Post-
Fukushima
accident

Slovakia

Peer review country report

Stress tests performed on European nuclear power plants

ENSREG
European Nuclear Safety Regulators Group
Stress Test Peer Review Board

1 GENERAL QUALITY OF NATIONAL REPORT AND NATIONAL ASSESSMENTS

The accident at the Fukushima nuclear power plant in Japan on 11th March 2011 triggered the need for a coordinated action at EU level to identify potential further improvements of Nuclear Power Plant (NPP) safety. On 25th March 2011, the European Council concluded that the safety of all EU nuclear plants should be reviewed, on the basis of comprehensive and transparent risk and safety assessments - the stress tests. The stress tests consist of three main steps: a self-assessment by licensees, followed by an independent review by the national regulatory bodies, and by a third phase of international peer reviews. The international peer review phase consists of 3 steps: an initial desktop review, three topical reviews in parallel (covering external initiating events, loss of electrical supply and loss of ultimate heat sink, and accident management), and seventeen individual country peer reviews.

Country review reports are one of the specific deliverables of the EU stress tests peer review process. They provide information based on the present situation with respect to the topics covered by the stress tests. They contain specific recommendations to the participating Member States for their consideration or good practices that may have been identified, and to some extend information specific to each country and installation. Draft country review reports were initiated during the topical reviews based on discussions with the country involved in the three topics and on the generic discussions within each of the three topical reviews. Issues identified for each country during the topical reviews, due to only limited time available for each country, have required follow-up discussions in more detail, both between the topical reviews and the country reviews, and during the country reviews.

The current Country Report was finalized at the end of the Country Review, after final discussion with the reviewed country and visit of nuclear power plant. It is a part of the Final Report combining the results of the Topical Reviews and Country Reviews.

1.1 Compliance of the national reports with the topics defined in the ENSREG stress tests specifications

The Nuclear Regulatory Authority of the Slovak Republic – Úrad Jadrového Dozoru Slovenskej Republiky (UJD SR) – is the state regulatory authority, which performs the state supervision of the nuclear safety of nuclear installations. UJD SR prepared the National Report on the Post-Fukushima stress test for the Nuclear Power Plants in Slovakia (National Report) and submitted it to the European Commission in December 2011. The National Report is compliant with the topics defined by the ENSREG stress test specifications. The structure of the ENSREG specifications is strictly followed, which facilitates the review and the understanding of the information.

The National Report encompasses the nuclear installations in Slovakia:

- Bohunice Nuclear Power Plant (Units 3 and 4);
- Mochovce Nuclear Power Plant (Units 1 and 2);
- Mochovce Nuclear Power Plant (Units 3 and 4, under construction).

Both the Bohunice NPP (EBO) and the Mochovce NPP (EMO) are owned and operated by Slovenske Elektrarne a.s. (SE a.s.). At both sites twin units are operated. The four units in operation and the two units under construction are Water cooled, Water moderated Energy Reactors ,VVER-440/V-213 type pressurized water reactors. All the units were significantly safety upgraded, already in the design phase and throughout the plant lifetime, in comparison with the original design.

The Stress Tests assessments presented in the National Report cover the nuclear units listed above, but not the interim wet storage facility in Bohunice (which is operated separately from the NPPs and was therefore considered to be out of the scope of the ENSREG stress tests specifications). Nevertheless, UJD SR asked the license holder to perform a similar assessment for this facility as well, in parallel to the stress tests. The results of this assessment were submitted to UJD SR and are being reviewed.

1.2 Adequacy of the information supplied, consistency with the guidance provided by ENSREG

The information in the National Report is considered to be adequate and consistent with the guidance provided. The report provides sufficient information with respect to design bases of earthquakes (DBE). Study for updating of floods and extreme weather conditions for Mochovce site was done in 2011. Similar study for updating of floods and extreme weather conditions for Bohunice site is planned to be completed in 2012. For the plant assessment relative to loss of electrical power and loss of ultimate heat sink (UHS), the explanations are supported by results of analyses and exceed the expected level of detailed information. For severe accident management (SAM), an appropriate description of the ongoing program and the organisation in place is provided.

1.3 Adequacy of the assessment of compliance of the plants with their current licensing/safety case basis for the events within the scope of the stress tests

In the National Report no cases are identified where the plants were non-compliant with relevant requirements and with their design bases.

The state supervision of nuclear safety is performed in accordance to the Atomic Act No.541/2004 coll. and amendments and subsequent regulations, in particular Regulation No.430/2011 coll. on the requirements for nuclear safety and Regulation No.55/2006 coll. on details concerning emergency planning in case of nuclear incident or accident. The legislation generally covers the issues relevant to the European stress tests.

The entire set of documents that constitutes the legal basis for nuclear safety has been updated in the period 2008-2011, in line with the progress in the development of the International Atomic Energy Agency (IAEA) Safety Requirements and the established Western European Nuclear Regulators' Association (WENRA) reference levels. The Atomic Act requires to reassess the safety level of nuclear facilities and to take adequate countermeasures after obtaining new significant information about the associated risks. The obligation to perform the relevant assessment and implementation of countermeasures is put on the licence holder.

The legislative requirements for the performance of periodic safety reviews (PSR) of NPPs are stipulated in article 23 of the Atomic Act No.541/2004 coll. Details on objectives, intervals, scope of PSR, and documentation submitted to the regulatory body as well as actions required after PSR are specified in the UJD SR regulation No.33/2012 coll., which replaced the previous regulation No.49/2006 coll. Recommendations on conducting PSRs are provided in the UJD SR guide on Complex and Systematic PSR. These regulation and guide are based on the corresponding IAEA standards (NS-G-2.10) and WENRA requirements. The PSR is conducted every 10 years.

The main objectives of the PSR are to identify and analyse long term trends in plant operation by:

- Comparing the achieved nuclear safety status at the nuclear facility with current nuclear safety requirements and with good technical practice.
- Verification of the cumulative effects of nuclear facility ageing, impact of performed and planned changes to the nuclear facility, operating experience and technical development on nuclear safety,
- Specification of justified and practical changes to the nuclear facility with the objective of maintaining the required high level of nuclear safety or increasing it to the level close to that of state-of-the-art nuclear facilities in the world,
- Demonstration that the required level of nuclear safety has been ensured until the next periodic assessment or until the end of permit validity.

Based on the results of PSR, the license holder has to implement an integrated plan of corrective actions and is obliged to submit updated required documentation that includes safety analysis report, and level 1 and level 2 probabilistic safety assessments (PSAs).

The latest PSR was completed in 2008 for Bohunice NPP and in 2009 for Mochovce NPP. Based on the results of these reviews, UJD SR issued operational permit for subsequent 10 years of operation. The permits were associated with safety upgrading programs aimed at closer compliance of the safety level with enhanced safety standards.

As to the compliance of the plants with these requirements and with their design bases, the National Report states that the relevant Safety Analysis Reports (SARs) for all plants have been updated in line with the regulatory requirements and accepted by the regulatory authority. The latest update of the SAR for Bohunice NPP Units 3&4 was performed in 2009, for Mochovce NPP Units 1&2 in 2010. For Mochovce NPP Units 3&4, the Preliminary SAR was issued in 2008 and the preparation of the Pre-operational SAR is currently in progress.

1.4 Adequacy of the assessments of the robustness of the plants: situations taken into account to evaluate margins

Regarding earthquakes, all equipment included in the List of Equipment for Safe Unit Shutdown after Seismic Event (SSEL) was re-evaluated using the Seismic Margin Assessment (SMA) method. For mechanical and electrical equipment, the assessment and the upgrade were based on a conservative approach considering elastic behaviour of the structures. For the earthquakes beyond the design bases (BDB), more refined elasto-plastic structural analyses are in progress in order to define the extra margin embedded in the original conservative design assumptions. Based on the preliminary results for EBO3,4, seismic safety margins of about 20-30% are generally expected for this kind of equipment. For EMO1,2 the safety margins for systems and components of the SSEL are expected to be quantified by ongoing evaluations. The results of the evaluation of the safety margins of the civil structures have been presented during the country visit.

Regarding flooding, a conservative calculation model was prepared for the quantification of time margins and the assumption of the flooding duration for the calculation of the vulnerability to some safety equipment and respective buildings.

Due to the lack of information on resistance of Systems, Structures and Components (SSCs) to the beyond design weather conditions in the plant documentation, engineering judgement is applied to estimate the plant response. A preliminary analysis has been performed for the safe shutdown routes. An assessment of the margins between the challenges (estimated for a return period of 10,000 years) and the design values was performed.

For the plant assessment relative to loss of electrical power and loss of UHS, comprehensive assessments of the robustness of the NPPs are provided in accordance with ENSREG declarations. All operational regimes are considered when analysing Loss of Offsite Power (LOOP), Station Black-out (SBO) and loss of UHS conditions. The overall conclusions confirm the appropriate robustness of the plant and the existence of adequate safety margins, but further improvements are still proposed.

As far as the management of severe accidents and emergencies is concerned, the essential provisions, including organizational arrangements of accident management and emergency planning, the respective hardware measures, as well as procedural arrangements (symptom based Emergency Operating Procedures (EOPs) and Severe Accident Management Guidelines (SAMGs)) are presented in the National Report.

Regarding the robustness of the plant in relation to SAM, the National Report mainly describes the ongoing implementation program for SAM measures. Multi-unit accident and management in extreme external conditions will be assessed in a further step.

1.5 Regulatory treatment applied to the actions and conclusions presented in national report

The National Report was prepared on the basis of the reports provided by Slovenske Elektrarne a.s. (SE a.s.) on the nuclear units, and provides evidence that the regulatory body was fully engaged in the whole process of stress tests realization.

The current legislation provides sufficient power and flexibility for the regulatory authority to adequately address situations such as occurred in Fukushima Daichi NPP.

The task to perform “stress tests” was outlined in a regulatory authority letter on 31 of May 2011. Following this, several meetings between the operator and the regulatory authority took place regarding the “stress tests” in order to provide for common understanding of the issues. The regulatory authority assessed the report on “stress tests” provided by the utility and made independent analytical evaluations. The obligation is put on the utility to perform the relevant assessments and to implement countermeasures.

The regulatory authority supports the commitments of the operator to perform a comprehensive assessment of plant vulnerabilities and of margins for external natural hazards, as well as the implementation of additional measures for further safety enhancement of the plants.
The plants in Slovakia are being upgraded towards closer compliance with new requirements in the framework of the PSR process and also regarding the lessons learned from the Fukushima event and the conclusions of the stress tests.
The regulatory body requires to perform a comprehensive assessment of the extreme meteorological conditions and to update the corresponding parts of the SARs by taking into account new meteorological data, on-going plant upgrading measures and state-of-the-art methodology. The regulatory body asks for further systematic and comprehensive assessment of plant resistance to SBO and loss of UHS, taking into account the measures for increasing robustness of the plants. Assessment of the adequacy of already available analyses for the progression of severe accidents is required. Consideration of severe accidents occurring simultaneously at several or all reactors in the given site under conditions of severely damaged area infrastructure is also requested. The regulatory body recommends to harmonize the approaches with the operators of similar reactor types, taking into account all relevant lessons learned from the stress tests. Completion of such works is expected in about 3 years.

2 PLANT(S) ASSESSMENT RELATIVE TO EARTHQUAKES, FLOODING AND OTHER EXTREME WEATHER CONDITIONS

2.1 Description of present situation of plants in country with respect to earthquake

2.1.1 DBE

2.1.1.1 Regulatory basis for safety assessment and regulatory oversight

The general regulatory basis is summarised in section 1.3. The legislation generally covers the issues relevant to the European stress tests.
Relevant legislative provisions for external events include requirements for siting of NPPs, site exclusion criteria, protection against external events and seismicity, prevention with respect to the occurrence and progression of equipment failure, etc. Seismicity related provisions are listed in the Annex 2 of the Regulation No. 430/2011 coll. including the scope of the documents to be developed within the Seismic Hazard Analysis (SHA) process. The minimal scope of external hazards initiating events are defined by the Annex 3 of the same regulation.
All operating units in Slovakia have been subject to a number of international missions performing independent review of their safety level. In particular four IAEA missions were specifically devoted to the issue of seismic inputs and seismic upgrading of the plants.

2.1.1.2 Derivation of DBE

The DBE for the Bohunice site was specified in 1970 with I=6–6.5^0 MSK-64, which was said to correspond to M=4.2 (Richter's Magnitude) and a peak horizontal ground acceleration (PGA)=0.025g for a recurrence interval of 200 years. Data is derived from the historical Dobra Voda earthquake in 1906. Due to the estimated low DBE, no earthquake effects were considered in the original design.
The original DBE of the EBO 3,4 units has been re-evaluated in several steps since the start up of the plant in 1986 in accordance with the development of methodologies, data and safety requirements. The assessment of the seismic level of the sites was developed in accordance with IAEA recommendations. The initial design basis with PGA=0.025g has been increased through PGA=0.25 g up to the current value PGA=0.344 g (as a result of Probabilistic SHA).
For EMO1,2 the DBE was initially estimated as I=6° MSK-64 (corresponding to PGA=0.06g for a return period of 10.000 years (1978). The DBE was increased based on the IAEA recommendations to 0.1 g. Recently the seismic level of EMO1,2 has been raised to 0.143 g (based on PSA on Seismic Hazard). Subsequently the regulatory body has set up the value PGA=0.15 g as a design basis for construction of MO 3,4 and for safety upgrading of EMO 1,2 units.

2.1.1.3 Main requirements applied to this specific area

Regulation №430/2011 defines the regulatory requirements and range of assessments with respect to earthquakes which are applicable to nuclear facility siting. The minimum level of seismic loading determined at the nuclear facility site must be represented by a standard free-field horizontal response spectrum corresponding to PGA equal to 0.1 g. The requirements include also clear “site exclusion” criteria with respect to seismically active faults, liquefaction of soils, tectonic activity and other phenomena. Assessments of the DBE are given by PGAs for return periods of 475 years (SL1) and 10.000 years (SL2).

2.1.1.4 Technical background for requirement, safety assessment and regulatory oversight

The first DBE estimate for EBO 3,4 in 1970 were based on expert opinion. The assessment led to the fact that earthquake effects were not considered in the original design. Subsequently, the initial design basis with PGA=0.025g has been increased through PGA=0.25 g up to the current value PGA=0.344 g. These significant changes in the DBE are based on a Probabilistic Seismic Hazard Assessment (PSHA) from 1997. It is stated that the study was performed in accordance with the IAEA recommendations valid at that time.

During the Country visit additional information was obtained that in the development of PSHA of the EBO site (1997), the zone of the Eastern Alps with a variable magnitude of 5.8 - 6.4 MSK-64 was included. The area of the Vienna Basin Fault is also indirectly covered through the source of Dobrá Voda zone, with magnitude 6.2–6.8. The seismic monitoring systems which are installed around Bohunice and Mochovce sites recorded also micro-earthquakes in the area of the Vienna Basin Fault. Currently the EBO site is evaluated in order to define the feasibility for the construction of a new nuclear installation. The evaluation is performed in accordance with the current state of the art of geology and seismology taking into account new data from micro and macro-seismicity of the region.

For the Mohovce site, a simplified probabilistic assessment was initially performed in order to define the DBE (I = 6^0 MSK-64, PGA = 0.06g with return period of 10,000 years). The DBE was confirmed by a deterministic hazard study after an IAEA mission in 1993. The DBE was subsequently upgraded to PGA=0.1g in order to comply with IAEA safety requirements. A second IAEA mission (1998) initiated a new PSHA and a detailed geological survey aiming at the identification of potential active faults. The procedure resulted in an upgrading of the DBE to PGA=0.143g, which was reviewed by IAEA in 2003. One of the main results of the 2003 mission was a recommendation to perform observation and measurement of the potential capable geological faults, to measure recent movements and based on these results to perform an updated estimation of the seismic hazard for the site. The recommended measurements were performed in full scope and were finished in 2007. Based on the investigations it has been confirmed that the capability of the faults can be excluded. Nevertheless, a new seismic hazard value for the site has been conservatively considered at the level of 0,143g. In 2008 a PSR after 10 years of operation was commenced and this new design basis value has been one of the key aspects of the review. The regulatory body finally specified in 2011 the value PGA = 0.15g as the DBE for Mochovce site.

2.1.1.5 Periodic safety reviews

The general requirements regarding PSR are summarised in section 1.3. Based on the results of the review, the regulatory body issued operational permit for subsequent 10 years of operation. The permits are associated with a safety upgrading program aimed at closer compliance of the safety level with contemporary safety standards.

The National Report mentions that earthquakes were considered within PSRs. The regulator clarified that the latest case is the review of the DBE for EMO 1,2 within the PSR for these NPPs in 2008-2010. In this context the PGA for the site has been increased from 0.1g to 0.143 and subsequently the regulator determined the value 0.15g as new target value for the seismic reinforcement of all relevant SSCs at this site.

2.1.1.6 *Conclusions on adequacy of design basis*

Since 1980, a number of different studies related to the seismic issues were elaborated, and which were mostly reviewed by the IAEA. The regulator considers that the current assessment of the DBE for both sites is performed in accordance with the state-of-the-art knowledge as it was valid at the time of the elaboration of the studies. Based on the described methodology for re-evaluation of the DBE it could be concluded that the upgraded DBE for the Slovak NPPs is widely compliant with the current state of the art.

2.1.1.7 *Compliance of plant(s) with current requirements for design basis*

The report claims that it has been confirmed for all SSCs that they are in compliance with their current licensing basis required by the regulatory body.
After reviewing the results of PSR, the Slovak regulator issued a new operational license in 2011 where the new value as target value for seismic reinforcement 0.15g has been put as one of the license conditions. Taking into account the fact that this value is by 50% higher than the previous one and that this measure will require significant interventions in many components and civil construction structures, the deadline for implementation of this measure was set for 2018.
During the plant visit a walk-down was performed in the fire brigade building, including the garage, the new command centre and its emergency power supply room. The reviewers observed that safety relevant computer systems and the UPS for the fire brigade control centre seem to have no proper seismic reinforcement. Some components in the garage not related to the civil structure itself seem to be also vulnerable.

2.1.2 Assessment of robustness of plants beyond the design basis

2.1.2.1 *Approach used for safety margins assessment*

For both operating plants, and within the framework of the plant safety upgrade to the defined site seismic level (PGA = 0.15 or 0.344g), all equipment included in the SSEL were re-evaluated using the SMA method. Robustness of each component was determined by its High Confidence Low Probability Failure (HCLPF) (which is also expression of the safety margin of a given component) using Conservative Deterministic Failure Margin (CDFM) and GIF VVER state-of-the-art methods (EPRI NP-6041, IAEA-SSS № 28, IAEA-TECDOC-1333). The evaluation of the seismic margins have been obtained through refined elasto-plastic structural analyses.

2.1.2.2 *Main results on safety margins and cliff edge effects*

The range of earthquakes leading to severe fuel damage has been analysed. For mechanical and electrical equipment, the assessment and the upgrade was based on a conservative approach considering elastic behaviour of the structures. Assessment of civil structures included, however, moderate structural inelastic behaviour of the structures. The same assessment as made for the range to severe fuel damage is valid also for the containment. It is stated that the loss of containment integrity in EBO 3,4 units is assumed not to occur below PGA = 0.35 g, and in EMO not below 0.2 g. These numbers indicate a very small safety margin BDB for EBO as the DBE for this plant is currently assessed with PGA=0.344g. However the report does not provide a justification for the adequacy of the safety margin for the containments of both the EBO 3,4 units and EMO units. However, during the country visit it was clarified that within the project for seismic re-evaluation and reinforcement of SSCs of EBO 3,4 enveloping floor response spectrum has been applied to all of the SSCs. As a result about 80% of SSCs have additional design margins estimated to be 30% above original as a minimum.
For EMO 1,2 the safety margins for SSC) of the SSEL are expected to be quantified by the ongoing evaluations. During the country visit it was presented that for the civil structures the study for margin evaluation against PGA=0.15g is recently submitted to the regulator for approval. The similar study for the components is still under elaboration.
No specific data and assessments are provided in the report for spent fuel pools (SFPs). However, additional information has been provided during the Topical review phase.

The key issue which is defined in the report is the vulnerability of the equipment needed for plant shutdown and cooldown. Such equipment is convincingly available for the earthquakes up to the safe shutdown (design basis) earthquake, as currently specified for individual sites. For the earthquakes beyond the design basis the refined analysis of the vulnerability of the key equipment is not available and therefore particular cliff-edges cannot be quantified at this time. The report claims that based on the preliminary results, seismic safety margins of about 20-30% are generally expected for this kind of equipment.

2.1.2.3 Strong safety features and areas for safety improvement identified in the process

During the stress-test assessment it was confirmed that VVER 440/V213 reactors have a number of inherent safety features favourable for plant recovery from design bases operating events (e.g. large coolant inventories and low power density in the reactor core and high safe shutdown margin). Improvements are identified mainly in the area of safety analyses (quantification of margins for earthquakes BDB and development of seismic PSA).

In relation to the DBE levels, the conservative assessments – as based on the latest scientific information in the field – yielded in setting relatively high DBE PGA values for both sites. The corresponding reinforcements are already fully implemented at the Bohunice site and are to be implemented before the next PSR at the Mochovce site.

During the visit to the Mochovce site, the review team identified some cases where some components of no primary safety feature potentially may have indirect influence on some safety functions. It is recommended that all such cases shall be re-evaluated by the licensee and the regulator.

2.1.2.4 Possible measures to increase robustness

The report states that the robustness of the plant against earthquakes has been significantly increased during their lifetime and it is considered adequate in accordance with the current regulatory requirements. Nevertheless, according to the regulator some additional safety upgrading measures are envisaged.

2.1.2.5 Measures already decided or implemented by operators and/or required for follow-up by regulators

The following measures for quantification of margins and further improvements are envisaged:

- Finalization of quantification of margins of key SSCs for earthquakes beyond BDB earthquake;
- Completion of the works aimed at increasing of seismic resistance of EMO 1,2 from 0.1g to 0.15g.
- Development of seismic PSA;
- Review of the procedure for logistic arrangements of transport to the NPP following an extreme earthquake.

2.1.3 Peer review conclusions and recommendations specific to this area

The original DBE assessments for Slovak NPPs have been questioned and subsequently re-evaluated in several steps in accordance with the development of methodologies, data and safety requirements. Comparing the latest DBE assessments against international standards and research results as requested in the ENSREG specification shows that the described methodology for deriving and re-evaluating the DBE for the Slovak NPP sites appears to be compliant with the current state of the art. All NPPs comply with the minimum DBE level defined by the IAEA standards.

Beyond design basis capabilities of the plants are discussed in the report but particular safety margins to cliff-edges are not quantified because the refined analysis of the vulnerability of the key equipment were not available at that time. However, the conservative approach to design of particular components, which was used during calculations allowed to demonstrate additional margins. This has been shown during the country visit by studies that have been completed for civil structures.

The robustness of the plant against earthquakes has been significantly increased recently and is considered adequate in accordance with the current requirements. In addition there are some safety upgrading measures envisaged.

It is recommended to the Slovak regulator to consider monitoring the implementation of measures for quantification of margins. In order to assure a timely completion of the measures for seismic resistance of the relevant SSCs of EMO 1,2 for the newly defined Review Level Earthquake (RLE) (PGA of 0.15g) it is also recommended to the regulator to consider prioritization of the seismic upgrading measures, e.g. in respect to the fire brigade building.

2.2 Description of present situation of plants in country with respect to flood

2.2.1 DBF

2.2.1.1 Regulatory basis for safety assessment and regulatory oversight

The general regulatory basis is summarised in sections 1.3 and 2.1.1.1. Regulation 430/2011 on nuclear safety requirements defines site exclusion criteria as well as the scope of safety analysis to be performed related with external events, including provisions related to flooding.

2.2.1.2 Derivation of DBF

Initially the design basis flood was not specified in the design documentation due to the specific favourable location of both sites far from and well above rivers. However, potential sources of flooding, and in particular a strong rainfall, were postulated. Within the stress tests, all other potential causes of flooding were evaluated, too. A seismic event with subsequent internal floods was also considered.

2.2.1.3 Main requirements applied to this specific area

Main requirements applied to the specific area of flooding are included in the Regulation 430/2011. The requirements of the Slovak regulatory body are not quantitative; however they are compliant with the IAEA Safety Standards.

2.2.1.4 Technical background for requirement, safety assessment and regulatory oversight

A deterministic approach is used during the safety assessment process. The following potential sources of flooding were evaluated: surface water sources (rivers, large water areas); failure of dams; ground water; extreme precipitation; internal floods caused by earthquake. The assessment of the extreme precipitation values for Mochovce site was done by extrapolation of historical time series of rainfall intensities in Slovakia using Depth Duration Frequency (DDF) curves. A similar meteorological study for the Bohunice site is mentioned to be in preparation in order to update the original design values.

2.2.1.5 Periodic safety reviews

The general requirements regarding PSR are summarised in sections 1.3 and 2.1.1.5. No specific information with respect to flood was provided in the report. However, during the Country review it was clarified that some measures have been considered for updating of SARs for EBO 3,4 and EMO 1,2 units with respect to flooding.

2.2.1.6 Conclusions on adequacy of design basis

The report claims that no protection against external sources of the site flooding is needed, except adequately designed capacity and ensured operability of the sewer system in order to cope with the extreme precipitation. Updated meteorological studies, however, indicate that initial design basis for maximum precipitation might be reconsidered. This reconsideration has been already taken into account in implementing upgrading design measures against flooding of safety important buildings.

2.2.1.7 Compliance of plant(s) with current requirements for design basis

External flooding was not postulated within the original design basis of EBO 3,4 and EMO 1,2. For MO 3,4 external flooding has been included in the plant design basis and therefore properly taken into account in the design of the units. Plant civil structures where safety important systems and components are located are adequately protected including newly conservative estimated level of potential external flooding. Conclusion of the report is that plans are in compliance with the original licensing bases and actions have been taken to strengthen their level of protection in order to cope with newly defined external threats of flooding. Based on the new meteorological data already available for Mochovce site and under development for Bohunice site it seems appropriate to reconsider the original design basis accordingly.

2.2.2 Assessment of robustness of plants beyond the design basis

2.2.2.1 Approach used for safety margins assessment

The report states that a very conservative calculation model was prepared for quantification of time margins and assumption of flooding duration for calculation of the vulnerability to some safety equipment and respective buildings. However, the approach used for systematic assessment of safety margins is not satisfactory described in the National Report. During the country visit additional clarification has been provided.

2.2.2.2 Main results on safety margins and cliff edge effects

The assessment of the extreme precipitation values for Mochovce site was done by extrapolation of historical time series of rainfall intensities in Slovakia using DDF curves. As a result of the assessment the recommended extreme values of meteorological parameters were defined for the return periods of 100 years and 10,000 years. In case of extreme precipitation the water level flowing around the civil structures could reach maximum height 74mm.
Similar meteorological study for Bohunice site is also under preparation in order to update the original design values. In the report is mentioned that it is expected to estimate more substantial difference in comparison with EBO3,4 design value of 65 l/s/ha and subsequently the capacity of the drainage system can be questioned. In Bohunice, the protection against external floods is less robust than in Mochovce, but taking into account the temporary measures already implemented, the margins are also sufficient, capable to protect plant SSCs against extreme rain with a return period of 10,000 years.
The report claims that no mechanism has been identified in the assessment which would lead to sudden flooding resulting in irreversible loss of safety function. Certain site flooding is only possible due to unlikely extreme precipitation combined with complete blockage of the sewer system and neglecting staff actions. This process would be gradually developing in time thus offering opportunities for recovery.
In Mochovce the existing margins are already so large that all potential cliff-edges can be convincingly screened out. In Bohunice, in the case of combination of flooding and loss of all sources of external power supply and no countermeasures taken, the availability of Diesel Generators (DGs) is vital. The vulnerability of DG station to flooding can be assumed above about 20 cm of constant level of water around the DG building, which is identified as a cliff-edge. This is however about 2-times higher than the extreme estimated value of the flooding.

2.2.2.3 Strong safety features and areas for safety improvement identified in the process

According to the report the NPPs in Slovakia are protected to some extend from flood hazard due to specific favourable location of both nuclear sites. Nevertheless, potential sources of flooding, and in particular a strong rainfall, were postulated and further evaluated.
Possible improvements are identified mainly in the area of safety analyses in order to reconsider the original design basis for Bohunice (new meteorological studies related to extreme precipitation), updating of different procedures, strengthening capability of buildings to prevent penetration of water and purchasing of different mobile equipment.

2.2.2.4 Possible measures to increase robustness

Based on the conclusions of the stress tests report, an action plan for implementation of both short term and long term corrective measures to increase plant robustness against flooding with defined deadlines for implementation has been developed and agreed by the regulator. The following measures are identified in the report:

- Finalization of the new meteorological study for Bohunice site in order to determine the maximum possible site flooding due to extreme precipitation.
- Subsequent updating of the Preoperational SAR for EBO 3,4 and EMO 1,2;
- Updating of different procedures related to flooding;
- Purchasing of different types of mobile pumps;
- Upgrading of the flooding protection of safety important buildings at Bohunice site.

2.2.2.5 Measures already decided or implemented by operators and/or required for follow-up by regulators

Based on the analysis, certain protective measures were promptly implemented during the period of stress tests (e.g. temporary passive protection of the reactor building and DG station).

2.2.3 Peer review conclusions and recommendations specific to this area

The flooding against which the plants are designed is defined for each plant. All relevant sources of flooding were considered. The strong rainfalls were defined to be the only potential sources of flooding. The approach used for the assessment of the Design Basis Flood (DBF) appears to be reasonable in compliance with the international standards. The protection against the DBF is adequate mainly due to relatively high altitude difference between the sites and nearby rivers.
A conservative calculation model was prepared for quantification of time margins and assumption of flooding duration for calculation of the vulnerability to some safety equipment and respective buildings. Large margins were proven at the Mochovce site. Bohunice site has a less favourable terrain shape with respect to flooding, but the margins were still assessed as adequate.
It is recommended that the Slovak regulator should consider monitoring the implementation of the measures for strengthening of the level of protection of the plants against flooding.

2.3 Description of present situation of plants in country with respect to extreme weather

2.3.1 DB Extreme Weather

2.3.1.1 Regulatory basis for safety assessment and regulatory oversight

The general regulatory basis is summarised in sections 1.3 and 2.1.1.1. In the Regulation 430/2011 on nuclear safety requirements are included some provisions related to external events (extreme weather conditions). The assessment of the extreme weather conditions also includes a comparison of current design basis for extreme weather conditions with IAEA recommendations, European Utility Requirements (EUR), and relevant national Slovak Technical Standard (STN) EN standards.

2.3.1.2 Derivation of extreme weather loads

The report claims that due to location of Slovakia in the mild meteorological region of Europe, extreme conditions were not considered as a major issue in the past, resulting in limited design information and lack of specific design bases.
In 2011 the general climatological evaluation of Mochovce site was completed, as well as evaluation of the meteorological variables. The study was performed according to the IAEA recommendations. Results of the study were also used for the reassessment of weather conditions applied for design basis. Similar study for the Bohunice site is under preparation in order to update the original design values. The tornados are also added to the actualised design basis and evaluated.
Expected frequency of the originally postulated or the refined design basis conditions was assessed and the values with return period of 100 years and 10,000 years were defined. Combination of loads was also considered in the design basis.

2.3.1.3 Main requirements applied to this specific area

Similar to that requirements for floods, see 2.2.1.3 above.

2.3.1.4 Technical background for requirement, safety assessment and regulatory oversight

Evaluations of the effects of extreme meteorological conditions in the report are mostly qualitative (in particular in EBO 3,4), based on operating experience and on engineering judgment. The evaluation follows procedures and guidance provided in the relevant IAEA documents. It uses on-site as well as off-site data from standard meteorological measurements and observations, data processing, extrapolations, prognosis, expert judgements, and conclusions.

2.3.1.5 Periodic safety reviews

The general requirements regarding PSR are summarised in sections 1.3 and 2.1.1.5. No specific information with respect to extreme weather was provided in the report. However, based on the additional information obtained during the Topical review phase, it was shown that a similar upgrading process is in place as described in section 2.1.1.5. During the Country review it was clarified that in the frame of the last PSR of EBO 3,4 some additional evaluations of the external events hazard were done and development of an action plan for further assessments is expected in the near future. Additional analysis should be performed on the basis of the latest IAEA guidelines and should consider also combination of Postulated Initiating Events (PIEs) with internal and external hazards.

2.3.1.6 Conclusions on adequacy of design basis

Evaluated meteorological phenomena and their combinations include extreme temperatures and humidity, drought, snow and icing, direct and rotating wind. The specifications of extreme weather conditions for Mochovce site are in compliance with the IAEA recommendations, EUR and relevant national STN EN standards. However, the Bohunice NPP has to finalize the updated assessment of site weather characteristics taking into account recent knowledge of meteorological conditions.

2.3.1.7 Compliance of plant(s) with current requirements for design basis

The report identifies that protection of the plants against extreme weather conditions is considered to be adequate. Provided evidences show that considered extreme weather conditions should not endanger the safety of nuclear power plants in Slovakia.

2.3.2 Assessment of robustness of plants beyond the design basis

2.3.2.1 Approach used for safety margins assessment

Due to the lack of information on resistance of SSCs to the beyond design weather conditions in plant documentation, engineering judgement is applied to estimate the plant response. Postulated external events and their characteristics caused by extreme meteorological conditions are considered complete and specified in line with international practice. Originally postulated events were extended by tornadoes. Specifications of the events are estimated for up to 10,000 year return period.

2.3.2.2 Main results on safety margins and cliff edge effects

The estimation of safety margins for extreme weather conditions beyond the design values goes beyond the regulatory requirements. Such analyses were not present in existing SARs. Preliminary analysis has been performed for safe shutdown routes. Buildings of safe shutdown routes have been successfully evaluated for the wind loads equal to 1.2 multiple load of tornado F1 category of Fujita scale.
Safety margins between the threats (estimated for return period 10,000 years) and design values were performed. Therefore, these values do not represent a cliff edge effect borders:
Extreme wind – 20% margin was confirmed.
Snow – 20% margin was confirmed.

Extreme temperatures – proved margins vary for different parameters between 5% and 20%.
For Mochovce NPP more detailed confirmation is needed regarding the detailed meteorological study and assessment of the impacts using state of the art methods. Precise quantitative specification on the cliff-edges is therefore not available at present.

2.3.2.3 Strong safety features and areas for safety improvement identified in the process

The results of analyses and evaluations highlight that the changes to the original design (e.g. seismic upgrading) affected favourably the increase of Bohunice and Mochovce plant resistance against the extreme weather conditions, and the possibility to compensate adverse effects of extreme weather on plant technological equipment.
The following areas of improvement are identified in the process:

- Studies and assessments (detailed site weather characteristics and updated SAR for the Bohunice NPP; vulnerability of off-site power supply for both sites);
- Plant operating procedures (include frequent walkdowns)
- Preventive arrangements (to maintain operability of equipment)

2.3.2.4 Possible measures to increase robustness

- Lightening should be considered in the final meteorological study for both sites;
- Adequacy of the personnel access to site in severe weather should be considered in the emergency arrangements

2.3.2.5 Measures already decided or implemented by operators and/or required for follow-up by regulators

In addition to measures specified in 2.3.2.4 above, the following measures are defined:

- Finalize the report of Slovak Hydro-meteorological institute for Bohunice site to consider recent knowledge on meteorological conditions;
- Update SAR for Bohunice NPP in line with the international recommendations and recent knowledge;
- Assess the impact of extreme weather conditions to the vulnerability of high voltage lines at Bohunice and Mochovce sites;
- Assess all roof constructions of Bohunice NPP against the EUR code;
- Design and implement preventive measures at ambient temperatures below design value to maintain the functionality of equipment relevant to safety;
- During the Country review it was clarified that evaluation of BDB high and low temperatures of selected civil structures of EBO 3,4 and EMO 1,2 is currently ongoing process (the assumed deadline is 31 December 2012). The obtained results will be used for the analysis of availability of heat removal and electric supply systems at extreme temperatures (high and low).

2.3.3 Peer review conclusions and recommendations specific to this area

Evaluations of the effects of extreme meteorological conditions in the report are mostly qualitative (in particular in EBO 3,4), based on operating experience and on engineering judgment. Evidence has been provided to the existence of additional safety margins but their quantification is pending. Due to the lack of information in the plant documentation on resistance of SSCs to the beyond design weather conditions, engineering judgement is applied to estimate the plant response and assess the safety margins. Further work is required in this respect.
It is recommended that the Slovak regulator should consider monitoring the implementation of the measures for strengthening of the level of protection of the plants against extreme weather conditions.

3 PLANT(S) ASSESSMENT RELATIVE TO LOSS OF ELECTRICAL POWER AND LOSS OF ULTIMATE HEAT SINK

3.1 Description of present situation of plants in country

3.1.1 Regulatory basis for safety assessment and regulatory oversight

The general regulatory basis is summarised in section 1.3.

3.1.2 Main requirements applied to this specific area

Provisions relevant to the loss of electrical power and loss of UHS are provided in Regulation No 430/2011 which covers nuclear safety requirements. There are specific requirements in the following areas:

- Electrical power systems.
- The electrical power supply system.
- Heat transfer.
- The nuclear reactor core cooling system.

Details of these requirements are included in the appendix of the National Report.

3.1.3 Technical background for requirement, safety assessment and regulatory oversight

The safety assessment relevant to LOOP, SBO and loss of UHS, as performed by the utility and reviewed by the regulatory authority within the stress test, is mainly based on a deterministic approach. However, many results also originated from PSA level 1 and level 2 studies and from operational experience.

3.1.4 Periodic safety reviews

General information on the PSRs is summarised in section 1.3. During the PSR, the issues linked to LOOP, SBO and loss of UHS features are analysed in the light of changes of safety requirements, ageing, operational experience and new information on safety analysis, including re-analysis of site specific conditions. As many improvement measures related to LOOP, SBO and loss of UHS scenarios were already identified, prioritised and applied in the framework of other safety studies, the PSRs did not identify major findings. Nevertheless, several additional measures were also proposed in this area.

3.1.5 Compliance of plants with current requirements

Legal requirements are regularly updated and all operating NPPs assess and address all new requirements through the process of PSR. Based on the recently performed PSRs, the country did not report any non-compliance of NPPs with current requirements.

3.2 Assessment of robustness of plants

3.2.1 Approach used for safety margins assessment

The general approach used in the assessment of safety margins with respect to the loss of electrical power and loss of heat sink consisted of several steps. First, the relevant systems together with their level of equipment redundancy and diversity are described. Furthermore, the timescales are presented in which various safety functions need to be (re-)established by this equipment in order to prevent significant fuel damage. Finally, the level of autonomy with respect to fuel or coolant supplies is quantified. These aspects are considered in section 3.2.2 below.

3.2.2 Main results on safety margins and cliff edge effects

- **Power Supply features**

In both Bohunice and Mochovce NPP sites, there are currently six different options for providing Alternating Current (AC) power supply to plant consumers, each of them with different vulnerabilities towards external hazards. Three of these options are independent from the electricity distribution grid. These options can be activated – either automatically or by plant staff – within a few tens of seconds up to two hours. These options are:

- plant generators;
- main grid with possibilities of various interconnections in case of need (400 kV/220 kV/110 kV);
- stationary on-site diesel generators (emergency diesel generators);
- stationary off-site diesel generators (EMO only);
- connection to hydropower stations;
- various interconnections between units.

For back-up power, a diverse off-site grid is capable of providing a power supply for an unlimited period of time. Internal power sources in the plant, independent from the external grid, include 3x100 % redundant emergency diesel generators (EDGs) with fuel reserves for 9-10 days.

A decision on the installation of additional diverse stationary diesel generators dedicated to the management of severe accidents has been made as a result of the PSR performed before the Fukushima accident, and implementation is currently in progress. In addition mobile diesel generators for recharging the batteries in the case of a long-term SBO and loss of all other AC power sources are being procured.

In addition to AC power supplies, there is the option for Direct Current (DC) power provided by batteries. The time of operation of the batteries demonstrated by operational testing is 8-11 hours for one redundancy.

The country stated that arrangements for electrical systems for Mochovce NPP 3 & 4 Units will be similar to 1 & 2 Units but with some design improvements.

- **Heat sink features**

The primary heat sink in the NPPs is the atmosphere. Heat is transferred by circulating water and (or) essential service water systems to cooling towers. It is also possible to use a bleed and feed cooling regime, for which the heat sink is also the atmosphere. The source of raw water is a river – in the case of Bohunice NPP – the river Váh, in the case of Mochovce NPP – the river Hron.

- **Loss of off-site power (LOOP)**

LOOP is considered in the design basis of all NPPs in the country.

LOOP from the 400kV grid is described as one of the cases. In such a situation a back-up power supply is available from the 110 kV/ 220 kV substations, which has no time limitations for power supply.

If the unit back-up supply is not available and if the plant is disconnected from the 400kV grid and the unit fails to transfer to home consumption, the unit home consumption is recovered automatically in the minimal configuration needed for provision of the principal safety functions from the emergency power supply sources – three diesel generators per unit representing 3 x 100% redundancy. They are fully autonomous and supplied with diesel fuel for about 10 days. The Regulator explained that the other supplies (lubricants etc.) were included in the analysis, but fuel stock is the limiting factor.

- **Station blackout (SBO)**

SBO with loss of the ordinary back-up AC power sources

The Slovak NPPs have no stationary diverse AC power source, and therefore a SBO with loss of the ordinary back-up AC power sources leads to a full SBO. However it is planned to install diverse diesel generators on the plants, as mentioned in section 3.2.2.1.

SBO with loss of permanently installed ordinary and diverse back-up AC power sources

The subset of the top priority consumers remains available in the case of SBO. The limited set of equipment dedicated to monitoring of plant conditions and equipment essential to maintain safe shutdown is available in this case. These consumers are supplied from the three first category (uninterruptable source) emergency power supply systems (3x100%) and as well as from additional two battery systems which also ensure safe turbines trip and power supply to plant information and communication systems. It was required at least 2 hours operation availability for batteries in case of SBO in original Bohunice NPP 3&4 design. For Mochovce NPP 1&2 the 220 V batteries were also required to be designed for 2 hours operation, nevertheless additional 24 V batteries in each vital power supply system for I&C equipment were installed as well. These batteries have been designed for 4 hours of operation. Operational tests of vital power supply systems were performed in Bohunice 3&4 and Mochovce 1&2. The tests have demonstrated that in reality the plant batteries can supply power to each vital power supply system for at least 8-10 hours. The capacity of Mochovce NPP 3&4 batteries is expected to be 2 times larger. Discharge time of the plant batteries can be further increased by power saving actions (for example, disconnection of non-essential lighting) specified in the corresponding emergency operating procedure. During the tests of the plant batteries capacity the power saving actions were considered, nevertheless the above mentioned times of operation of the batteries are conservative. A system monitoring the status (including time to discharge) of the batteries during normal operation and emergency conditions is already implemented in Mochovce NPP 1&2 and procurement of such system is going on in Bohunice NPP 3&4.

The results of the SBO analysis are provided in the report for all relevant operational regimes. The analyses were focused on the evaluation of challenges to plant safety functions and the identification of margins to significant deterioration of plant safety, taking into account different initial conditions and possible recovery actions.

In case of SBO, feedwater supply to the steam generators would be lost. If SBO occurred during power operation, the heat removal from reactor core would be ensured for at least 5 hours due to availability of water contained in the steam generators. During this time the high pressure mobile emergency feedwater system (such system installed on a fire truck is currently available in Mochovce NPP Units 1&2, and a similar one for Bohunice NPP Units 3&4 is being procured) would be connected to a designated steam generator. The usage of mobile equipment for emergency feedwater supply from water sources available on-site for steam generators feeding would extend the time of heat removal from reactor core to more than 10 days, without any off-site assistance. In the most limiting case, if SBO occurred during reactor full power operation and no operator actions are considered, the core damage would occur in 9 hours. If operators perform actions to establish steam generator feeding from feedwater tanks by gravity, the time to core damage will be extended up to 32 hours, when considering the coolant inventory available in the primary and the secondary circuit. For shutdown regimes, in the most limiting case when initial water inventory in the reactor coolant system is minimal and no operator actions are assumed, the core damage would occur not earlier than after 9 hours following the SBO event. The operator actions dedicated for the establishment of alternative heat removal can extend the time to core damage by up to 12 days following the SBO event, without any off-site assistance. All equipment required for residual heat removal to the alternative UHS is manually operable and easy accessible.

The performance of safety functions (maintenance of subcriticality and heat removal) in the \SFP in case of SBO was evaluated. During SBO systems dedicated for residual heat removal from the SFPs are inoperable. Residual heat from the spent fuel pool can be removed by alternative methods only. Time margins to fuel damage in the SFPs depend on residual power and on initial coolant inventory in the SFP. Several cases were analysed assuming no operator intervention. It is reported that in the most unfavourable situation, boiling of water in SFPs begins in less than 3 hours and fuel damage can begin in less than 30 hours following the SBO event. These margins can be extended by using water from seven trays of the bubbler condenser tower. Evaporation of one tray in the most limiting case would extend heat removal from SFP for at least 14 hours (seven trays would assure water for at least 98 hours of cooling). All these and other additional options (for example using fire trucks) for the supply of cooling water to SFPs are described in emergency operating procedures.

Recharging of the plant batteries in the case of long-term SBO is planned to be performed by a mobile 0.4 kV DGs (one per each unit) which are under procurement.

- **Loss of Ultimate Heat Sink (UHS)**

Heat removal from the reactor core, spent nuclear fuel pools and containment to the Essential Service Cooling Water (ESCW) system is provided by various systems. Complete, immediate and long term loss of operability of all 3 ESCW systems is bounded by the SBO analysis discussed above.
The National Report focuses on a loss of UHS scenario due to interruption of raw make-up water supply.
In terms of robustness it is noted that the ESCW system is designed with 3x 100% redundancy. Each train contains 2 pumps per unit (2x100%) and 2 forced draught cooling towers (2x100%). The ESCW system is resistant against a single failure and a common cause failure (fire, flooding, seismic events, interactions with high-energy pipes, missiles, drop of a load, environmental conditions and extreme meteorological conditions). ESCW trains are independent and physically separated. Each ESCW train is supplied from a respective train of the emergency power supply in compliance with supplying of independent trains of the emergency core cooling system. Analysis of water stocks is provided, as well as the possibility to replenish from rivers and reservoirs. Taking into account only internal resources, the time constrains for cooling of reactors and spent nuclear fuel are evaluated.
The integrity of reactor coolant pump seals is indicated as important factor, because due to the failure of the seals a loss of cooling water may occur. The tightness of the reactor cooling pump seals has been experimentally confirmed for 24 hours. The seal tightness for longer times should be confirmed by data from the additional tests that are going to be obtained.
The case of loss of all ESCW trains is analysed as well. The alternative heat sink in such a case is the removal of decay heat via the steam generator's Steam Dump Station to Atmosphere (SDSA) which requires feedwater to be provided to the steam generators. Without external (off-site) feedwater supplies it is claimed that this is sufficient for 10 days (Mochovce NPP), 7 days (Bohunice NPP) for each unit. It is also noted that the heat removal via this system does not provide cooling to intermediate circuits, vent systems etc. but these systems are out of operation during SBO. The report takes into account various shutdown regimes. The reported time constrains for the recovery of UHS are summarised as follows:
- the nominal water volume of ESCW ensures at least 72 hours of ESCW availability after loss of raw make-up water;
- the additional water inventory that is available in circulating water pools on the sites provide for an additional 10-30 days of ESCW availability;
- after loss of all ESCW trains, the basic design provides a minimum margin of 200 hours to fuel damage in the reactor (for regime 6 approx. 140 hours);
- after loss of all ESCW trains, the basic design provides a minimum margin of 30 hours to fuel damage in SFP (conservative estimate without operator's intervention).

- **3.2.2.6. Loss of UHS & SBO**

The case of a combined SBO and loss of UHS in a plant of VVER 440/V213 design is covered by the SBO alone, since the SBO always leads to the loss of UHS.

3.2.3 Strong safety features and areas for safety improvement identified in the process

The strong features to ensure power supply for on-site demand and cooling capability in country NPPs are as follows:
- several possibilities to supply off-site power, including hydropower stations;
- availability of diverse water sources to ensure heat removal via the steam generators to the atmosphere, and adequate systems installed to feed the steam generators, which do not require service water;
- possibility to use water from bubbler condenser trays for SFP cooling, filling up of reactor vessel, cavity and pit by gravity;
- availability of a back-up to the alternate UHS by additional operator actions;
- large thermal inertia of the units providing for appropriate time margins.

The following good practice should be mentioned :

- mobile high-pressure pump for ESG feeding;
- large capacity of batteries and availability of several batteries trays;
- battery status monitoring system;
- equipment configuration management system (SSCs configuration matrix) dedicated for assessment of situation during extreme events including possible combinations of events, optimisation of emergency actions to maintain safety functions (will be finalised soon);
- availability of emergency operating procedure for usage of water from bubbler condenser tower for SFP cooling, filling up of reactor vessel, cavity and pit;
- availability of EOP to remove the decay heat by steam generator when reactor is opened.

The main areas for safety improvement linked to LOOP, SBO and loss of UHS features are the following:

- NPPs have no diverse diesel generators (procurement is in process);
- The existing diesel generators are cooled by essential service water, and will be lost in case of loss of UHS (the issue should be analysed taking into account plans to obtain diverse diesel generators).

3.2.4 Possible measures to increase robustness

All identified measures are understood to have either been implemented or to be planned, and are therefore considered in section 3.2.5 below.

3.2.5 Measures (including further studies) already decided or implemented by operators and/or required for follow-up by regulators

The following measures have been identified to increase robustness against BDB events:

- To increase resistance and reliability of emergency power supply for BDB events by installation of a new 6kV emergency air cooled diesel generator for SAM;
- To provide for 0.4 kV mobile diesel generator for each unit for charging batteries and supplying selected unit consumers during SBO, modifications of the power supply (also from 0.4 kV diesel generators) of the high-pressure boron system pumps enabling their use during SBO;
- To provide technical solution and cable preparation in order to facilitate mechanical actions needed for interconnection of batteries (for Mochovce NPP only);
- To provide a mobile high-pressure feedwater pump for each unit for injection into steam generators, available during SBO, with minimal flow rate 20-25 m^3/hr and with pressure head 6 MPa, and ensure logistics of supplies for the mobile pump, with possible use at both Bohunice NPP 3&4 Units and Mochovce NPP 1-4 Units (the same nozzle types);
- Move relevant nozzles dedicated for feeding of steam generators using mobile means to more convenient position to facilitate their connection;
- To optimize emergency lightening in order to extend life time of batteries (subdivision into sections with the possibility for switching off unnecessary parts, use of energy-saving bulbs);
- To obtain data documenting the behaviour of reactor coolant pump seals during a long-term failure of cooling (more than 24 hours);
- To provide for a battery capacity monitoring system (for Bohunice NPP Units3&4);
- To provide for mobile measuring instruments able to utilize standard measuring sensors (e.g. thermocouples);
- To provide for power supply of containment bubble condenser trays drainage valves and hydro accumulator isolation valves from the vital power supply system (Mochovce NPP);
- To consider the possibility to control selected valves without vital power supply by means of small portable motor 3-phase generator 0.4 kV (about 7 kW);
- To install two physically separated fixed pipelines for make-up of the coolant to spent fuel pools (from a mobile source – fire pumps and external water source dedicated for SAM);
- To assure long-term serviceability of communication means for main control room operators and shift service staff;
- To develop operating procedures for the possible use of diesel generators installed in Levice switchyard for SBO event (for Mochovce NPP);

- To provide for mobile pumps for essential service cooling water make-up from circulating water;
- To establish the logistic system for provision of emergency feedwater to suction of mobile emergency pumps from external water sources;
- To modify connection of emergency mobile source to essential service cooling water suction and discharge to be accessible from level 0 m, beyond the anti-freezing barrier (in Mochovce NPP) in order to ensure emergency mobile supply in case of internal and external floods and fires;
- To prepare measures for steam removal from the SFPs in case of coolant boiling.

3.3 Peer review conclusions and recommendations specific to this area

The National Report indicates that a comprehensive complementary safety analysis has been performed by the licensee for all NPPs. Measures are proposed to increase safety capabilities in case of LOOP, SBO and loss of UHS, and have been assessed by the National Regulator including own calculations and modelling.
As a reaction to the Fukushima event, the utilities and the National Regulator carried out walk-downs and inspections on structures, systems and components relevant to LOOP, SBO and loss of UHS. As a result of these special reviews and assessments, measures to improve the safety of the plants have been planned and prioritised. Special tests also were performed (for example: test of feeding steam generators using the fire truck high pressure pump, test of water supply to SFP from bubble condenser trays) to validate the possibilities to apply dedicated measures.
Some measures were implemented immediately (e.g. the procurement of fire truck containing high-pressure pump).

4 PLANT(S) ASSESSMENT RELATIVE TO SEVERE ACCIDENT MANAGEMENT

4.1 Description of present situation of plants in Country

4.1.1 Regulatory basis for safety assessment and regulatory oversight

The general regulatory basis is summarised in section 1.3.
According to the National Report, severe accident related requirements are given in the Slovak legislative requirements, in particular with the Act No.541/2004 on the Peaceful Use of Nuclear Energy (Atomic Act), Decree No. 55/2006 on details concerning emergency planning in case of nuclear incident or accident, and regulation No. 430/2011 on Nuclear Safety Requirements, and some others.
The objective of Emergency Planning and Preparedness (EPP) is to assure technical, personnel and documentation preparedness of plant staff and involved external organizations to efficiently manage extraordinary events. EPP of nuclear units is integrated into the national emergency response organization of the Slovak Republic with the Slovak government being responsible for emergency preparedness at the national level.
The basic provisions concerning accident management are laid down in the Regulation No. 430/2011 on Nuclear safety requirements and given in Appendix 1 of the national report. These provisions cover the most important requirements concerning containment behaviour during severe accidents and also the safety analysis of BDB events including severe accidents. The legislative requirements also cover emergency response organizations and other relevant aspects.

4.1.2 Main requirements applied to this specific area

The regulatory requirements concerning severe accidents are summarized in the Appendix 1 of the National Report. These requirements impose a number of conditions on the containment building and connected systems, to limit the potential radioactive releases, and define the scope of the safety analysis by listing the initiating events and external conditions to be analysed.

In 2006, severe accidents requirements where already introduced in the Slovak legislation. The latest update of these requirements is in full compliance with IAEA safety standards and WENRA reference levels.
The utility has developed since 2002 SAMG and also some safety concepts for severe accident (dedicated severe accident equipment with diversification and/or redundancy from existing safety systems, and seismic qualification …). The detailed technical requirements associated with SAM are defined by the utility and approved by the regulator.
For the new plants EMO 3,4, European Utilities Requirements' quantitative targets related to the radiological impact of accidents have been used as safety objectives (beyond the existing regulations) to develop SAM provisions. It has for example lead to dedicate provisions for containment spray in severe accidents. These quantitative criteria are not defined for existing plants, but the ALARA principle (As Low As Reasonably Acheivable) is used to define improvement as far as possible. In particular, all recognised technical provisions contributing to the mitigation of the consequences of SAs, which are technically feasible in VVER V213 units, were decided to be implemented.

4.1.3 Technical background for requirement, safety assessment and regulatory oversight

The development of full power symptom based EOPs was initiated in 1995 and was fully implemented in 1999. Later EOPs for events initiated at shutdown reactor or in the SFP have been developed. Since 2006 symptom based EOPs cover all operation regimes. Symptom based SAMG have been developed between 2002 and 2004. As explained below, this development and also other projects lead to identify the need of some hardware modifications to practically eliminate situations of large releases. These modifications are part of the on-going SAM implementation programme which has been approved by the regulatory body.
The basis for the development of the SAM was the analysis of the VVER 440/V213 NPP response to severe accidents, the identification of the containment failure mechanisms, and the applicability of the basic severe accident management strategies identified for Western containment types. This analysis was complemented by studies on filtered venting and hydrogen control. The outcome of these studies (performed jointly by an engineering company and research institutes from Slovakia, Czech Republic and Hungary) was the identification of the vulnerabilities of the VVER-440/V213 units under severe accident conditions. These served as a preparatory phase for accident management implementation. Consequently, a PSA level 2 for EBO 3 and 4 was completed in 2000.
With the input derived from the studies described above, the SAMG were prepared under a common project for all operating units. The approach used was to eliminate or mitigate the consequences of all identified containment vulnerability mechanisms by suitable modifications or extensions of V213 basic design. It can be noted here that generic SAMGs for Pressurized water reactor (PWR) have been extended for Slovak VVER 440 containment specifics. In particular, the reliance on only the existing systems was identified as insufficient.
Level 2 PSA has been used in the SAMG project in two main areas:

- Identification of critical phenomenology which needs to be covered by SAMG strategies and help for decision on optimal modifications for SAM design upgrade (all vulnerabilities with highest probability /negative impacts have to be covered by SAM dedicated hardware modifications),
- Licensing purposes (plant modifications, power uprate, ...) with last update in 2012.

4.1.4 Periodic safety reviews

General information on the Periodic Safety Reviews is summarized in section 1.3.
One topic of the PSR is the compliance of plants with existing national legislation, including severe accident requirements.
In the 2008 PSR, this compliance was discussed based on the legislation updated in 2006. Implementation of hardware modifications was identified as necessary to ensure compliance with the legislation.
The utility has initiated in 2010 the SAM implementation programme.

4.1.5 Compliance of plants with current requirements

Slovak NPPs have been subjected to systematic safety assessments and upgrading in accordance with Slovak legislation and international standards in the framework of IAEA and EU projects.
Relevant SARs, updated as appropriate and accepted by the regulatory body, are available for all plants.
PSA studies Level 1 and 2 are also available, demonstrating compliance with internationally established safety objectives. The latest update of the SAR for EBO 3,4 was performed in 2009, for EMO 1,2 in 2010. For MO 3,4 the Preliminary SAR was issued in 2008, preparation of the Preoperational SAR is currently in progress. Similarly, the latest update of PSA Level 1 and 2 was done in 2010 for EBO 3,4 and in 2011 for EMO 1,2.
The SAM implementation project included a safety concept (prepared by the licensee) defining the safety objective, project scope, design principles, and design basis for new and modified equipment, which was approved by the Regulator.

4.2 Assessment of robustness of plants

4.2.1 Adequacy of present organizations, operational and design provisions

4.2.1.1 Organization and arrangements of the licensee to manage accidents

Operation of the units for each plant is provided by plant employees in shifts. Minimal number of shift personnel and its professional composition is approved by the regulatory body. The shift supervisor has a full authority and responsibility for the safe operation. He directly manages reactor unit supervisors, shift foremen of reactor coolant system, secondary circuit, electric part, technical workers in water management system, Instrumentation and Control System (I&C), radiation monitoring and chemistry technicians.
In case of an emergency event, its management is performed by the plant Emergency Response Organization (ERO). The director of the plant is a designated head of ERO delegating his authorities to the shift supervisor in duty and to the Emergency Commission (EC) shift manager. Decisions taken by EC are binding for all plant and SE, a.s. employees and for all persons on the site. The shift supervisor is permanently responsible for performance of all interventions in technological objects.
The main control room (MCR) is the basic working place of the operators. The emergency control room (ECR) is a back-up working place in case of the inhabitability of MCR or if the reactor and emergency systems cannot be controlled from the MCR. MCR and ECR (in smaller scope) were reinforced to improve their habitability during accidents. MCR and ECR are not designed for long term stay in case of a severe accident leading to major radioactive release. It can be noted here that MCR and ECR are close to each other and have (at Mochovce NPP) airtight windows on the outside. The ECR is not better protected than the MCR.
Emergency Control Centres (ECC in EBO 3,4, and EMO 1,2, which is currently being extended to accommodate also EMO 3,4 teams) are located in seismic and hermetic shelters, providing conditions for the long term management of an accident. ECC is equipped with information system providing operational data from the reactor units. After implementation of SAM, it will be possible to control the main SAM related equipments by remote control from ECC.
A backup ECC in Trnava and Levice allows for short-stay of personnel and contains sufficient means for accident management. A monitoring centre for external evaluation is located in Trnava and Levice, and contains the equipment and means for forecasting and assessing the accident consequences.
The shift staffing includes also the physical protection staff and the plant fire brigade.
There are instructions and procedures in place for the staff for management of emergency situations. The basic Emergency Response Organization (ERO) principles and procedures are covered by the on-site emergency plan (EP), EOPs, emergency instructions for implementing EP, SAMG and related plant technical documentation. These procedures define responsibilities and authorities of the plant staff and ERO members. The non-technological intervention groups (plant fire brigade, physical protection staff, police corps) are promptly available on the site and are used for rescue, localization and recovery activities immediately after the event.

During the country visit means available for the fire fighter brigade in EMO site have been presented. In particular, a special truck is able to inject water at 7 MPa and would be used to supply water to Steam Generators (SGs) in SBO conditions. Such a pressure is sufficiently high to guarantee water injection whatever the status of SG valves. A practical demonstration of this configuration has been performed during the plant visit (realization of the connection within a few minutes).
It is planned that such a truck will be available for each unit. The precise location of fire brigade means may need to be precise later by the utility (all equipment are stored in the same building today).
Additionally, a number of mobile devices (submersible pumps, portable generators, mobile fire pumps, etc), are available for BDB and SAM strategy implementation. Mobile DGs (usable for batteries charging) are under procurement.
The organization of ERO complies with the applicable recommendations and requirements for accident management in NPPs, thus the organizational issues are adequately covered as long as the severe accident occurs at one unit at a given site. However, the structure and scope of the emergency response teams, especially SAMG team should be further strengthened to cope also with multi-unit events. This is a topic still under evaluation. This conclusion is supported also by the national report.

4.2.1.2 Procedures and guidelines for accident management (Full power states, Low power and shutdown states)

Symptom-oriented EOP covering design basis and BDB conditions (up to the core melt) were implemented both in EBO 3,4 and EMO 1,2 in 1999 for events initiated during power operation, and in 2006, for events initiated at shutdown reactor or in the SFP . It was stated during the peer review question/answers process that training on SAMG took place for staff involved in SAMG development and upgrading.
Plant specific SAMG were prepared for EBO 3,4 and EMO 1,2 between 2002 and 2004. Between 2004 and 2007, the project to implement modifications in support to SAM (in compliance with the Slovak legislation) was defined. The SAM program (including both SAMG and plant modifications) started in 2009, and will be fully implemented in 2013 in EBO 3,4 and in 2015 in EMO 1,2, respectively.
SAMG for shutdown states and SFP severe accidents will be developed by the end of 2012.
It is worthwhile to mention that most important parts of EOP procedures for stress-tests conditions have been tested by the utility (long term 72h test of DG, reactor and SG emergency venting, SFP water make-up from bubble condenser, test of recovery of water in SG by mobile equipment …).

4.2.1.3 Hardware provisions for severe accident management

Hardware provisions are now being implemented in the SAM program. A short description of each measure and more details on the implementation schedule are provided in chapter 4.2.3.2.

4.2.1.4 Accident management for events in the spent fuel pools

In VVER-440/V213 NPP units, spent fuel is stored in pools inside the reactor building but not in a containment structure. Thus, to restrict radioactive releases from the SFP, the approach is to “practically eliminate” the possibility of fuel damage by reinforcing the available means to maintain the SFP inventory. In this frame, two mutually independent routes for the emergency make-up of borated coolant into the SFP were installed (from the external emergency coolant source and connection to the external reactor building wall), in addition to the existing ones (e.g from bubble condenser). Guidance is not yet given in the SAM handbook, but it is under development. To complement the normal operation instrumentation (level and temperature), two new dosimetry measurements will be installed in the reactor hall for the indirect monitoring of the SFP conditions.
Sub-criticality in SFPs is maintained by configuration and material composition of fuel racks and in addition by the use of borated water.
It has been considered that there is no need to install passive autocatalytic recombiners (PAR) because the hydrogen generated during spent fuel degradation and released to the 160,000 m^3 free volume of the reactor hall would not reach the minimum concentration for PAR operation. However, detailed analysis of the possibility of local high concentrations (e.g. on top of the spent fuel pool) are still ongoing.

Fuel uncovery scenarios in the SFP and the corresponding time frames for intervention are discussed in the national report (Section 5.2). Though the robustness of the plant against these scenarios is qualified as sufficient, the licensee plans to install a fixed line for maintaining the coolant inventory in SFP from a mobile source (fire pumps) and to prepare measures for steam removal from the SFP in case of coolant boiling.

4.2.1.5 Evaluation of factors that may impede accident management and capability to severe accident management in multiple units case

The accident management concept has been originally based on the assumption of severe accident evolving only in one unit, in line with the existing legislation and recommendations. The structure and scope of the emergency response teams, especially SAMG team cannot cope with multi-unit events without its further strengthening.

The national report states that due to adaptation of the ongoing SAM project in the light of Fukushima lessons the original scope (SA in 1 unit) has been extended to capability to deal with SA in 2 units almost in all relevant areas. Upgrade examples are the increase of SAM DG capacity and the implementation of 3 redundant pipelines from external walls of buildings to allow for replenishment of coolant in tanks by mobile pumps.

In the implementation of the SAM project, it is planned to perform further investigations in order to demonstrate the feasibility of operator actions in high radiation areas.

During the plant visit, it was explained that there has been an exercise organized during which the EBO site was supplied by water from remote off-site resources by alternative ways (trucks, helicopters …). This would be applied in case of beyond design natural disasters if access routes would be heavily damaged.

4.2.2 Margins, cliff edge effects and areas for improvements

4.2.2.1 Strong points, good practices

Most of SAM measures are not yet implemented but regarding the future situation, the following points can be highlighted as good practices:

- the well-known relatively low thermal loads and high water reserves of the VVER-440/V213 design during normal operation, incidents and accidents form a strong point of the Slovak NPPs. Design modifications increased the robustness of the design,
- the capability to extend this autonomy through mobile equipments ; especially the trucks able to inject water whatever the pressure in SG,
- the definition of safety concepts to guide the design of dedicated new SA equipments (SA equipments independent from existing safety system, qualified for the conditions of their use, seismically qualified),
- the SAM program includes measures to avoid large early release situations but includes also long term management of the damaged plant,
- application of EUR safety objectives for the new units (EMO 3,4),
- the continuous improvement of safety features, which is visible on the continuous improvement of containment tightness of all plants,
- the new concept for the emergency control centres with remote control of SA equipment.

4.2.2.2 Weak points, deficiencies (areas for improvements)

The severe accident programme was initiated at the beginning of 2002 by initiation of the SAMG development project but the implementation programme started in 2010. There is now a precise schedule of implementation of the necessary measures identified to cope with the vulnerabilities of the original design.

Long term over-pressurization is supposed to be solved by restoration of the containment spray and essential service cooling water system. This approach is justified by the time available before reaching the containment design pressure (several days) but the demonstration of the feasibility of such restoration, taking into account bad radiological conditions, has not yet been achieved. The option of a filtered containment venting system should be considered as an ultimate possibility to preserve the containment integrity by passive means.

The containment integrity relies for an important part on the tightness of all penetrations. During the country visit, it was explained that the reactor cavity door tightness was examined in details but not all of the other penetrations. The verification of tightness of all containment penetrations (e.g closure above the vessel, above the SG) in SA conditions should be further examined (resistance of seal in particular).

4.2.3 Possible measures to increase robustness

4.2.3.1 Upgrading of the plants since the original design

The Slovak plants have been significantly upgraded throughout their operational lifetime. In spite of the robustness of the original design, several modifications dictated by operational experience and by international and domestic safety assessments have already been carried out.
As mentioned above, improvement of the containment tightness of existing plants is one of the major achievements.
In this way the units comply with the requirements of the Slovak regulatory body and the international expectations and recommendations.

4.2.3.2 Ongoing upgrading programs in the area of accident management

The project for the implementation of the plant modifications and the development of the SAM was ongoing before the Fukushima accident. After Fukushima, the deadline for completion at Bohunice was maintained to 2013 (but includes some new improvements) and was accelerated from 2018 to 2015 at Mochovce NPPs.
In the utility safety concept, all dedicated SA modifications are physically and electrically independent of other original safety systems and are seismically qualified. They are also qualified for the conditions in which they should be used. They are supposed to be used only during severe accident conditions (they can nevertheless also be used in the core damage preventive phase, under specified conditions). In addition, each modification has to be approved by the regulator before implementation.
The most significant modifications are described hereafter.
<u>Reactor Cavity Flooding</u>
Modification allowing water to enter the reactor cavity (through cavity ventilation ducts and providing paths for better steam evacuation from the cavity) ; this modifications, associated with reliable RCS depressurization, intend to ensure external RPV cooling,
<u>RCS depressurization</u>
Installation of an additional line for RCS depressurization with motor-valves qualified for use at the entry point into SAMG (qualified for Loss of Coolant Accident (LOCA) conditions) to prevent vessel failure at high pressure,
<u>Containment Hydrogen Management</u>

- hydrogen and oxygen concentration measurement is already installed since 2008 (2 trains of 8 electronic measurements),
- installation of 32 PARs qualified for SA conditions,
- the operators should use the measurements to decide if containment spray can be activated (in SAMG) ; the precise SAMG procedure still to be approved by the regulator.

As an additional improvement (complementary to the SAM programme) to improve the hydrogen management and the radioactive leakages management in case of loss of integrity between containment and auxiliary building the ventilation systems (normal operation system, not seismically qualified) in auxiliary building will be supplied by SA DG in order to improve their reliability providing hydrogen dilution and radioactive substances filtering. This function can be considered as a substitute function of secondary containment.

<u>Containment Vacuum Breaker</u>

Installation of a system enabling prevention of excessive containment under-pressure (manual valves, double power supply); these valves put into communication some dedicated volumes of the bubble condensers with the main part of the containment.

Alternative Power Supply System

Installation of an emergency power supply source for power supply during severe accidents (a 6 kV, 1,2 MW DG independent from the existing systems, serving both units, 3 days of autonomy) ; dedicated distribution bus will be installed.

Alternative Coolant System

To increase coolant source redundancy, 3 existing, seismically qualified coolant tanks (500 m^3 each) will be devoted to provide borated coolant make-up for the primary circuit, containment spray and the SFP. Two new pumps will be added and supplied by SA DG. One system per two units will be available for EMO 1,2 and one for EBO 3,4. EMO 3 and 4 will have their own system.

I & C – Post-Accident Monitoring System (PAMS), Control

In 2008, a post-accident monitoring system was installed in line with recommendations of US NRC RG 1.97 (measuring sensors, cabling and evaluation devices). The system is being extended by measurement needed for implementation of SAMG and will be connected to the ECC. Control of components needed for SAM will be included.

After implementation of SAM, it will be possible to control the main SAM related equipments by remote control from ECC.

Containment Long Term Heat Removal

Heat is supposed to be removed by the existing containment spray system in recirculation mode. The system will be modified to be able to operate in severe accident conditions. Spray system and essential service cooling water system can be supplied by SA DG.

Sump clogging is supposed to have been solved in previous plant upgrade; nevertheless, solution to bypass possible clogged inlet from the containment sump cavity by external means is included in the SAM project.

The utility proposes to remove internal containment isolation valves on spray system to avoid any inoperability of the system in severe accident condition. The possibilities of recovery of spray system are reinforced and resistance of spray pump against radiation is addressed.

Long term water supply in ultimate phase

The three 500 m^3 tanks, the cavity and the SFP can be filled by fire truck (connecting points will be available at the exterior of the respective buildings.

The use of non-borated water in the SAM strategies is forbidden in order to safely prevent re-criticality of partially damaged core.

SAMG for shutdown states and SFP severe accidents will be developed by the end of 2012.

The following table summarizes the current status of the programme implementation.

Title of subproject SAM	Bohunice 3/4	Mochovce 1/2
Reactor Cavity Flooding	**2010**	**2011/2012**
PC Depressurization	**2011/2012**	**2013/2014**
Containment Hydrogen Management	**2011/2012**	**2012/2013**
Containment Vacuum Breaker	**2011/2012**	**2014/2015**
Alternative Coolant System	**2011/2013**	**2014/2015**
Alternative Power Supply System	**2012/2013**	**2013/2014**
I & C – PAMS, Control	**2012/2013**	**2014/2015**

Containment Long Term Heat Removal	**2013**	**2015**

(green)	Implemented
(yellow)	Partly Implemented

4.2.4 New initiatives from operators and others, and requirements or follow up actions (including further studies) from Regulatory Authorities: modifications, further studies, decisions regarding operation of plants

4.2.4.1 Upgrading programmes initiated/accelerated after Fukushima

The national report concludes that additional safety margins were confirmed and additional safety upgrading measures were identified in the stress tests. These will allow further enhancement of the existing safety level beyond the design basis. The deadline for the implementation of the SAMG and related plant modifications has been moved earlier to 2015 instead of originally planned 2018. A re-evaluation of potential SAMG extensions will be carried out after completion of the programme. However, a number of improvements have already been identified after Fukushima and will be implemented in the framework the existing SAM implementation programme:

- Increase of the power of SAM DG from 0.8 MW to 1.2 MW. The new capacity is sufficient to provide AC power for all new SAM project consumers and other necessary equipment in two units
- Increase of robustness of the long term heat removal capabilities – installation of two additional pumps of Essential service water system powered from new SBO DGs 0.4 kV (one per unit).
- Installation of two additional lines into the spent fuel pool, into the reactor cavity and into the external emergency coolant system tank, allowing replenishing coolant from mobile pump/fire truck from the exterior of the respective buildings. This solution eliminates the original limitation - volume of coolant supplies in the emergency coolant system in case of severe accidents in two units,

4.2.4.2 Further studies envisaged

The following studies are considered for further analysis:

- Verification of available provisions for multi-units accidents,
- Possibility to use containment heat removal by operating the containment ventilation systems (role also for H2 mixing),
- Possible measures extending the current scope of the SAM project will be analyzed after the project completion, based on results of SAMG validation and analytical justification of strategies for management of representative severe accident scenarios.
- No input data are yet available for assessment of MCR accessibility and habitability in case of severe accident in the spent fuel pool. Such assessment will be subject to further investigation for the development of SAMG for SFP accident (even if practically eliminated),
- Considering the SFP structure and its connection with the reactor hall, no possibilities have yet been evaluated to increase the pool reinforcement against severe accidents and its isolation with another barrier.
- Radiological feasibility of recovery actions contemplated in the SAMG will be subject to further investigation, especially during the long term phase of the accident.

Decisions on performing the studies above will only be made in conjunction with the adoption of the results of the stress test peer review.

4.2.4.3 Decisions regarding future operation of plants

The national report states that none of the measures initiated by the stress test correspond to an imminent risk requiring new prompt actions. Many relevant actions in this context were already in progress and some of them were accelerated.

Therefore there is no change concerning the future operation of the Slovak plants.

4.3 Peer review conclusions and recommendations specific to this area

The national report and the information gathered during the country visit provide satisfactory information on the severe accident management programme developed for the Slovak NPPs. It can be highlighted that severe accident requirements are included in the Slovak regulations and that verification of compliance is part of the PSR process.

The hardware modifications proposed by the utility are based on a consistent set of analysis (deterministic and probabilistic studies) and correlated to advanced safety concepts for severe accident management. Use of dedicated, independent measures for mitigation of severe accidents with large refillable source of additional coolant can be mentioned as an important contribution to the robustness of the defence in depth.

It is however important that the SAM modification will be implemented according to the proposed schedule. It is suggested to consider locating the special equipment for SAM in dedicated locations qualified against external hazards.

With the strategy developed for the Slovak VVER 440, Reactor Pressure Vessel (RPV) failure is considered very unlikely after the modifications for molten core in-vessel retention. Nevertheless, investigation to limit the consequences in case of RPV failure could be considered in further steps.

The verification of tightness of all containment penetrations (e.g closure above the vessel, above the SG) in SA conditions should be further examined (resistance of seal in particular).

The strategy of long term management of containment pressure without any containment venting system should lead to further verification to check the real feasibility of long term containment heat removal in severe accident conditions.

List of acronyms

AC	Alternating Current
BDB	Beyond Design Basis
CDFM	Conservative Deterministic Failure Margin
DBE	Design Basis Earthquake
DBF	Design Basis Flood
DC	Direct Current
DDF	Depth Duration Frequency
EDG	Emergency Diesel Generator
EBO	Bohunice Power Plant
EC	Emergency Commission
ECC	Emergency Control Centre
ECR	Emergency Control Room
EMO	Mochovce Nuclear Power Plant
EOP	Emergency Operating Procedures
EPP	Emergency Planning and Preparedness
EP	Emergency Plan
ERO	Emergency Response Organization
ESCW	Essential Service Cooling Water
EUR	European Utility Requirements
HCLPF	High Confidence Low Probability Failure
I&C	Instrumentation and Control System
IAEA	International Atomic Energy Agency
LOCA	Loss of Coolant Accident
LOOP	Loss of Offsite Power
MCR	Main Control Room
NPP	Nuclear Power Plant
PAMS	Post-Accident Monitoring System
PAR	Passive Autocatalytic Recombiner
PIE	Postulated Initiating Events
PSA	Probabilistic Safety Assessment
PSHA	Probabilistic Seismic Hazard Assessment
PSR	Periodic Safety Review
RLE	Review Level Earthquake
RPV	Reactor Pressure Vessel
SAM	Severe Accident Management
SAMG	Severe Accident Management Guidelines
SAR	Safety Analysis Report
SBO	Station Black-out
SDSA	Steam Dump Station to Atmosphere
SE, a.s.	Slovenske Elektrarne, Inc.
SFP	Spent Fuel Pool
SG	Steam Generator
SHA	Seismic Hazard Analysis
SMA	Seismic Margin Assessment
SSC	Systems, Structures and Components
SSEL	List of Equipment for Safe Unit Shutdown after Seismic Event
STN	Slovak Technical Standard
UHS	Ultimate heat Sink
UJD SR	Nuclear Regulatory Authority of the SR
WENRA	Western European Nuclear Regulators' Association
VVR	Vodo-Vodyanoi Energetichesky Reactor; Water-Water Energetic