ROMANIA

National Commission for Nuclear Activities Control

Romanian National Action Plan post - Fukushima

Revision 1, December 2014

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INTRODUCTION

Following the Fukushima Daiichi accident occurred in March 2011, the Romanian authorities and the nuclear industry performed reassessments of nuclear safety and emergency preparedness arrangements and implemented improvements, in line with the international efforts in this direction.

There are currently several public reports which document the actions taken by the National Commission for Nuclear Activities Control (CNCAN) and Cernavoda NPP to take account of the lessons learned from the Fukushima accident:

- National Report of Romania on the implementation of the stress tests (December 2011);
- Peer-Review Country Report for Romania (April 2012);
- National Report of Romania for the 2nd Extraordinary Meeting under the Convention on Nuclear Safety (May 2012);
- Romanian National Action Plan post-Fukushima, Revision 0 (December 2012);
- National Report of Romania under the Convention on Nuclear Safety, Sixth Revision (August 2013).

A national action plan has been developed for bringing together the actions identified from regulatory reviews, self-assessments, peer-reviews and generic recommendations at international level. This action plan has been elaborated by CNCAN taking account of the guidance provided by ENSREG. The action plan was issued for the first time in December 2012 and has been reviewed and revised in December 2014.

CNCAN monitors the licensee's progress in the implementation of the planned improvements and continues to perform safety reviews and inspections to ensure that all the opportunities for improvement are properly addressed taking account of the lessons learned from the Fukushima accident. The action plan will be reviewed periodically and revised as necessary.

GENERAL INFORMATION ABOUT CERNAVODA NPP

Romania has one nuclear power plant, Cernavoda NPP, with two units in operation, pressurised heavy water reactors of CANDU 6 design (CANadian Deuterium Uranium), each with a design gross output of 706.5 MWe. Unit 1 and Unit 2 started commercial operation on the 2nd of December 1996 and on the 1st of November 2007, respectively. Cernavoda NPP Units 1 and 2 cover up to 19% of Romania’s total energy production.

Cernavoda NPP is owned and operated by the National Company Nuclearelectrica (Societatea Nationala Nuclearelectrica - SNN). SNN is the license holder for Cernavoda NPP.

The Romanian Government has plans to further increase nuclear generating capacity through completion of the project of Units 3 and 4 of the Cernavoda NPP. All the design improvements resulting from the "stress tests" for the operating units will be implemented also in Units 3 and 4.

All of the Cernavoda NPP units are pressurised heavy water reactors (PHWR), of CANDU-6 type, designed by AECL (Atomic Energy of Canada Ltd.). Extensive information on the design of the Cernavoda NPP is provided in the national report elaborated by CNCAN on the implementation of the "stress tests", which is publicly available.

GENERAL INFORMATION ABOUT THE ACTION PLAN POST-FUKUSHIMA

The action plan has been developed by CNCAN, based on the safety reviews performed after the Fukushima accident.

The revision 1 of the action plan reflects the situation as of December 2014. The action plan will be reviewed quarterly by CNCAN to verify the progress with its implementation and revised, as necessary, to reflect any relevant new information and developments.

CNCAN will publish the action plan on its website and will inform the public periodically on the progress with implementation.

The updates to the document in comparison with revision 0 are presented using italic type font. The action plan is summarized in Table 1 - Romanian Action Plan post-Fukushima - Summary of improvement activities – December 2014 update. As compared to the revision 0 from December 2012, Table 1 has now an additional column in which details are provided on the status of the implementation of the improvement actions.

PART I

TOPIC 1 - EXTERNAL EVENTS

1.1. Overview of activities performed and planned by the licensee

Protection against earthquakes

A seismic margin assessment was performed for Cernavoda NPP, with a review level earthquake (RLE) established at a reasonably high level seismic ground motion, based on site seismicity and plant specific design features. The seismic margin assessment shows that in comparison with the original design basis earthquake of 0.2g, which has a frequency of 1E-3 events/year, all SSCs which are part of the safe shutdown path after an earthquake would continue to perform their safety function up to 0.4g, which has a frequency of 5E-5 events/year. This margin is considered adequate as it meets the safety goals applied internationally for new NPPs. Additional margins exist beyond the value of 0.4g, but they have not been quantified.

The potential of Cernavoda NPP units flooding induced by an earthquake exceeding the DBE has been analysed by considering all the failure mechanisms consisting of failure of dams and other hydrological or civil structures collapsing and the tsunamigenic potential of a Black Sea originating earthquake. The results of these analyses show that the effect of these failure mechanisms has physically no potential for seismically induced flooding of the Cernavoda site.

The potential for seismic induced internal plant flooding was also analysed and it was concluded that this does not pose a threat to the equipment qualified to perform the essential safety functions after an earthquake. The inspections conducted post-Fukushima confirmed the design robustness and good material condition regarding the fire protection.

The seismic walk-downs and subsequent seismic robustness analyses done as part of the seismic margin assessment have not revealed a need for any safety significant design change. However, several recommendations resulted from these inspections, such as increasing the seismic robustness of the batteries, *have been implemented* by the licensee as part of the regular plant seismic housekeeping program.

Protection against external flooding

Based on the analysis results obtained by making use of the latest deterministic tools and complemented by probabilistic approach, it was concluded that the Cernavoda NPP design intent in relation with flooding hazards provides sufficient safety margins, therefore no further measures were envisaged in this area.

However, following a generic recommendation from a "stress test" peer review, concerning the improvement of volumetric protection of the buildings containing safety related equipment located in rooms below plant platform level (so that protection does not rely solely on the elevation of the platforms), potential measures have been identified and design modifications were approved to replace selected doors with flood resistant doors and penetrations sealing. Sand bags have also been made available on site to be used as temporary flood barriers, if required.

Improvements have been implemented for volumetric protection (replacement of selected access doors with flood resistant doors and room penetrations sealing) of several areas were safety related equipment are located underground (e.g. SCA, T/B basement, Class III SDG fuel transfer pumps house), in addition to the passive protection measure ensured by the plant platform elevation.

Based on review of the enhanced design provisions and operating procedures, the plant strategy in response to internal and external flooding events *has been* revised and required modifications of plant procedures *have been* performed. Flood protected areas are periodically inspected as per dedicated plant routines.

Protection against extreme weather events

Based on the assessment performed, the licensee concluded that adequate safety margins exist in relation to extreme weather conditions, taking account margins provided in the design of the safety related SSCs as well as the time available for preventative measures in slow developing scenarios.

For cases in which the extreme weather conditions could affect the availability of the off-site power supply and / or the transfer of heat to the ultimate heat sink, based on the review of severe weather conditions and their impact on the plant, it was concluded that these would not generate accident scenarios worse than the analyzed SBO, LOUHS and SBO + LOUHS events.

Even though the possibility to have on site winds corresponding to the 1000 year return period is very remote, the specific procedure which is in place for extreme weather conditions and which covers also the actions to be taken in case of high winds has been revised to include more proactive actions.

1.2. Overview of activities performed and planned by the regulator

The regulatory reviews post-Fukushima have been performed in the context of the "stress tests" and have focused on verification of the completeness and quality of the stress test reports and of the supporting analyses prepared by the licensees. CNCAN has reviewed the methodology used for the assessment of external events and the results and has acknowledged that these reflect the current standards and good practices and state-of-the-art knowledge.

The "stress test" peer-review for Romania acknowledged the comprehensive studies and work performed to increase protection of the Cernavoda plant against seismic events and the substantial and recent studies for the assessment of flooding hazards.

As regards compliance with the "stress test" specifications devised by ENSREG, the country report resulting from the peer review states that "although the Romanian report complies entirely with the ENSREG stress tests specifications, it does not adequately address in depth margins to cliff edge effects for earthquakes and extreme external events" and "The Romanian report is judged to be adequate and at an appropriate level of detail except for earthquakes and extreme external events where it does not adequately address weak points and cliff-edge effects and the measures for the prevention of cliff-edge effects".

The above statements from the peer-review report for Romania are due to the fact that the

ENSREG specifications requested "an evaluation of the range of earthquake severity above which loss of fundamental safety functions or severe damage to the fuel (in vessel or in fuel storage) becomes unavoidable" and "the range of earthquake severity the plant can withstand without losing confinement integrity.

Regarding the protection against earthquakes, the assessments performed for Cernavoda NPP demonstrated that the safety functions for the success paths for seismic events are fulfilled with a margin of minimum 0.4g, corresponding to an event with a frequency of occurrence of less than 1 in 20000 years. In addition, based on deterministic studies performed by national competent institutes for earth physics, seismic events yielding a PGA > 0.2g are considered physically not possible. There are no cliff-edge effects occurring for PGA ≤ 0.4g. Therefore, assessments of plant behaviour for PGA values greater than 0.4g have not been performed, meaning that any additional seismic capacity above this value has not been quantified, especially in the context that there is no agreed methodology yet for the performance of assessments focused on cliff-edge effects rather than of seismic margins expressed in HCLPF values.

The licensee's re-assessment of the protection against external flooding has not identified the need for any further activities, since the margins for such events were judged as sufficient. Based on the analysis results obtained by making use of the latest deterministic tools and complemented by probabilistic approach, it was concluded that the Cernavoda NPP design intent in relation with flooding hazards provides sufficient safety margins, therefore no further measures were envisaged in this area. CNCAN has found the assessment satisfactory. However, the "stress test" peer-review team suggested that the regulator and the licensee consider improving the volumetric protection of the buildings containing safety related equipment located in rooms below plant platform level (so that protection does not rely solely on the elevation of the platforms). This was accepted as a generic improvement suggestion and actions for implementation are in progress.

The reassessment of protection against extreme weather events has been less systematic than the reassessment of protection against seismic and flooding events. This was due to the shorter time available for the review, since the initial specifications for the "stress tests" did not explicitly include requirements for the assessment of extreme weather events. Based on the assessments performed to date, it was concluded that the worst-case scenarios that could be initiated by extreme external events are bound by SBO, LOUHS and SBO + LOUHS. The "stress test" peer-review considered that the information presented is limited and the safety margins to cliff-edge effects are not quantified.

The peer-review report for Romania recommends that CNCAN further investigates safety margins to cliff-edge effects for extreme external events. This is a generic issue and the peer review revealed that there is a lack of consistency identified at international level with respect to the assessment of natural hazards, that significant differences exist in national approaches and difficulties were encountered with beyond design margins and cliff-edge effects assessments.

The ENSREG report on the stress tests performed for European nuclear power plants recommends that "WENRA, involving the best available expertise from Europe, develop guidance on natural hazards assessments, including earthquake, flooding and extreme weather conditions, as well as corresponding guidance on the assessment of margins beyond the design basis and cliff-edge effects". CNCAN will use of the outcome of this work. Further studies will be required once a common methodology is developed and agreed upon, in accordance with the ENSREG recommendations following the peer-review of the "stress tests" for European NPPs.

CNCAN has elaborated a regulation on the protection of nuclear installations against external events of natural origin, based on Issue T of the 2014 WENRA RHWG Safety Reference Levels for existing reactors. This regulation has been through external consultation in 2014 and is ready for publication. It is envisaged that it will be published at the end of December 2014 or early in January 2015. The regulation includes requirements on the assessment of the margin for cliff-edge effects. However, no guidance has been yet provided by CNCAN to the licensee on how to perform this particular type of assessment if the aim of the cliff-edge analysis is not only to demonstrate sufficient margins but also to identify the ultimate-load capacity / the ultimate failure point of safety-related structures and systems. A common methodology at EU level is desirable, based on a joint regulatory effort. The guidance document for Issue T, which is under development by WENRA RHWG may be of some use for this purpose.

TOPIC 2 - DESIGN ISSUES

2.1. Overview of activities performed and planned by the licensee

In compliance with the "stress test" specifications, the licensee has analyzed the following scenarios:

- loss of offsite power;
- station blackout (SBO);
- loss of primary ultimate heat sink (UHS);
- loss of both primary and alternate ultimate heat sinks;
- loss of primary ultimate heat sink with station blackout.

For each scenario, the licensee has identified the plant design capabilities to fulfill the safety functions (shutdown reactor, cooldown the reactor core, contain and monitor the plant parameters), including the supplementary measures available on site.

The licensee has increased the protection against SBO and LOUHS scenarios by specific design changes and operational measures, in order to ensure that such events would not lead to fuel failures. A new emergency operating procedure for responding to SBO has been developed and implemented.

Two 880 kW, 0.4 kV mobile diesel generators (one for each of Unit 1 and Unit 2) have been procured immediately after the Fukushima accident and have been tested by powering the 380 VAC EPS buses and the EWS pumps. The capacity of each mobile diesel generator is almost equivalent to that provided by the design non-mobile EPS diesel generators. Since then, the licensee has replaced the above mentioned Diesel generators with other 2 Diesel generators 2x1MW (to cover entirely the EPS loads), which are more versatile as they can supply also 6KV loads supplementary to 0.4 KV loads.

Furthermore, the licensee has procured a mobile diesel engine driven pump which is available on site along with 2 electrical mobile submersible pumps already available on site. Also, two smaller diesel generators were procured for electrical power supply for the two pumps that can provide water in the domestic water system from the deep underground wells.

The licensees implemented also modifications for increasing the safety margins, such as providing the possibility for manual operation of important equipment for ensuring heat removal path (e.g. MSSVs).

In order to minimize the time for connecting the mobile Diesel generators, the licensee has installed special connection panels to the loads which may be supplied from these Diesels.

2.2. Overview of activities performed and planned by the regulator

The regulatory reviews post-Fukushima have been performed in the context of the "stress tests" and have focused on the verification of the completeness and quality of the stress test reports and of the supporting analyses prepared by the licensees. CNCAN has performed reviews and inspections of the measures taken by the licensee to cope with SBO and LOUHS scenarios and has found them satisfactory. The inspections of the new equipment and procedures, including their maintenance and testing, *have become* part of the annual inspection plans established by CNCAN.

The country review report issued for Romania after the finalisation of the peer-review process organised in the framework of the "stress tests" acknowledged the work performed by the licensee and by CNCAN and did not include any particular recommendations related to the management of SBO and LOUHS.

There are no further regulatory activities scheduled in relation to SBO and LOUHS scenarios, except for the monitoring and periodic verification of licensee's maintenance, testing and training associated with the new equipment installed, the design changes performed and the operational measures implemented.

TOPIC 3 – SEVERE ACCIDENT MANAGEMENT AND RECOVERY (ON-SITE)

3.1. Overview of activities performed and planned by the licensee

After the Fukushima accident, the licensee has performed a re-assessment of the accident management programme, including a review of the arrangement for severe accident management and recovery on-site.

The SAMGs for Cernavoda NPP have been developed based on the generic CANDU Owners Group (COG) SAMGs for a CANDU-6 type of plant. In developing the generic SAMGs, COG adopted the Westinghouse Owners Group (WOG) approach, with the necessary technical modifications suitable for implementation in CANDU plants, based on extensive CANDU specific severe accident analysis and research. Preparation of plant-specific SAMGs was done by customisation of the generic COG documentation package for Cernavoda NPP, removing extraneous information not applicable to the station, incorporating station-specific details and information and making any other adjustments required to address unique aspects of the plant design and/or operation.

The SAMGs have been developed based on the existing systems and equipment capabilities. A limited and focused set of information requirements was defined to support SAMG diagnostics and evaluations. The primary source is from plant instrumentation, supplemented by additional measurements and data expected to be available through emergency response procedures and Computational Aids where appropriate.

The review and revision of SAMGs is in progress to take account of the plant modifications and upgrades implemented after the Fukushima accident.

An On-Site Emergency Plan is in place to respond to any emergency, ranging from the lowest incident classification (“Alert” level) to the highest classification (“General Emergency”) that requires the evacuation of all non-essential personnel on-site. Off-site emergency response is under the responsibility of the local, county and national authorities.

The licensee has also performed a conservative evaluation of the on-site vital areas habitability and accessibility, based on selected severe accident scenarios.

Based on the review performed in the framework of the “stress test”, the licensee's organisation for accident management and emergency response has been found adequate. The resources allocated are sufficient also for the situation in which both units would be affected by an accident.

Improvement measures have been identified and are under implementation for increasing the reliability of the communication systems and of the on-site emergency control centre. The set-up of an Alternative Off-site Emergency Control Centre is in progress. Also, improvements to the plant instrumentation are *in progress* to support the implementation of the SAMGs.

The human and equipment resources appointed for emergency response activities have been assessed and allocated based on the assumption that both Cernavoda NPP Units would be affected by an accident, in conformance with the specifications for the “stress test”.

Design provisions and accident management measures are in place to prevent and mitigate radioactive releases for a range of accidents, including severe core damage scenarios. The robustness of the CANDU design to severe accidents has been acknowledged as a strong point in the peer-review conducted in the framework of the European "stress tests". Accidents involving loss of cooling to the SFB do not pose a threat in terms of radioactive releases.

Several design improvements have been identified to enhance the capability to maintain containment integrity in case of severe accidents and their implementation *has been completed or is in advanced stage of completion*. These include the provision of water make-up to calandria vessel and calandria vault to arrest the progression and relocation of the core melt, the provision of hydrogen monitoring systems and passive autocatalytic recombiners for hydrogen management and the installation of filtered containment venting systems.

3.2. Overview of activities performed and planned by the regulator

The regulatory reviews post-Fukushima have been performed in the context of the "stress tests" and have focused on verification of the completeness and quality of the stress test reports and of the supporting analyses prepared by the licensees.

In addition to the review of the licensee’s stress test report, a set of inspections have been performed by CNCAN staff for verifying the quality of the process implemented by the licensee in the development of plant specific SAMGs, training records from training in the implementation of the SAMGs, the availability of up-to-date emergency operation procedures at the points of use, the procedures for connecting the mobile diesel generators and the related test reports, the procedures for injecting fire water into plant cooling systems, etc.

The country review report issued for Romania after the finalisation of the peer-review process notes the good progress in the implementation of SAMGs, associated with a significant number of hardware modifications during a short time period and provides recommendations for:

- review of severe accidents and the development of SAMGs for shutdown states;
- verification of the completeness of event-based and symptom-based EOPs for all accident situations;
- continuation of the MCR habitability analysis (e.g. to account for situations involving total core melt with voluntary venting);
- finalisation of the incorporation of requirements for severe accident management in the national regulations.

All the above recommendations have either been implemented or are in advanced stage of completion. Details are provided in Table 1 – actions 26, 27, 28 and 33.

The challenge identified by Romania at the 2013 ENSREG Workshop in relation to the implementation of the national action plan was related to the enhancement of instrumentation and monitoring under severe accident conditions (especially in the long term) as a challenge. This issue has since then been solved and improvements to the instrumentation are in progress. Details are provided in Table 1 – action 24.

PART II

TOPIC 4 – NATIONAL ORGANISATIONS

Following the Fukushima accident, CNCAN has focused on the technical reviews of the protection of the plant against extreme external events and of beyond design basis accident analysis, severe accident management and emergency response. The lessons learned from the Fukushima accident are still under development as regards the organisational factors that have contributed to the accident. However, recognising the importance of these factors, CNCAN *has performed* an evaluation of its own organisation and of the regulatory framework and processes, with the aim of identifying opportunities for improvement, in addition to those already identified from previous self-assessments and peer-reviews such as the IRRS mission received in 2011. The implementation of the recommendations and suggestions from the 2011 IRRS mission provided is ongoing.

Starting with July 2014, Romania has a National Strategy for Nuclear Safety and Security, which was officially approved by the Government and by the Supreme Council of National Defence. The strategy includes a policy statement with nuclear safety and security principles, including the ten fundamental safety principles outlined in the IAEA SF-1 Publication, and takes account of the relevant provisions of the IAEA GSR Part 1 Publication. The strategy will be reviewed and revised as necessary, at least every 5 years. A process will be established to monitor the implementation of the strategy and of its corresponding action plan, and the results would be presented annually to the Government.

CNCAN will review the lessons learned from the Fukushima accident as more information becomes available and will take account of any generic implications as regards organisational factors relevant for nuclear safety and decision-making in emergency management.

In addition, CNCAN is committed to continue to keep itself informed of any new information related to the lessons learned from the Fukushima accident and bring this to the attention of all national organisations in the nuclear field, especially to licensees and to public authorities involved in emergency response.

Following the Fukushima accident, the licensee performed a review of their On-Site Emergency Organisation and modified it in order to assure an improved response in case of a severe accident. The Technical Support Group (TSG) has been supplemented with the Electrical Systems Specialist position, the Operation Specialist position from TSG has been designated as SAMG Technical Adviser and the Safety Analyses Specialist and Process Systems Specialist from TSG have been designated as SAMG Evaluators. In addition, the licensee is committed to take account of and use any applicable lessons learned from the Fukushima accident with respect to organisational factors.

TOPIC 5 – EMERGENCY PREPAREDNESS AND RESPONSE AND POST-ACCIDENT MANAGEMENT (OFF-SITE)

The licensee reviewed and revised the Emergency Plan and Procedures, Conventions, Protocols and Contracts in place, in order to better accommodate emergency response to severe accidents coincident with natural disasters. Cernavoda NPP has agreed a protocol with a number of state bodies (e.g. the Constanta County Inspectorate for Emergency Situations, Police County Inspectorate, etc.) to ensure the transportation of Cernavoda personnel, fuel supplies, etc. to the site should access become hindered due to extreme meteorological conditions, natural disasters or other traffic restrictions. Also, Cernavoda has protocols in place with medical centres and hospitals in the region, for the provision of medical services (first aid, initial treatment and decontamination, treatment of overexposed personnel).

In addition, the licensee has identified potential improvements in the cooperation with local and national authorities involved in emergency response in case of radiological and nuclear accidents and has proposed them for consideration by CNCAN and IGSU.

The licensee has also taken actions to set up an alternative Off-site Emergency Control Centre, which will be located in an existing facility in Constanta city (60 km away from Cernavoda). Improvements to the communication systems have also been implemented.

CNCAN has organised meetings with the representatives of the licensee and the representatives of IGSU and of other national organisations with roles in emergency response and has contributed to the review of national (off-site) emergency response strategy with an assessment of the lessons learned from the Fukushima accident.

The recommendations made by CNCAN are being incorporated in the revision of the national response plan for radiological and nuclear emergencies.

TOPIC 6 – INTERNATIONAL COOPERATION

Romania is committed to international cooperation for improving nuclear safety and emergency preparedness and response and maintains relations with a number of nuclear regulatory authorities and organisations worldwide, through bilateral arrangements and commitments under international conventions in the nuclear field.

The international activities in which CNCAN is involved include those organised by the IAEA, those organised by WENRA and its technical working groups, the annual meetings of the Senior Regulators from countries that operate CANDU NPPs, the periodic meetings of the European High Level Group on Nuclear Safety and Waste Management (ENSREG) and its working groups and the contribution to the initiatives at European Union. CNCAN also participates, as observer, in the annual session of the Nuclear Law Committee (NLC) of the NEA/OECD (Nuclear Energy Agency of the Organisation for Economic Co-operation and Development) and keeps itself informed of activities of the CNRA (Committee of Nuclear Regulatory Activities) and CSNI (Committee on the Safety of Nuclear Installations) committees of NEA/OECD.

In order to ensure the exchange of information relevant to nuclear safety, CNCAN has a number of bi-lateral agreements with regulatory bodies from other countries. Also, CNCAN has established agreements or arrangements with neighbouring countries on notification and assistance in case of nuclear accidents.

With regard to technical assistance received from international organisations, CNCAN is a beneficiary of technical cooperation projects managed by the IAEA, at national and regional level. Through these projects, CNCAN received expert missions and support in the organisation of international and national seminars.

In the period 2009 - 2011, CNCAN and the Norwegian Radiation Protection Authority (NRPA) have funded an IAEA Extra Budgetary Programme (EBP) on safe nuclear energy in Romania. This programme was aimed at improving nuclear safety and emergency preparedness in Romania and its activities have been completed in April 2011. A new such programme *is being implemented* starting with 2013 and the associated activities include development of regulatory requirements, guidance and safety review methodologies to take account of lessons learned from Fukushima.

CNCAN has participated in various meetings organised by IAEA, WENRA and ENSREG for reviewing the implications of the Fukushima accident and for devising actions for the re-assessment of safety in the light of the lessons learned to date.

CNCAN staff has participated in the peer-review process in the implementation of the "stress tests" for European nuclear power plants and is committed to implement the resulting recommendations and suggestions. In addition, CNCAN has shared experience on the measures taken post-Fukushima not only with the European regulators, but also with the CNSC and with the other regulators from countries operating CANDU nuclear power plants (in the framework of the CANDU Senior Regulators' Group).

CNCAN will continue to participate in the regulatory groups working on action plans for improving safety at international level, as well as in technical cooperation activities aimed at disseminating and acting upon lessons learned from the Fukushima accident. Also, CNCAN will consider benefitting from relevant peer-review services provided by the IAEA, in addition to the IRRS missions.

The licensee maintains close cooperation with organisations such as IAEA, WANO, INPO, COG, FORATOM, etc. and participates in the industry technical working groups in charge of evaluating the factors that contributed to the Fukushima accident and the lessons learned. In addition, the licensee will continue to benefit from international peer-reviews and participate in international cooperation activities aimed at improving nuclear safety and emergency preparedness and response.

PART III

Conclusions and generic activities

The main safety re-assessments performed by Romania after the Fukushima accident have been based on the ENSREG "stress test" specifications and WANO SOER 2011-02 recommendations.

Table 1 provides a summary of all the improvement measures identified in the national action plan. As of the end of December 2014, the status of the completion of improvement measures is as follows:

- *Implemented: actions 1, 2, 3, 4, 6, 7, 8, 9, 11, 12, 13, 14, 16, 17, 18, 19, 20, 21, 22, 23, 26, 27, 29, 30, 34, 35, 37, 38, 39, 41, 42.*
- *In progress: actions 5, 15, 24, 25, 28, 31, 32, 33, 36, 40, 43 (continuous activity).*
- *Planned: action 10.*

CNCAN monitors the development of lessons learned from the Fukushima accident and of the generic actions arising from regulatory and industry safety reviews and will update its national action plan as necessary to reflect any relevant and applicable new information.

PART IV

The Romanian National Action Plan is summarised in Table 1, which provides an outline of the main improvement activities resulting from the post-Fukushima safety reviews performed to date. The table identifies, for each action, the organisation(s) responsible for implementation (SNN - the licensee, CNCAN, or both), the status of the action (implemented, in progress, planned or under evaluation) and the target date for completion.

The correlation between the national actions in Table 1 and the actions outlined in the "stress test" peer-review report for Romania and in the compilation of generic recommendations isued by ENSREG is provided in Tables 2, and 3, respectively.

The National Action Plan is not a frozen document. It will be reviewed periodically and updated to reflect progress in its implementation, as well as any necessary changes to reflect new knowledge and experience.

Table 1 – Romanian Action Plan post-Fukushima - Summary of improvement activities – December 2014 update

Action	Responsible for implementation	Status	Target date for implementation	*Details*
Topic 1 – External events (earthquakes, floods and extreme weather conditions)				
1. Review the specific procedure which is in place for extreme weather conditions in order to include the appropriate proactive actions for plant shutdown.	SNN (licensee)	Implemented	-	*This action was finalized in 2011.*
2. Identification of potential measures to improve protection against flooding.	SNN (licensee)	Implemented	-	*This action was finalized in 2011.*
3. Provision of on-site of sand bags to be used as temporary flood barriers, if required.	SNN (licensee)	Implemented	-	*This action was finalized in 2011.*
4. Improvement of the seismic robustness of the existing Class I and II batteries.	SNN (licensee)	Implemented	-	*This action was finalized in 2011.*
5. Design modifications to replace selected doors with flood resistant doors and penetrations sealing (for improving the volumetric protection of the buildings containing safety related equipment located in rooms below plant	SNN (licensee)	In progress	End of 2015	*The target date for implementation was initially set for the end of 2014.* *The change of the target date for implementation was due to the complexity of the engineering solutions for*

Action	Responsible for implementation	Status	Target date for implementation	***Details***
platform level).				*penetrations' sealings.* *All identified flood resistant doors (around 50) were installed in Unit 1 and Unit 2.* *Activities to improve penetrations sealing of selected T/B rooms are in progress, as per an approved Design Modification Package. The remaining activities are introduced in the Work Management System and are monitored.*
6. The seismic walk-downs and subsequent seismic robustness analyses done as part of the seismic margin assessment have not revealed a need for any safety significant design change. However, several recommendations resulted from these inspections, which have been included in the regular plant seismic housekeeping program. These do not impact on the seismic margin assessment.	SNN (licensee)	Implemented	-	*The target date was set for the end of 2014.* *All the activities associated with safety-related recommendations raised after the seismic walk-downs are implemented at both units and consisted in:* *-strengthening of the supports of various equipment;* *-reducing the likelihood of seismic interaction by improving anchorage of various cabinets and equipment.*
7. The regulator to consider routine inspections of the flood protection design features.	CNCAN	Implemented	-	*The initial target date was set for the end of 2013.* *CNCAN has an internal instruction for performing inspections of the flood*

Action	Responsible for implementation	Status	Target date for implementation	***Details***
				protection design features of Cernavoda NPP and this has become part of the site inspectors' program of routine inspections.
8. The peer review recommended that a seismic level comparable to the SL-1 of IAEA leading to plant shutdown and inspection is established. It was suggested to the regulator to consider implementing adequate regulations. Currently the actions taken by the licensee following an earthquake are based on decision making criteria that include the estimated damage to the plant (walkdowns using a specific procedure) rather than on pre-defined level.	CNCAN	Implemented	-	*The initial target date was set for the end of 2013.* *Cernavoda NPP has established a seismic level for which the decision to shut down the plant is taken without prior inspections for assessing the damage. The decision to shut down the plant will be taken when the PGA exceeds 0.1g.* *CNCAN has elaborated a regulation on the protection of nuclear installations against external events of natural origin, based on Issue T of the 2014 WENRA RHWG Safety Reference Levels for existing reactors. This regulation has been through external consultation in 2014 and is ready for publication. It is envisaged that it will be published at the end of December 2014 or early in January 2015.*
9. Elaboration of more detailed regulatory requirements on the protection of NPPs against extreme external events, taking account of the				*The initial target date was set for the end of 2014.* *CNCAN has elaborated a regulation on*

Action	Responsible for implementation	Status	Target date for implementation	***Details***
lessons learned from the Fukushima accident and of the results of the "stress tests" peer reviews.	CNCAN	Implemented	-	*the protection of nuclear installations against external events of natural origin, based on Issue T of the 2014 WENRA RHWG Safety Reference Levels for existing reactors. This regulation has been through external consultation in 2014 and is ready for publication. It is envisaged that it will be published at the end of December 2014 or early in January 2015.*
10. The peer review concluded that there is only little information about margins to cliff edges due to external events and weak points. Further work is proposed in this area and it is recommended that CNCAN obtains good quality programmes from licensees and ensures that the work is appropriately followed up.	CNCAN	Planned	Depending on the development of a common methodology, at EU-level, for assessing margins to cliff-edge effects due to external events	*The above mentioned regulation on the protection of nuclear installations against external events of natural origin includes requirements on the assessment of the margin for cliff-edge effects. However, no guidance has been yet provided by CNCAN to the licensee on how to perform this particular type of assessment if the aim of the cliff-edge analysis is not only to demonstrate sufficient margins but also to identify the ultimate-load capacity / the ultimate failure point of safety-related structures and systems. A common methodology at EU-level, based on a joint regulatory effort, would be welcome.*

Action	Responsible for implementation	Status	Target date for implementation	*Details*
Topic 2 – Design Issues				
11. Procurement and testing of mobile equipment (e.g. mobile diesel generators, mobile pumps, connections, etc.).	SNN (licensee)	Implemented	-	*This action was finalized in 2011.*
12. Provision of a facility to open the MSSVs after a SBO.	SNN (licensee)	Implemented	-	*This action was finalized in 2011.*
13. Provision of connection facilities required to add water using fire fighters trucks and flexible conduits to supply the primary side of the RSW/RCW heat exchangers and SGs under emergency conditions.	SNN (licensee)	Implemented	-	*This action was finalized in 2011.*
14. Specific emergency operating procedures to cope with Station Blackout and Loss of Spent Fuel Pool Cooling events.	SNN (licensee)	Implemented	-	*This action was finalized in 2011.*
15. The option of charging the batteries or the installation of a supplementary uninterruptible power supply for the SCA is being considered by the licensee as a potential improvement.	SNN (licensee)	In progress	End of 2015	*In the revision 0 of the action plan, from December 2012, this action had the status "under evaluation" with the target date end of 2015. The status has been changed to "in progress" because the evaluation has been finalized and the technical*

Action	Responsible for implementation	Status	Target date for implementation	***Details***
				solution has been established. *A few options to supply plants critical parameters from SCA, during severe accident (SBO), from a seismically qualified power supply, were analyzed and documented. The solution selected for implementation was to add a new power supply to SCA instrumentation panels from 100 kW mobile Diesels, which are already procured. The new design modification was approved by the plant technical committee and its implementation is closely monitored.*
Topic 3 – Severe Accident Management and Recovery (On-Site)				
16. Validation of the station Severe Accident Management Guidelines (SAMG) through emergency exercises.	SNN (licensee)	Implemented	-	*This action was implemented in 2011 and 2012.*
17. Training for severe accident scenarios, including as part of the emergency drills.	SNN (licensee)	Implemented	-	*This action was implemented in 2011 and 2012. Refreshment training will be performed periodically.*
18. Special agreements were established with the local and national authorities				

Action	Responsible for implementation	Status	Target date for implementation	*Details*
involved in the emergency response in order to ensure that in case of a SBO coincident with loss of primary UHS the plant has absolute priority to grid re-connection and supply of light and heavy equipment and the necessary diesel fuel.	SNN (licensee)	Implemented	-	*This action was implemented in 2011.*
19. Accident management provisions for events in the spent fuel pools (natural ventilation for vapours and steam evacuation, seismically qualified fire-water pipe for water make-up).	SNN (licensee)	Implemented	-	*This action was implemented in 2011.*
20. Improvement of the existing provisions to facilitate operator actions to prevent a severe accident in SFB (water level and temperature monitoring from outside the SFB building).	SNN (licensee)	Implemented	-	*The initial target date was set for the end of 2014. The action has been completed.* *Design improvements have been implemented at both units. Water level gauges were installed to allow operators SFB level measurement in case of severe accident from an accessible location, outside the SFB building. Portable devices will be used for water temperature measurement.*
21. Installation of PARs for hydrogen management.	SNN (licensee)	Implemented	-	*The installation of PARs has been implemented in both Cernavoda NPP units. It was completed in Unit 1 in 2012 and at the end of 2013 for Unit 2.*

Action	Responsible for implementation	Status	Target date for implementation	***Details***
22. Installation of dedicated emergency containment filtered venting system for each NPP unit.	SNN (licensee)	Implemented	-	*Emergency filtered containment venting systems (EFCVS) have been installed in each Cernavoda NPP unit in 2013 - 2014, the commissioning tests have been performed, the training of the operating staff has been performed and the operating documentation has been issued and approved. The EFCV systems for both units are operational.*
23. Additional instrumentation for SA management e.g. hydrogen concentration monitoring in different areas of the reactor building.	SNN (licensee)	Implemented	-	*The action had as target date the end of 2013. It has been implemented.* *The hydrogen monitoring systems are operational in both units (they have been installed, the commissioning tests have been performed, the training of the operating staff has been performed and the operating documentation has been issued and approved.)*
24. Improvements to the reliability of existing instrumentation by qualification to SA conditions and extension of the measurement domain.	SNN (licensee)	In progress	End of 2016	*The target date for implementation was initially set for the end of 2014 and the status of the action was set as planned. The target date has been changed due to difficulties in procuring items qualified to the specifications issued by the licensee. These problems were noted in 2013, when it was found that the products available on the market are not generally qualified*

Action	Responsible for implementation	Status	Target date for implementation	*Details*
				for long term survivability and functionality under severe accident conditions (e.g. radiation fields, temperatures, etc.). This issue has been highlighted on the occasion of the first peer review workshop, in April 2013, when Romania mentioned the qualification of instrumentation and monitoring under severe accident conditions (especially in the long term) as a challenge. *Since 2013, the manufactures/suppliers have adapted to the demand for equipment qualified for severe accidents conditions, as required post-Fukushima, so the licensee could identify suitable suppliers.* *The action is now in progress and the actual status of the design changes implementation is as follows:* *-monitoring of R/B pressure - is fully implemented at both units,* *For the remaining modifications:* *- monitoring of Calandria Vault level,* *-monitoring of Calandria Vessel (moderator) level, and*

Action	Responsible for implementation	Status	Target date for implementation	*Details*
				-monitoring of Heat Transport temperature, *at Unit 1 the new required cables through R/B penetrations were installed, and the remaining activities will be implemented in 2016 Planned Outage. At Unit 2, the same design changes are scheduled to begin in the 2015 Planned Outage.*
25. Implementation of a design modification for water make-up to the calandria vessel and the calandria vault (completed for Unit 2 calandria vessel).	SNN (licensee)	Implemented for Unit 1 In progress for Unit 2	Mid 2015	*The target date for the completion of all the associated design changes was initially set for the end of 2013, based on the conceptual design modification packages.* *At Unit 1, all the necessary permanent modifications have been implemented.* *At Unit 2, the modification for water make-up to the calandria vessel is partially implemented; it will be finalized during the planned outage of Unit 2, in 2015. This modification was delayed because the installation of a certain valve requires plant shutdown state.* *Compensatory actions are in place to ensure the function of water make-up to the Calandria vessel can be performed, if required, even if the permanent*

Action	Responsible for implementation	Status	Target date for implementation	***Details***
				modification is not yet completed.
26. Verification of the completeness of event-based and symptom-based EOPs for all accident situations.	SNN (licensee) CNCAN	Implemented	-	*The initial target date was set for the end of 2013. The action was completed in 2013 and 2014. In 2013, the licensee performed its own self-assessment of the completeness of EOPs. In January 2014, CNCAN issued a regulation on the response to transients, accidents and emergency situations at NPPs and the compliance with this regulation was demonstrated by the licensee and verified by the regulator in 2014.*
27. Severe accident management requirements to be included in a regulation.	CNCAN	Implemented	-	*The initial target date was set for the end of 2013. In January 2014, CNCAN issued a regulation on the response to transients, accidents and emergency situations at NPPs. This regulation includes requirements on severe accident management.*
28. MCR habitability analysis to be continued (e.g. assessment of total core melt with voluntary venting, implementation of close ventilation circuit with oxygen supply).	SNN (licensee)	In progress	Mid 2015	*The initial target date for the completion of the action was set for the end of 2014, with the status set to planned. The target date was changed due to delays in the procedure for contracting the necessary studies from external companies.* *The preliminary results of the analysis*

Action	**Responsible for implementation**	**Status**	**Target date for implementation**	***Details***
				have been submitted to CNCAN for information in December 2014. *Note: Unit 2 has already a close ventilation circuit with oxygen supply, implemented as part of the original design.*
29. Review of Level 1 PSA & completion of Level 2 PSA (to include SFB accidents).	SNN (licensee)	Implemented	-	*The action has been finalized in 2013 as planned.*
30. Measures have been identified (and will be implemented) that aim to improve the reliability of the: (i) communication system and, (ii) on-site emergency control centre.	SNN (licensee)	Implemented	-	*The action has been finalized in 2013 as planned.*
31. Cernavoda NPP will establish a new seismically qualified location for the on-site emergency control centre and the fire fighters. This location will include important intervention equipment (mobile DGs, mobile diesel engine pumps, fire-fighter engines, radiological emergency vehicles, heavy equipment to unblock roads, etc) and will be protected against all external hazards.	SNN (licensee)	In progress	End of 2017	*The target date was initially set for the end of 2015. It was changed due to legal and administrative issues, related to transfer of property of the physical location.* *Until the completion of the action, equivalent measures have been implemented to ensure that all intervention equipment (mobile Diesels, Diesel fire pump, fire trucks, and so) are protected from external hazards (e.g. the*

Action	Responsible for implementation	Status	Target date for implementation	***Details***
				equipment have been relocated so that they would not be impaired by external events).
32. Review of SAMGs taking account of plant modifications and upgrades performed after Fukushima.	SNN (licensee) CNCAN	In progress	Mid 2015	*The SAMGs have been reviewed and revised and in December 2014 they are in process of internal evaluation and approval by the licensee. The target date was initially set for the end of 2014, but it was moved to mid 2015, because the revised SAMGs need to be submitted to the regulator for review.*
33. The development of SAMGs specifically for shutdown states.	SNN (licensee)	In progress	End of 2015	*A common technical basis developed by a CANDU Owner Group Joint Project has been used by CNE Cernavoda to extend the site specific SAMG application to shutdown state. The procedures for Unit 1 are in process of internal evaluation and approval by the licensee, and at Unit 2 the same process will be used.*
Topic 4 – National Organisations				
34. Improvement of on-site emergency organisation.	SNN (licensee)	Implemented	-	*This action was implemented in 2011.*

Action	Responsible for implementation	Status	Target date for implementation	***Details***
35. Review of lessons learned from the Fukushima accident with regard to organisational factors and applicability to national organisations in the nuclear sector.	CNCAN SNN (licensee)	Implemented	-	*The National Strategy for Nuclear Safety and Security and the associated action plan, issued in 2014, have incorporated the lessons learned from the Fukushima accident.*
36. Implementation of recommendations from the 2011 IRRS mission.	CNCAN	In progress	End of 2015	*The initial target date was set for the end of 2013. Most of the nuclear safety related technical recommendations have been implemented.*
37. Review of the national regulatory framework for nuclear safety to identify and implement actions for improvement.	CNCAN	Implemented	-	*The initial target date was set for the end of 2014. A National Strategy for Nuclear Safety and Security has been issued in 2014 and CNCAN has a plan for revising and improving the regulatory framework. Work is in progress to incorporate the latest WENRA RHWG Safety Reference Levels into regulations. However, this is a continuous process, as the international standards are reviewed and revised periodically.*

Action	Responsible for implementation	Status	Target date for implementation	*Details*
Topic 5 – Emergency Preparedness and Response and Post-Accident Management (Off-Site)				
38. Review the existing protocol with Public Authorities in order to ensure the necessary support for the Cernavoda NPP personnel in case of severe accident, when the roads are blocked due to extreme meteorological conditions, natural disasters (earthquakes, flooding, etc.) or other traffic restrictions.	SNN (licensee)	Implemented	-	*This action was implemented in 2011.*
39. Installation of Special Communication Service phones in each Main Control Room (Intervention Support Center) and Secondary Control Area.	SNN (licensee)	Implemented	-	*This action was implemented in 2011.*
40. An alternative off-site emergency control centre is being developed.	SNN (licensee)	In progress	End of 2015	*The construction phase has been finalized. The installation of the communication and data systems is scheduled for 2015.* *The initial target date had been set for the end of 2014. It was changed due to legal and administrative issues, related to transfer of property of the physical location.*

Action	**Responsible for implementation**	**Status**	**Target date for implementation**	***Details***
41. A review of the national off-site response is in progress to take account of the lessons learned from the Fukushima accident.	CNCAN + other national authorities	Implemented	-	*This action has been implemented in 2013 – 2014. The national action plan for responding to emergency situations has been reviewed and revised.*
Topic 6 – International Cooperation				
42. Identification and consideration of additional relevant peer-review services.	CNCAN SNN (licensee)	Implemented	-	*Both CNCAN and the licensee are committed to make use of the available peer review services offered by the IAEA and by WANO.*
43. Participation in international activities for sharing experience on lessons learned from the Fukushima accident and on actions taken to improve safety.	CNCAN SNN (licensee)	In progress	Continuous activity	*This is a continuous activity, controlled by the CNE Cernavoda OPEX process. Next action for the licensee will be the participation at WANO-Paris Center workshop on "Lesson learned after Fukushima event".*

Table 2 – Correlation between the recommendations in the peer-review report for Romania and the improvement actions outlined in Table 1

#	Reference for a recommendation or suggestion in the peer review report for RO	Action item in the NAP - Table 1
1.	2.1.3 [...] The absence of a seismic level comparable to the SL-1 of IAEA leading to plant shutdown and inspection is regarded a critical issue at the background that the probability of large earthquakes occurring during the lifetime of the plant is extremely high (recurrence intervals for the Vrancea seismic zone: 50y for Mw>7.4). It is suggested to the regulator to consider implementing adequate regulations. Currently the actions taken by the licensee following an earthquake are based on decision making criteria that include the estimated damage to the plant (walkdowns using a specific procedure) rather than on pre-defined ground motion design response spectra.	Action 8
2.	2.1.3 [...] There is only little information about margins to cliff edges, weak points and no evidences that further improvements in the seismic upgrading have been considered. Further work is proposed in this area and it is recommended that the CNCAN obtains good quality programmes from the licensees and ensures that the work is appropriately followed up. 2.3.3 There is limited information about extreme weather conditions. [...]There is no information about the plant capability beyond the design basis, no identification of cliff edge effects and weak points.	Actions 9 and 10

3.	2.2.3 [...] A number of safety significant equipment is located underground and improvements of the provisions to protect them against flooding (other that the elevation of the plant platform) should be considered (volumetric protection). [...] It is suggested to the regulator to consider routine inspections of the flood protection design features. 2.2.2.4 Possible measures to increase robustness: It is suggested to consider improving the volumetric protection of the buildings containing safety related equipment located in rooms below plant platform level [...].	Actions 2, 3, 5 and 7
4.	4.2.1.2 [...] During the Country visit the utility has presented the new EOP for SBO. The verification of completeness of existing EOPs for all types of accident (multiple failures….) has been discussed as a possible area of improvement. 4.2.2.2 The following areas for improvement have been identified: - Verification of the completeness of event-based and symptom-based EOPs for all accident situations should be undertaken 4.3 [...] The following points are provided for Romania's consideration; [...] − Verify the completeness of event-based and symptom-based EOPs for all accidental situations.	Actions 26

5.	4.2.1.2 [...] The current SAMGs are only applicable to the at-power state of reactor. Romania considers the at power SAMGs would still provide valuable guidance to respond to an accident that originated from a shutdown condition, because severe accident phenomena are largely independent of the initial state of the plant. However, the development of SAMGs specifically for shutdown states is under consideration. 4.2.2.2 The following areas for improvement have been identified: [...] − Further study is required for shutdown states. Including: SAMGs development, identification of possible weakness in case of external event ... 4.3 [...] The following points are provided for Romania's consideration; − The licensee should examine, for particular plant shutdown states, any possible weaknesses of the Cernavoda NPPs in agreement with the stress test specifications. − SAMGs for shutdown states should be developed (it is noted that it is under consideration)	Action 33
6.	4.2.1.5 The habitability of the MCR and SCA was assessed for various types of accidents (such as limited core damage with containment isolation failure or SA with no containment failure) and it is concluded, that all (five) shift crews can perform their work either from the MCR or from the SCA without exceeding an integrated dose of 100 mSv in the seven days following an accident. However, the case of a total core melt accident associated to a containment failure (or voluntary venting) has not been assessed. 4.2.2.2 The following areas for improvement have been identified: [...] − MCR habitability analysis to be continued (e.g. implementation of a close ventilation circuit with oxygen supply)	Action 28

7.	4.3 [...] The following points are provided for Romania's consideration; [...] − CNCAN should finalize the incorporation of severe accident management requirements in the Romanian regulation and, if possible, some qualitative or quantitative safety objectives related to the protection of the population. This should be done for existing power plants. Such objectives should then, in response to the continuous plant safety improvement, be incremented at each PSR	Action 27

Table 3 – Correlation between the generic recommendations compiled by ENSREG and the improvement actions outlined in Table 1

#	Reference in the Compilation of Recommendations and Suggestions from the Review of the European Stress Tests	Action item in the NAP - Table 1 / comments
1.	**2.1. European guidance on assessment of natural hazards and margins** [...] The peer review Board recommends that WENRA, involving the best available expertise from Europe, develop guidance on natural hazards assessments, including earthquake, flooding and extreme weather conditions, as well as corresponding guidance on the assessment of margins beyond the design basis and cliff-edge effects.	Actions 9 and 10 CNCAN is a member of WENRA and is following the developments of the dedicated working groups.
2.	**2.2. Periodic Safety Review** [...] The peer review Board recommends that ENSREG underline the importance of periodic safety review. In particular, ENSREG should highlight the necessity to reevaluate natural hazards and relevant plant provisions as often as appropriate but at least every 10 years.	Implemented This is a mandatory requirement in Romania. A regulation on PSR was issued in 2006. The first PSR for Cernavoda NPP Unit 1 has been completed in 2012.
3.	**2.3. Containment integrity** [...] Urgent implementation of the recognised measures to protect containment integrity is a finding of the peer	Actions 21 and 22 (*installation of PARs and of emergency filtered containment venting systems has been completed for both Cernavoda NPP units*).

	review that national regulators should consider.	
4.	**2.4. Prevention of accidents resulting from natural hazards and limiting their consequences** [...] Necessary implementation of measures allowing prevention of accidents and limitation of their consequences in case of extreme natural hazards is a finding of the peer review that national regulators should consider.	Actions 1 - 14, 18, 25 - 27, 30, 31, 37 - 39, 41 *A regulation on the protection of nuclear installations against external events of natural origin, based on the WENRA Safety Reference Levels in Issue T, has been elaborated and is ready for publication as of December 2014 (it is expected to be published at the end of December 2014 or in the beginning of January 2015).*
5.	**3.1.1 Hazard Frequency** The use a return frequency of 10^{-4} per annum (0.1g minimum peak ground acceleration for earthquakes) for plant reviews/back-fitting with respect to external hazards safety cases.	Implemented Based on the seismic margin assessment performed for Cernavoda NPP, all SSCs which are part of the safe shutdown path after an earthquake would continue to perform their safety function up to a PGA corresponding to an earthquake having an estimated frequency of 5E-5 events/year.
6.	**3.1.2 Secondary Effects of Earthquakes** The possible secondary effects of seismic events, such as flood or fire arising as a result of the event, in future assessments.	Implemented The secondary effects of earthquakes have been considered in the safety reviews performed for the "stress tests" and in response to WANO SOER 2011-02.
7.	**3.1.3 Protected Volume Approach** The use a protected volume approach to demonstrate flood protection for identified rooms or spaces.	Actions 2, 3, 5 and 7

8.	**3.1.4 Early Warning Notifications** The implementation of advanced warning systems for deteriorating weather, as well as the provision of appropriate procedures to be followed by operators when warnings are made.	Implemented Protocols are in place with the National Meteorological Administration and the procedure for responding to extreme weather events has been reviewed and revised (see Action 1).
9.	**3.1.5 Seismic Monitoring** The installation of seismic monitoring systems with related procedures and training.	Implemented
10.	**3.1.6 Qualified Walkdowns** The development of standards to address qualified plant walkdowns with regard to earthquake, flooding and extreme weather – to provide a more systematic search for non-conformities and correct them (e.g. appropriate storage of equipment, particularly for temporary and mobile plant and tools used to mitigate beyond design basis (BDB) external events).	Implemented
11.	**3.1.7 Flooding Margin Assessments** The analysis of incrementally increased flood levels beyond the design basis and identification of potential improvements, as required by the initial ENSREG specification for the stress tests.	Implemented (described in the national stress test report issued in December 2011)
12.	**3.1.8 External Hazard Margins** In conjunction with recommendation 2.1 and 3.1.7, the formal assessment of margins for all external hazards including, seismic, flooding and severe weather, and identification of potential improvements.	Action 10

13.	**3.2.1 Alternate Cooling and Heat Sink** The provision of alternative means of cooling including alternate heat sinks. Examples include steam generator (SG) gravity alternative feeding, alternate tanks or wells on the site, air-cooled cooling towers or water sources in the vicinity (reservoir, lakes, etc) as an additional way of enabling core cooling.	Implemented (described in the national stress test report issued in December 2011)
14.	**3.2.2 AC Power Supplies** The enhancement of the on-site and off-site power supplies. Examples include adding layers of emergency power, adding independent and dedicated backup sources, the enhancement of the grid through agreements with the grid operator on rapid restoration of off-site power, additional and/or reinforced off-site power connections, arrangements for black start of co-located or nearby gas or hydro plants, replacing standard ceramic based items with plastic or other material that are more resistant to a seismic event. Another example is the possible utilization of generator load shedding and house load operation for increased robustness, however, before introducing such arrangements the risks need to be properly understood.	Implemented (described in the national stress test report issued in December 2011) See also Actions 11 and 18
15.	**3.2.3 DC Power Supplies** The enhancement of the DC power supply. Examples include improving the battery discharge time by upgrading the existing battery, changing/diversifying battery type (increasing resistance to common-mode failures), providing spare/replacement batteries, implementing well-prepared load shedding/ staggering strategies, performing real load testing and on-line monitoring of the status of the batteries and preparing dedicated recharging options (e. g.	Actions 4 and 15

	using portable generators).	
16.	**3.2.4 Operational and Preparatory Actions** Implementation of operational or preparatory actions with respect to the availability of operational consumables. Examples include, ensuring the supply of consumables such as fuel, lubrication oil, and water and ensuring adequate equipment, procedures, surveillance, drills and arrangements for the resupply from off-site are in place.	Implemented (described in the national stress test report issued in December 2011)
17.	**3.2.5 Instrumentation and Monitoring** The enhancement of instrumentation and monitoring. Examples include separate instrumentation and/or power sources to enable monitoring of essential parameters under any circumstances for accident management and the ability to measure specific important parameters based on passive and simple principles.	Actions 20, 23 and 24
18.	**3.2.6 Shutdown Improvements** The enhancement of safety in shutdown states and mid-loop operation. Examples of improvements include, reducing or prohibiting mid-loop operation, adding dedicated hardware, procedures and drills, the use of other available water sources (e. g. from hydro-accumulators), requiring the availability of SGs during shutdown operations and the availability of feedwater in all modes.	Action 33 *Due to design differences between CANDU and PWR, the safety precautions for the shutdown state are different. The "Outage Heat Sink Manual" provides the heat sink configurations for all the shutdown conditions (for both normal and abnormal conditions). This includes provisions for having two means for residual heat removal available at all times, one "primary heat sink" (shutdown cooling system) and one alternate heat sink provided by SGs and feedwater during shutdown state. Reference is made to Action 33 in Table 1 only because it addresses development of SAMGs for shutdown states.*
19.	**3.2.7 Reactor Coolant Pump Seals**	This is not considered applicable, due to specific CANDU design

	The use of temperature-resistant (leak-proof) primary pump seals.	features.
20.	**3.2.8 Ventilation** The enhancement of ventilation capacity during SBO to ensure equipment operability.	This is not considered applicable, due to specific CANDU design features.
21.	**3.2.9 Main and Emergency Control Rooms** The enhancement of the main control room (MCR), the emergency control room (ECR) and emergency control centre (ECC) to ensure continued operability and adequate habitability conditions in the event of a station black-out (SBO) and in the event of the loss of DC (this also applies to Topic 3 recommendations).	Implemented
22.	**3.2.10 Spent Fuel Pool** The improvement of the robustness of the spent fuel pool (SFP). Examples include reassessment/upgrading SFP structural integrity, installation of qualified and power-independent monitoring, provisions for redundant and diverse sources of additional coolant resistant to external hazards (with procedures and drills), design of pools that prevents drainage, the use of racks made of borated steel to enable cooling with fresh (unborated) water without having to worry about possible recriticality, redundant and independent SFP cooling systems, provision for additional heat exchangers (e. g. submerged in the SFP), an external connection for refilling of the SFP (to reduce the need for an approach linked to high doses in the event of the water falling to a very low level) and the possibility of venting steam in a case of boiling in the SFP.	Implemented (described in the national stress test report issued in December 2011) See also Actions 19 and 20

23.	**3.2.11 Separation and Independence** The enhancement of the functional separation and independence of safety systems. Examples include the elimination of full dependence of important safety functions on auxiliary systems such as service water and the introduction of an alternate source of cooling.	Implemented (described in the national stress test report issued in December 2011)
24.	**3.2.12 Flow Path and Access Availability** The verification of assured flow paths and access under SBO conditions. Ensure that the state in which isolation valves fail and remain, when motive and control power is lost, is carefully considered to maximise safety. Enhance and extend the availability of DC power and instrument air (e. g. by installing additional or larger accumulators on the valves). Ensure access to critical equipment in all circumstances, specifically when electrically operated turnstiles are interlocked.	Implemented (described in the national stress test report issued in December 2011)
25.	**3.2.13 Mobile Devices** The provision of mobile pumps, power supplies and air compressors with prepared quick connections, procedures, and staff training with drills. Mobile devices are intended to enable the use of existing safety equipment, enable direct feeding of the primary or secondary side, allow extended use of instrumentation and operation of controls, allow effective fire-fighting, and ensure continued emergency lighting. The equipment should be stored in locations that are safe and secure even in the event of general devastation caused by events significantly beyond the design basis (this also applies to Topic 3 recommendations).	Implemented (described in the national stress test report issued in December 2011) See also Actions 11, 13 and 31

26.	**3.2.14 Bunkered/Hardened Systems** The provision for a bunkered or "hardened" system to provide an additional level of protection with trained staff and procedures designed to cope with a wide variety of extreme events including those beyond the design basis (this also applies to Topic 3 recommendations).	Action 31
27.	**3.2.15 Multiple Accidents** The enhancement of the capability for addressing accidents occurring simultaneously on all plants of the site. Examples include assuring preparedness and sufficient supplies, adding mobile devices and fire trucks and increasing the number of trained and qualified staff (this also applies to Topic 3 recommendations).	Implemented (described in the national stress test report issued in December 2011)
28.	**3.2.16 Equipment Inspection and Training Programs** The establishment of regular programs for inspections to ensure that a variety of additional equipment and mobile devices are properly installed and maintained, particularly for temporary and mobile equipment and tools used for mitigation of BDB external events. Development of relevant staff training programmes for deployment of such devices.	Implemented

29.	**3.2.17 Further Studies to Address Uncertainties** The performance of further studies in areas where there are uncertainties. Uncertainties may exist in the following areas: • The integrity of the SFP and its liner in the event of boiling or external impact. • The functionality of control equipment (feedwater control valves and SG relief valves, main steam safety valves, isolation condenser flow path, containment isolation valves as well as depressurisation valves) during the SBO to ensure that cooling using natural circulation would not be interrupted in a SBO (this is partially addressed in recommendation 3.2.10). • The performance of additional studies to assess operation in the event of widespread damage, for example, the need different equipment (e.g. bulldozers) to clear the route to the most critical locations or equipment. This includes the logistics of the external support and related arrangements (storage of equipment, use of national defence resources, etc.).	These are considered covered by the reviews already performed and actions taken in the framework of the "stress tests".
30.	**3.3.1 WENRA Reference Levels** The incorporation of the WENRA reference levels related to severe accident management (SAM) into their national legal frameworks, and ensure their implementation in the installations as soon as possible. This would include: • Hydrogen mitigation in the containment - Demonstration of the feasibility and implementation of mitigation measures to prevent massive explosions in case of severe	Actions 21 - 25 and 27 *The WENRA Safety Reference Levels related to severe accident management (Issue LM) have been incorporated into the national legal framework.* • *PARs have been installed in Cernavoda NPP Units 1 and 2.* • *Hydrogen monitoring systems have been installed in both units.*

	accidents. • Hydrogen monitoring system - Installation of qualified monitoring of the hydrogen concentration in order to avoid dangerous actions when concentrations that allow an explosion exist. • Reliable depressurization of the reactor coolant system – Hardware provisions with sufficient capacity and reliability to allow reactor coolant system depressurization to prevent high-pressure melt ejection and early containment failure, as well as to allow injection of coolant from low pressure sources. • Containment overpressure protection - Containment venting via the filters designed for severe accident conditions. • Molten corium stabilization - Analysis and selection of feasible strategies and implementation of provisions against containment degradation by molten corium.	• *High pressure core melt ejection scenarios do not exist as a challenge for a CANDU reactor. Primary heat transport system depressurization (either directly through a break in the system or indirectly via automatic depressurization of the secondary side by the opening of the main steam safety valves) occurs well before the potential formation of molten corium conditions. Even if the engineered depressurization mechanisms would fail, fuel overheating will cause a limited number of fuel channels to fail, depressurizing the PHT. Thus, the fuel channels of the CANDU-6 reactor act as 'pressure relief fuses' should an accident evolve and produce high PHT pressure and elevated PHT coolant temperature.* • *Emergency filtered containment venting systems have been installed in both units.* • *Design modifications have been implemented in both units to allow for water make-up to the calandria vessel and the calandria vault in case of severe accidents, to provide for the in-vessel retention of molten corium.*
31.	**3.3.2 SAM Hardware Provisions** Adequate hardware provisions that will survive external hazards (e.g. by means of qualification against extreme external hazards, storage in a safe location) and the severe accident environment (e.g. engineering substantiation and/or qualification against high pressures, temperatures, radiation levels, etc), in place, to perform the selected strategies.	Actions 21 - 25, 27 and 31

32.	**3.3.3 Review of SAM Provisions Following Severe External Events** The systematic review of SAM provisions focusing on the availability and appropriate operation of plant equipment in the relevant circumstances, taking account of accident initiating events, in particular extreme external hazards and the potential harsh working environment.	Actions 27 and 32
33.	**3.3.4 Enhancement of Severe Accident Management Guidelines (SAMG)** In conjunction with the recommendation 2.4, the enhancement of SAMGs taking into account additional scenarios, including, a significantly damaged infrastructure, including the disruption of plant level, corporate-level and national-level communication, long-duration accidents (several days) and accidents affecting multiple units and nearby industrial facilities at the same time.	Action 32
34.	**3.3.5 SAMG Validation** The validation of the enhanced SAMGs.	To be considered, depending on the outcome of Action 32 and to the extent practicable given the recommendations in para. 3.3.4 of the ENSREG compilation of recommendations.
35.	**3.3.6 SAM Exercises** Exercises aimed at checking the adequacy of SAM procedures and organizational measures, including extended aspects such as the need for corporate and nation level coordinated arrangements and long-duration events.	Actions 16, 17, 41.

36.	**3.3.7 SAM Training** Regular and realistic SAM training exercises aimed at training staff. Training exercises should include the use of equipment and the consideration of multi-unit accidents and long-duration events. The use of the existing NPP simulators is considered as being a useful tool but needs to be enhanced to cover all possible accident scenarios.	Action 17
37.	**3.3.8 Extension of SAMGs to All Plant States** The extension of existing SAMGs to all plant states (full and low-power, shutdown), including accidents initiated in SFPs.	Actions 27 and 33 The SFP design, the modifications implemented post-Fukushima and the existing emergency operating procedure for response to loss-of-cooling to the SFP events preclude the need for SAMGs for the SFP.
38.	**3.3.9 Improved Communications** The improvement of communication systems, both internal and external, including transfer of severe accident related plant parameters and radiological data to all emergency and technical support centre and regulatory premises.	Actions 30 and 39
39.	**3.3.10 Presence of Hydrogen in Unexpected Places** The preparation for the potential for migration of hydrogen, with adequate countermeasures, into spaces beyond where it is produced in the primary containment, as well as hydrogen production in SFPs.	Actions 19, 21 and 23
40.	**3.3.11 Large Volumes of Contaminated Water** The conceptual preparations of solutions for post-accident contamination and the treatment of potentially large volumes of contaminated water.	To be considered, taking account of developments in international guidelines on this matter.

41.	**3.3.12 Radiation Protection** The provision for radiation protection of operators and all other staff involved in the SAM and emergency arrangements.	Implemented See also Action 28
42.	**3.3.13 On Site Emergency Center** The provision of an on-site emergency center protected against severe natural hazards and radioactive releases, allowing operators to stay onsite to manage a severe accident.	Actions 30 and 31
43.	**3.3.14 Support to Local Operators** Rescue teams and adequate equipment to be quickly brought on site in order to provide support to local operators in case of a severe situation.	Actions 31, 34, 38 and 41
44.	**3.3.15 Level 2 Probabilistic Safety Assessments (PSAs)** A comprehensive Level 2 PSA as a tool for the identification of plant vulnerabilities, quantification of potential releases, determination of candidate high-level actions and their effects and prioritizing the order of proposed safety improvements. Although PSA is an essential tool for screening and prioritizing improvements and for assessing the completeness of SAM implementation, low numerical risk estimates should not be used as the basis for excluding scenarios from consideration of SAM especially if the consequences are very high.	Action 29

45.	**3.3.16 Severe Accident Studies** The performance of further studies to improve SAMGs. Examples of areas that could be improved with further studies include: • The availability of safety functions required for SAM under different circumstances. • Accident timing, including core melt, reactor pressure vessel (RPV) failure, basemat melt-through, SFP fuel uncovery, etc. • PSA analysis, including all plant states and external events for PSA levels 1 and 2. • Radiological conditions on the site and associated provisions necessary to ensure MCR and ECR habitability as well as the feasibility of AM measures in severe accident conditions, multi-unit accidents, containment venting, etc. • Core cooling modes prior to RPV failure and of re-criticality issues for partly damaged cores, with un-borated water supply. • Phenomena associated with cavity flooding and related steam explosion risks. • Engineered solutions regarding molten corium cooling and prevention of basemat melt-through. • Severe accident simulators appropriate for NPP staff training.	Implemented as described in the national stress test report issued in December 2011. In addition, see Actions 27 - 29 and 32 - 33.

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LIST OF ACRONYMS

AC	Alternating Current
CANDU	Canadian Deuterium Uranium
CL I/II/III/IV	Class I/II/III/IV electrical power
CNCAN	National Commission for Nuclear Activities Control
CNS	Convention on Nuclear Safety
COG	CANDU Owners Group
DBE	Design Basis Earthquake
DC	Direct Current
DG	Diesel Generator
EFCVS	Emergency Filtered Containment Venting System
EOP	Emergency Operating Procedure
EPS	Emergency Power Supply
EWS	Emergency Water Supply
HCLPF	High Confidence Low Probability of Failure
IAEA	International Atomic Energy Agency
INPO	Institute of Nuclear Power Operations
MCR	Main Control Room
MSSVs	Main Steam Safety Valves
NPP	Nuclear Power Plant
PARs	Passive Auto-Catalytic Recombiners
PHWR	Pressurized Heavy Water Reactor
PSHA	Probabilistic Seismic Hazard Assessment
R/B	Reactor Building
RLE	Review Level Earthquake
SAM	Severe Accident Management
SAMG	Severe Accident Management Guidance
SBO	Station Blackout
SCA	Secondary Control Area
SDG	Stand-by Diesel Generator
SFB	Spent Fuel Bay
SG	Steam Generator (boiler)
SNN	National Company Nuclearelectrica (licensee for Cernavoda NPP)
SSCs	Structures, Systems and Components
T/B	Turbine Building
TSG	Technical Support Group
UHS	Ultimate Heat Sink
WANO	World Association of Nuclear Operators