the TETRA system to provide communications of emergency teams. Because this system is different from the one provided by the MTC, redundancy of connections is ensured.

Improving the data exchange efficiency between the Operator and the BNRA in case of emergency

In case of an emergency at the operating organization, the BNRA Emergency team performs analyses and makes prognoses for emergency's development and its potential consequenses for population and environment and provides the results to the National Headquarters. These prognostic results are serving as a base for making desicions on protective actions to be promptly taken in order to be effective. For time optimization of the incoming information concerning the on-site conditions, measure EP-2-1 was fulfilled.

Providing access for national and international organizations to the overall picture of radiological conditions

Republic of Bulgaria has ratified the Convention on Early Notification of a Nuclear Accident, and the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency. During an emergency, the information released contains a variety of data, described in the Convention on Early Notification of a Nuclear Accident, and in the Regulation on Emergency Planning and Preparedness in case of a nuclear accident and radiation emergency. Data is provided and respectively received through the Emergency Information Exchange Systems - IAEA USIE and ECURIE of the EU. By fulfilling the requirements of the Convention and the EU Decisions, Bulgaria provides access for national and international organizations to the overall radiation situation in case of emergency. The data from BULRaMo is automatically sent in real-time on specified intervals to EURDEP from where is available for transfer to IAEA IRMIS.

Development of reference levels for cross-border processing of goods and services such as container transport

Bulgarian legislation has established operational intervention levels for identifying the level of contamination with radioactive substances. These levels are defined in the Regulation, issued by the Minister of Health, on the terms and conditions for medical provisions and health limits for protection of people in case of a radiological accident.

Reevaluation of the approach and associated limits to govern the "recovery" phase

According to the off-site emergency plan, Teams for Long-term Protective Actions are established by the National Headquarters with the aim of assisting the management activities on recovering the normal conditions in the emergency area. They organize and manage the recovery

on the site ensuring the safety of the other parts of URS and population within the UPAZ; establish organizational structires for managing the recovery; coordinate the recovery activities for the environment till pre-emergency condition or condition which does not induce any risk is reached. In the recovery phase a “case by case” approach is used.

Requirements on transition from emergency situation to existing exposure situation

The Regulation on Radiation Protection defines the conditions for transition from emergency situation to existing exposure situation.

Improvement of the approach to establish contamination monitoring standards and locations during the recovery phase

The environmental monitoring mobile lab of the Kozloduy NPP performs measurements of gamma background and transmits the data in real-time through GPRS or TETRA to ERC. In addition the data could be transmited in summarized form to the BNRA Emergency center and the National Headquarters.

Strengthen the supporting infrastructure (Emergency Response Centres, sheltering facilities, essential support facilities, like Corporate Offices) providing back-up power, environmental radiological filtering, etc.

The Emergency Response Centre and sheltering facilities located within the emergency planning zone are equipped with independent power supply and independent filter ventilation system. Measure D-1-2 for construction of off-site ERC, protected from external, including radiological impacts has been implemented.

Supporting infrastructure located outside the emergency planning zone has emergency power supply. Analysis shows that it is not expected to reach radioactive contaminations and radiation doses requiring radiological filtering.

Analyzing medical and human aspects of response to support Emergency workers

The Minister of Health analyzes the medical and human aspects of response in support of emergency workers. The On-site Emergency Plan identifies the hospitals, their accommodation capacities, medicines and care needed for individuals exposed in nuclear or radiation accidents. The Off-site Emergency Plan defines the routes for medical evacuation. If necessary, international humanitarian aid could be requested through the established procedure**.**

Implementation of processes to enable access to international support

Republic of Bulgaria has actual experience in rendering international support in case of disasters. Bulgaria has ratified the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency. Following the requirements of the convention, the order of requesting/rendering support in case of a nuclear or radiological emergency is stipulated into the Off-site Emergency Plan. There was an established practice of preliminary preparation of documents and technical equipment of the rescue team which covers procedures for easy crossing of the border and customs and border clearance.

In 2018, Bulgaria became a member of the IAEA Response and Assistanse Network (RANET). Through RANET, member states which have ratified the Assistance Convention have the opportunity to request or offer assistance timely and efficiently, thus easing the Convention’s mechanism and shortening the time for receiving and providing the assistance needed.

Systematic assessment of all aspects of organizations that contribute to emergency response using tools like job and task analysis

The national legislation stipulates the activities and tasks of all organizations with the obligation to respond in case of a nuclear or radiological emergency. The Off-site Emergency Plan specifies in details the activities and tasks of these organizations and describes the resources for the activities implementation, as well as the time schedule. In the process of off-site emergency plan updating, the activities and tasks of the organizations involved are evaluated. This evaluation is based on the experience gained during the exercises conducted and during the response in actual emergencies. The established shortcomings and omissions are removed by introducing changes into the Off-site Emergency Plan.

Develop radiological reference levels for rescue and emergency response personnel in extreme events

In the Regulation on Radiation Protection a set of reference levels for population and emergency workers are established.

Develop reference levels for the application of immediate countermeasures such as sheltering, iodine distribution and evacuation

The reference levels for application of urgent protective actions as sheltering, iodine prophylaxis, and evacuation are defined in the Regulation, issued by the Minister of Health on the terms and conditions for medical provisions and health limits for protection of people in case of a radiation accident are defined by the values of the averted doses.

TOPIC 6 - INTERNATIONAL COOPERATION

One of the lessons learned from the Fukushima Daiichi accident brought to the foreground the importance of the exchange of information in crisis situations. The various existing mechanisms up to this point in this field in each country and, in particular, in the countries with nuclear programmes, were subjected to reassessment and analysis with regard to their efficiency. The significance of this issue was assessed at a high international level and it was included for discussions as a separate topic in the Second Extraordinary Review Meeting of CNS. The interaction and the exchange of information between the countries, the Operating organizations and the respective NPPs in operation at a multilateral, regional and bilateral level were reviewed in a new light. Several main groups of measures stemmed from this are aimed at reinforcement of the already established international cooperation and the undertaking of additional initiatives.

Strengthening the peer reviews process of CNS and of IAEA and WANO missions

Lessons learned from operating experience of a single country and its ability to maintain a high level of safety, including using a mechanism to overcome or reduce the occurrence of unwanted effects 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. Traditionally Bulgaria has been a host to such forms of cooperation under operational and under the regulatory practices.

Bulgaria shares the opinion that in the future CNS national reports information should be included with regard to the peer review missions performed, the findings and the results of these missions. With regard to the strengthening of the CNS peer reviews process and of the IAEA and WANO expert missions the following measures have been implemented EO-2-1, EO-2-2, EO-2-

3, EO-2-4, EO-2-5, EO-2-6, EO-2-11, EO-2-12, EO-2-13, EO-2-14 and N-1-1, which have all been indicated in *Attachment 3*.

Optimization of the global safety regime

Bulgaria shares the view expressed at the Second Extraordinary Meeting of the CNS that the growing number of international meetings, assessments, peer reviews and expanding mandates is placing high demands on existing human resources, which may become counter productive. The necessity of optimization of the reviews, of reduction of the duplication of topics and initiatives is obvious and this is one of the main tasks of the managers of these organizations. At the same time the concurrence of the future reviews with the Operating organization would be beneficial for the general preparation and for achieving the goals set.

Strengthening communication mechanisms through regional and bilateral cooperation

Cooperation agreements on a bilateral or multilateral basis are a very important mechanism for connection with the international community. This mechanism is quite popular and appropriate for maintaining cooperation relationships with neighbouring or close states.

After the Fukushima Daiichi accident, the BNRA performed an analysis of the existing cooperation agreements concluded by the Republic of Bulgaria with almost all neighbouring countries. In respect of improving the interactions in case of regional crisis, initiatives were undertaken for preparation and signing new agreements on Regulatory Bodies level. These activities are addressed as measures EO-1-1, EO-1-2, EO-1-3, EO-1-4 in *Attachment 3*.

Kozloduy NPP on their part undertook measures to increase the efficiency of the activities and the information exchange between the Operating organizations in case of crisis situations, which is addressed in measures EO-2-7 and EO-2-8 in *Attachment 3*.

In addition, within the frames of interaction with the IAEA under the Technical Cooperation Programme, the BNRA presented a national project related to the strengthening of its activity in the field of emergency planning and preparedness - measure EO-1-5 in *Attachment 3*.

Effectiveness of experience feedback mechanisms

The main tools for sharing operational experience feedback are located mainly in the cooperation with the respective structures of IAEA, EU, OECD, and WANO and on a bilateral basis. After the Fukushima Daiichi accident at every single conference held under the aegis of these organizations such issues were discussed and specific problems were reviewed, stemming from the development of the accident.

The Forum of the regulators from the countries operating WWER reactors is a part of this system. Regular participation is planned at its annual meetings - measure EO-1-6 in *Attachment 3*. Regarding the Operating organization participation in the regular conferences for the Chief Engineers of NPPs with WWER reactors is also planned where the lessons learned from the accident are discussed - measures EO-2-10 and EO-2-16 in *Attachment 3*.

Strengthening and expanded use of IAEA Safety Standards

Significant part of the IAEA Safety Standards has been incorporated in the Bulgarian legislation. The Government policy is to observe and apply the requirements of the international documents, including the ones related to nuclear safety and through the National Act on Regulations to perform the procedure for their transposition within the national legislation. When it is necessary to introduce changes in the regulations in the field of nuclear and radiation safety, the leading safety requirements of the IAEA are always reviewed and considered. Meanwhile it

is a standard practice and approach in the licensing process for the BNRA to monitor whether the licensee (or the applicant) justifies safety by observing the internationally acknowledged practices addressed in the IAEA standards. This way the regulator should be convinced of the operator's capability to maintain high safety level. Bulgaria is also transposed within the state legislation the reference safety levels developed by WENRA.

PART III – ADDITIONAL MEASURES AND ACTIONS

1. Recommendations ensuing from the ENSREG Peer Review

In the beginning of 2012, an ENSREG Peer Review was conducted to assess the results of plant stability analyses and improvement measures planned after the Fukushima Daiichi accident.

The report includes the following recommendations, which have been addressed in topics 1 through 3 and are included in the attachments of the Report:

- The Kozloduy NPP considers delivering of the two additional mobile generators. As long as these mobile generators will be considered for beyond design basis events, they should be adequately protected for such events – included in measure A-1-1;
- To perform a consolidated review of extreme weather hazards in line with IAEA guidance and development of a plan to monitor identified improvements – included in measure E-1;
- The issue of the management of large volume of liquid releases in the event of a severe accident should be investigated further – it should be evaluated whether the available provisions would be adequate – included in measure D-3-6;
- The consequences of possible adverse effects of earthquakes to the national infrastructure for severe accident management should be further investigated – included in measure A-3-1;
- Simultaneous core melt/fuel damage accidents in different units/installations at the site should be further investigated and assessed regarding interactions and the resulting special requirements that would arise for severe accident management – included in measure D-2-7;
- SAMGs fully covering shutdown states, including those with open reactor, should be developed – included in measure D-2-6;
- Accidents in spent fuel pools should be analysed in detail – included in measure D-2-6.

2. Operator's activities as per the WANO programme

In order to share and apply international operational experience to enhance nuclear safety, Kozloduy NPP actively participates in the WANO International Cooperation Programme. The activities and events under this programme at the Moscow WANO Centre are listed in *Attachment 3*:

- Support the process of WANO peer reviews and missions (EO-2-5);
- Optimize coordination between operators and the WANO Regional Centre in Moscow (EO-2-1, EO-2-2, EO-2-3);
- Initiatives related to the Regional Crisis Centre of WWER reactor NPP operators, implemented by the Moscow WANO Centre (EO-2-7);
- Exchange of information and feedback among the operators through different forms of communication – workshops, working meetings, technical support missions, suggestions, and analyses (EO-2-6, EO-2-10, EO-2-11, EO-2-12, EO-2-13, EO-2-15);
- Improve communication mechanisms through regional and bilateral co-operation (EO-2-8).

LIST OF ABBREVIATIONS

BNRA	Bulgarian Nuclear Regulatory Agency
BPS	River Bank Pump Station
CNS	Convention on Nuclear Safety
DBE	Design Bases Earthquake
DG	Diesel Generator
EC	European Commission
ECCS	Emergency Core Cooling Systems
ECR	Emergency Control Room
ENSREG	European Nuclear Safety Regulators Group
EOM	Extraordinary Meeting
EP	Emergency Plan
ERC	Emergency Response Centre
ESO	Electricity System Operator
EU	European Union
FSS	Full-Scope Simulator
IAEA	International Atomic Energy Agency
INRNE	Institute for Nuclear Researches and Nuclear Energy
KNPP	Kozloduy Nuclear Power Plant
LSN	Local Seismic Network
MCR	Main Control Room
MDG	Mobile Diesel Generator
MEW	Ministry of Environment and Water
MH	Ministry of Health
MI	Ministry of Interior
MWL	Maximum water level
NAP	National Action Plan
NEK	National Electricity Company
NPP	Nuclear Power Plant
OBE	Operational Bases Earthquake
PSA	Probabilistic Safety Assessment
RAW	Radioactive Waste
RLE	Review Level Earthquake
SAM	Severe Accident Management
SAMG	Severe Accident Management Guidelines
SBEOP	Symptom-based Emergency Operating Procedure
SBO	Station Blackout
SFP	Spent Fuel Pool
SFSF	Spent Fuel Storage Facility
SG	Steam Generator
SNF	Spent Nuclear Fuel
SSCs	Structures, Systems and Components
WANO	World Association of Nuclear Operators
WENRA	Western European Nuclear Regulators' Association
WWER	Water Water Energy Reactor

ATTACHMENT No. 1: ACTIVITIES IMPLEMENTATION ON PART I: TOPICS 1 – 3

ID №	NF	Topic	Measure/Action	ENSREG Recommendations	Source	Status	
A-1-1	Units 5&6	External Initiating Events	Provision of two additional MDGs for units 5&6 *New measures envisaged in Field FA-1, Attachment 4*	13, 15, 26, 27, 30, 33	ENSREG, CNS	Completed	December 2013
A-1-2	Units 5&6	External Initiating Events	Investigate possible alternatives for residual heat removal in case of loss of service water system using the Units 3 and 4 additional SGs emergency feedwater system for Units 5&6	13, 14, 33	ENSREG, CNS	Completed	March 2013
A-1-3	Units 5&6	External Initiating Events	Ensuring the availability of at least one tank of the SG Emergency Feedwater System as an alternative for residual heat removal in shutdown mode	13, 14, 19, 33	ENSREG, CNS	Completed	March 2012
B-1-1	NPP	External Initiating Events	Development of an emergency response procedure for the operating personnel in case of damage of Zhelezni Vrata-1 and Zhelezni Vrata-2 Water Power Facilities	7, 9, 12	ENSREG, CNS	Completed	November 2012
B-2-1	Bank Pumping Station	External Initiating Events	Investigation of the possibilities for protecting the equipment at the river bank pumping stations in case of external flooding with maximum water level 32.93 m	8, 12	ENSREG, CNS	Completed	October 2012
B-2-2	Units 5&6	External Initiating Events	Development of measures to prevent water intake in the plant sewage network in case of valley flooding *New measure envisaged in Field FB-2, Attachment 4*	8, 12	ENSREG, CNS	Completed	October 2013
B-2-3	Units 5&6	External Initiating Events	Modernisation of the sewage network and drain pump system	8, 12	ENSREG, CNS	Completed	November 2015
B-3-1	NPP	External Initiating Events	Initiation of activities to improve the operational condition and the protective functions of the state dike in the region of the Kozloduy valley	12	ENSREG, CNS	Completed	December 2014
C-1-1	Units 5&6	Design Issues	Provision of recharging of one of the batteries of the safety systems by a mobile DG	16, 25, 27, 30	ENSREG	Completed	December 2013
C-2-1	NPP	Design Issues	Assess the condition, efficiency and availability of the water supply system from the Shishamnov Val dam	14	ENSREG, CNS	Completed	May 2012

ID №	NF	Topic	Measure/Action	ENSREG Recommendations	Source	Status	
C-2-2	Units 5&6	Design Issues	Ensure power supply through the mobile DG for the SFP cooling systems, or for feeding the SFP	14, 23, 27	ENSREG, CNS	Completed	December 2013
C-2-3	Units 5&6	Design Issues	Analysis of the need for and possibilities to power the valve motors at the hydroaccumulator connecting pipelines to the primary circuit from the batteries in order to provide for making up the primary circuit in reactor cold shutdown state and failure of the emergency DGs	14, 19, 30	ENSREG, CNS	Completed	December 2013
C-2-4	Spent Nuclear Fuel Storage Facility (SNFSF)	Design Issues	Analysis of the possibility to install an alternative water cooling system with an independent power supply in the SNFSF *New measure is envisaged in the Field FC-2-4*	14	ENSREG, CNS	Completed	December 2014
D-1-1	NPP	Severe Accidents	Review of the KNPP on-site and off-site emergency plans to consider the possible effects from physical isolation due to external hazards: - impeded access to the Units 5, 6 ECRs; - possible draining of the spent fuel storage sections at the SFSF followed by increase of the dose rate; - provision for alternative routes for evacuation, transport of necessary fuels and materials to the plant, and operational staff access.	28, 34	ENSREG, CNS	Completed	December 2014
D-1-2	NPP	Severe Accidents	Construction of Kozloduy NPP off-site ERC	22, 44	ENSREG	Completed	December 2022
D-2-1	Units 5&6	Severe Accidents	Implementation of a set of symptom-based emergency operating procedures for shut-down reactor mode with closed primary circuit	19	ENSREG	Completed	February 2012
D-2-2	Units 5&6	Severe Accidents	Implementation of the set of symptom-based emergency operating procedures for shut-down reactor mode with open primary circuit	19, 39	ENSREG	Completed	February 2013
D-2-3	Units 5&6	Severe Accidents	Implementation of severe accident management guidelines (SAMGs)	34, 39, 47	ENSREG, CNS	Completed	October 2012

ID №	NF	Topic	Measure/Action	ENSREG Recommendations	Source	Status	
D-2-3-3	Units 5&6	Severe Accidents	Validation of the SAMGs set of documents	36	ENSREG	Completed	July 2012
D-2-4	Units 5&6	Severe Accidents	Develop technical means to provide direct injection of water to the reactor core, SG, SFP and the containment by mobile fire protection equipment in extreme conditions *Transformed into 3 new measures in Field FD-2 of Attachment 4 and part in Measure D-3-5*	14	ENSREG, CNS	Completed	Terms for the corresponding measures
D-2-5	Spent Nuclear Fuel Storage Facility	Severe Accidents	Develop technical means to provide direct injection of water to the SNFSF by mobile fire protection equipment in extreme conditions *New measure envisaged in Field FD-2, Attachment 4*	14	ENSREG, CNS	Completed	December 2014
D-2-8	Units 5&6	Severe Accidents	Analysis of the possible deterioration of operational parameters due to a high contamination level (in certain zones) and equipment failure on-site (including the impact on accessibility and habitability of the MCR and the ECR) *Four new measures envisaged in Field FD-2-8-1,2,3,4, Attachment 4*	22, 43, 47	ENSREG	Completed	December 2014
D-3-1	Units 5&6	Severe Accidents	Installion of additional hydrogen recombiners in the containment	31, 41	ENSREG	Completed	June 2014
D-3-2	Units 5&6	Severe Accidents	Installation of measuring channels to monitor and evaluate the concentration of steam and oxygen in the containment	18, 31	ENSREG	Completed	August 2022
D-3-3	Units 5&6	Severe Accidents	Implementation of the project for plugging the ionization chamber channels located in the walls of the reactor vessel cavity	31, 33, 47	ENSREG	Completed	December 2014
D-3-4	Units 5&6	Severe Accidents	Complete the installation of a wide-range temperature sensors to monitor the reactor vessel temperature	18, 31, 47	ENSREG	Completed	October 2012
D-3-5	Units 5&6	Severe Accidents	Study the possibilitiesfor molten core retention in case of severe accidents	47	ENSREG	Completed	December 2021

ATTACHMENT No. 2: ACTIVITIES IMPLEMENTATION ON PART II: TOPICS 4 – 6

№	O*	Topic	Action / Activity	CNS	Status	
N-1-1	BNRA	National organizations	Develop a programme to review the regulatory requirements taking into account the lessons learned from the Fukushima Daiichi NPP accident	101, 127, 128	Completed	December 2013
N-1-2	BNRA	National organisations	Revise the existing regulatory requirements upon issue of new IAEA documents that consider the lessons learned from the accident	101	In progress	On a regular basis
N-1-3	BNRA	National organisations	Participation of Bulgarian experts in the review of IAEA standards and issuance of new ones	101	In progress	On a regular basis
N-1-4	BNRA	Nationa organisations	Periodic review and update of the regulatory guidelines to consider the lessons learned and the relevant new documents of the IAEA and the European Commission	101	Completed	December 2014
N-2-1	BNRA	National organisations	Review of BNRA activities by IRRS mission of the IAEA	103	Completed	April 2013
EP-1-1	Ministry of Interior	Emergency preparedness and response	Revise and update the National (Off-site) Emergency Plan	107, 108, 109	Completed	June 2015
EP-1-2	Ministry of Interior	Emergency preparedness and response	Analyse the existing and develop new procedures, instructions and methodologies for actions of the emergency teams in line with the National Emergency Plan	107, 108	Completed	June 2015
EP-1-3	Ministry of Interior	Emergency preparedness and response	Update and maintain the data base of the currently functioning volunteer emergency response teams	112	Completed	June 2015
EP-1-4	Ministry of Environment and Water	Emergency preparedness and response	Update of the National System for Radiation Background Monitoring, BULRaMo	114	Completed	December 2014
EP-2-1	BNRA	Emergency preparedness and response	Installation of safety parameter display system (SPDS) and critical parameters post accident monitoring system (PAMS) of KNPP units 5&6 in the BNRA Emergency Centre	115	Completed	May 2011
EO-1-1	BNRA	International Cooperation	Preparation and signing of bilateral agreement with the Regulatory Body of the Russian Federation	105, 130	Completed	April 2014

№	O*	Topic	Action / Activity	CNS	Status	
EO-1-2	BNRA	International Cooperation	Preparation and signing of bilateral agreement with the Government of Serbia	105, 130	Completed	December 2018
EO-1-3	BNRA	International Cooperation	Preparation and signing of bilateral agreement with the Regulatory Body of Greece	105, 130	Completed	September 2016
EO-1-4	BNRA	International Cooperation	Preparation and signing of bilateral agreement with the Regulatory Body of Romania	105, 130	Completed	January 2016
EO-1-5	BNRA	International Cooperation	Plan for systematic training of the staff of the Emergency Response Team in BNRA	130	Completed	December 2015
EO-1-6	BNRA	International Cooperation	Participation in the meetings of the Forum of WWER Regulators	131	In progress	On a regular basis
EO-2-4	BNRA	International Cooperation	IAEA OSART Mission	128	Completed	November 2012
EO-2-14	BNRA	International Cooperation	IAEA Follow-up OSART Mission	128	Completed	June 2014

*O – organization

ATTACHMENT No. 3: ADDITIONAL ACTIVITIES IMPLEMENTATION

ID No.	NF	Topic	Action/Activity	Source	Status	
A-3-1	KNPP	External Initiating Events	Assess the possible damage on the regional road infrastructure surrounding the plant in the event of extreme external impacts and evaluate the reliability of routes, ensuring accessibility to the plant site for machinery, supplies and personnel	Peer Review Report	Completed	December 2014
D-2-6	Units 5&6	Severe accidents	Extension of the scope of SAMGs - for the spent fuel pools and for specific reactor shutdown states, not covered by the current SAMGs	Peer Review Report	Completed	July 2015
D-2-7	KNPP	Severe accidents	Assess the current organizational measures and technical means for management of simultaneous accidents with core melt/fuel damage on the various facilities on-site *New measure envisaged in Field FD-2, Attachment 4*	Peer Review Report	Completed	December 2015
D-3-6	Units 5&6	Severe accidents	Assess the volume of the generated liquid RAW in the event of a severe accident as well as the adequacy of the available measures to prevent the release into the environment.	Peer Review Report	Completed	December 2015
E-1	KNPP	External Initiating Events	Analysis of the extreme weather conditions on the Kozloduy NPP site, using probabilistic methods according to the IAEA methodology, and considering combinations of extreme weather conditions	Peer Review Report	Completed	December 2015
EO-2-1	KNPP	International Cooperation	Establish a local WANO office on the Kozloduy NPP site	WANO Programme/ CNS	Completed	August 2012
EO-2-2	KNPP	International Cooperation	Appoint a WANO representative at the Kozloduy NPP site	WANO Programme/ CNS	Completed	September 2012
EO-2-3	KNPP	International Cooperation	Choose a Kozloduy NPP representative at the WANO-Moscow Centre.	WANO Programme/ CNS	Completed	April 2012
EO-2-5	KNPP	International Cooperation	WANO Peer Review	WANO Programme/ CNS	Completed	November 2013
EO-2-6	KNPP	International Cooperation	WANO Workshop – Significant Operating Experience Reports (SOER) and corrective actions efficiency	WANO Programme/ CNS	Completed	March 2013
EO-2-7	KNPP	International Cooperation	Participation in the Regional Crisis Centre in Moscow	WANO Programme	Completed	According to an approved working plan
EO-2-8	KNPP	International Cooperation	Preparation and signing of bilateral agreements with other NPPs for benchmarking	WANO Programme	Completed	December 2013

ID No.	NF	Topic	Action/Activity	Source	Status	
EO-2-10	KNPP	International Cooperation	Participation in the working meeting of the Chief Engineers of NPPs with WWER to discuss Lessons Learned from the Fukushima Daiichi NPP accident	WANO Programme	Completed	September 2012
EO-2-11	KNPP	International Cooperation	Respond to WANO about the implementation of the recommendations from SOER 2011-2, 2011-3, 2011-4	WANO Programme	Completed	May 2012
EO-2-12	KNPP	International Cooperation	Analysis of the stress test results for other nuclear power plants	WANO Programme	Completed	November 2013
EO-2-13	KNPP	International Cooperation	Participation in a joint WANO and IAEA workshop on sharing of operating experience in the light of the Fukushima Daiichi NPP accident	WANO Programme	Completed	October 2012 October 2013
EO-2-15	KNPP	International Cooperation	Conduct technical support missions in various areas (planned for 2013: industrial safety – June; radiation protection –September)	WANO Programme	Completed	June 2013 September 2013
EO-2-16	KNPP	International Cooperation	Participation in the annual working meeting of the Chief Engineers of NPPs with WWER-1000 reactors	WANO Programme	Completed	On a regular basis

ATTACHMENT No. 4: MEASURES AND ACTIVITIES RESULTING FROM THE PERFORMED ANALYSES AND STUDIES FOR THE PREVIOUS AREAS

ID No.	NF	Measure/Action	Interface with measure	Status	
Field FA		**Provision of alternatives for residual heat removal**			
FA-1-1-1	Units 5&6	Implementation of provisions to power the reliable supply cabinets from 6 kV MDG	A-1-1	Completed	November 2016
FA-1-1-2	Units 5&6	Implementation of provisions for charging the batteries of the safety system trains from 0,4 kV MDGs	A-1-1	Completed	November 2016
FA-1-1-3	KNPP	Seismic upgrade of the overhead passage-wayss between Auxiliary Building and the Reactor Buildings of Units 5&6	A-1-1	Completed	November 2016
FA-1-1-4	KNPP	Construction of buildings for the MDGs sheltering	A-1-1	Completed	October 2015
Field FB		**Measures to prevent and mitigate the consequences of floods**			
FB-2-2-1	KNPP	Implementation of provisions to prevent water penetration into the plant sewage when the valley is flooded	B-2-2	Completed	December 2016
Field FC		**Measures to improve stability in case of a loss of ultimate heat sink**			
FC-2-4-1	SNFSF	Installation of an independent cooling system in SNFSF	C-2-4	Cancelled	December 2015
Field FD		**Measures for improving the capabilities for severe accident management**			
FD-2-4-1	Units 5&6	Installation of additional pipeline to the spent fuel pool cooling system for back up from an external source	D-2-4	Completed	June 2022
FD-2-4-2	Units 5&6	Feasibility study of direct water injection to the reactor core from an external source	D-2-4	Completed	December 2020
FD-2-4-3	Units 5&6	Feasibility study of direct water supply to SGs from an external source	D-2-4	Completed	December 2020
FD-2-5-1	SNFSF	Installation of pipeline for direct water supply to the SNFSF pools from external source (diesel pumps or fire truck)	D-2-5	Completed	June 2015

ID No.	NF	Measure/Action	Interface with measure	Status	
FD-2-7	Units 5&6	Development of Procedure for actions of the emergency teams during the simultaneous accidents in different units/installations at the Kozloduy NPP site	D-2-7	Completed	March 2018
FD-2-8-1	Units 5&6	Prevention of airbourne release to the MCR in the event of a severe accident by implementation of a set of organizational and technical measures	D-2-8	Completed	November 2016
FD-2-8-2	Units 5&6	Modifications of SAMGs and electricity supply recovery procedures from MDG to ensurerestarting of the ventilation systems for recirculation and air filtration in the MCR	D-2-8 FA-1-1-1	Completed	November 2016
FD-2-8-3	Units 5&6	Instructions on the evacuation of the MCR staff to the ECR upon reaching the dose limit of 1mSv/h shall be added to the SAMGs	D-2-8	Completed	July 2015
FD-2-8-4	Units 5,&6	Prevention of airbourne release to the ECR in case of a severe accident by replacement of the corridor doors with gas tight ones	D-2-8	Completed	July 2015