Post-
Fukushima
accident

Czech Republic

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 European Union (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 in 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

There are two plant sites in Czech Republic: Dukovany NPP with 4 units of WWER-440/213 (Water-cooled water-moderated power reactor) design, and Temelin NPP with 2 units of WWER-1000/320 design, all of them pressurised water reactors of Soviet design.

The content and structure of the national report is basically in compliance with the European Nuclear Safety Regulators Group (ENSREG) specifications. All requested data regarding design are provided in sufficient scope. The report is logically divided into two parts; assessment is done separately for Dukovany and for Temelin NPP in the same scope. Format and the content of the report provide good basis for review and assessment of NPPs response to relevant events.

General conclusions are drawn including measures, which were already implemented for safety enhancement and potential safety improvements of the Dukovany and Temelin NPPs.

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

The adequacy of the information supplied is consistent with the guidance provided by ENSREG. The national report describes the actions of the State Office for Nuclear Safety of the Czech Republic (SÚJB), which started immediately after the Fukushima accident.

The information given about the natural external hazards, the related design basis evaluation and beyond design basis margins are described in adequate detail for both plant sites. Information provided by the National report is in appropriate level to understand plants behaviour during the events defined in the ENSREG specification.

The inclusion of figures helps a lot, serving to understand the differences compared WWER reactor technology to others. The report gives comprehensive information on the national requirements related to nuclear safety and accident management. However, in some instances, more detailed information would be appropriate.

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

Legal requirements are well developed. The assessments referred in the report have established adequately that the plants comply with their licensing case with respect the natural external events considered, in correspondence with the national legal requirements.

SUJB states that: "Western European Nuclear Regulator Association reference levels (WENRA RLs) are already, in majority, implemented in the current nuclear legislation (legally binding). All RL are already reflected in the SUJB Safety Guides and their main principles have been implemented in legally binding regulatory decisions. New Atomic Act and its providing regulations will again address the whole set of WENRA RL."

Requirements for safety related systems, for emergency preparedness and for accident management are defined and introduced in the report. Moreover provisions and requirements specified for beyond design basis accidents have been defined in legal documentation for a relatively long period. In general there is no evidence in the report indicating that the plants are not in compliance with the current legal requirements, however it is noted that at Dukovany NPP currently there is no diverse ultimate heat sink. In addition the cooling towers which are part of the essential service water system (ESW) are not specified as safety class components.

The upgrading of the Dukovany plant to the currently approved Design Basis Earthquake (DBE) is still on-going and it is to be completed before 2015 the end of the Periodic Safety Review (PSR) period.

Conformity with the requirements of both national and international legislative documents, WENRA requirements and other international recommendations in Internatonal Atomic Energy Agency (IAEA) documents (Safety Guides) are applied within the Periodic Safety Review (PSR). In the frame of 10-year intervals PSRs are performed to prove compliance of the Units with national requirements and international recommendations. Appropriate safety improvements are identified and schedules for their implementation are fixed, being a basic requirement for the permit of further operation. This includes the implementation of Emergency Operating Procedures (EOP) and Severe Accident management Guidelines (SAMG); the latter was first implemented with the activation of the Temelin NPP. Level 1 and 2 Probabilistic Safety Assessment (PSA) studies have been conducted for both plants.

The regulatory authority stated that no significant current non-conformity of with the design basis requirements was identified during the special inspections, aimed to verify the seismic and flood resistance of the NPPs after the events in the Fukushima NPP.

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

The information contained in the report confirms the robustness against design basis events. Czech NPPs seem to have a clear margin to manage such events; in order to manage the case of complete loss of external and internal AC (alternating current) supplies, Station Black Out (SBO) or loss of Ultimate Heat Sink (UHS), some of the foreseen safety improvements, considered in the report, should be implemented.

The situations that have been taken into account to decide about such safety improvements are adequately considered in the sections II.5 and III.5 of the national report.

The measures that can be envisaged to increase the robustness of the plant are defined for every assessed event.

The report addresses all components, which are considered essential for management of severe accidents and which are installed, still planned to be implemented or in the phase of discussion/analysis. These include organizational arrangements of the accident management and emergency planning, existing hardware measures to address severe accidents (primary circuit depressurization, hydrogen management for design basis accident, containment isolation etc.), as well as procedure arrangements (symptom-oriented EOPs and SAMGs).

Emergency situations are described and the available time margins are quantified for Dukovany and Temelin NPPs.

Additional analyses/measures are suggested to be performed/implemented regarding the issues associated with survivability of the accident management and mitigation systems in case of earthquake and severe accident conditions, presence of multi-unit severe accident, radiological conditions under severe accidents, and regarding the potential extensive damage of the infrastructure in and around the NPP. SAMGs for shutdown states and spent fuel pool (SFP) are under development.

The description of the adequacy of the assessment of the robustness of the plants against the external phenomena (specifically for earthquake resistance) were elaborated during the country visit.

1.5 Regulatory treatment applied to the actions and conclusions presented in national report (review by experts groups, notification to utilities, additional requirements or follow-up actions by Regulators, openness,…)

The national report describes the activities of SÚJB after the Fukushima accident. The evaluations in the framework of the stress test were carried out both by the operating organizations and by regulatory body with significant involvement of external consultants. The detailed requirements of the regulatory body were given to the operators through official letters, initiating the review process. Assessments performed by the regulatory authority is based on plant documentation, plant specific Safety Analysis Reports (SARs), Probabilistic Safety Assessment (PSA) studies, PSR documentation, EOP, SAMG. International requirements of e.g. the IAEA and World Association of Nuclear Operators (WANO) are considered as well as the outcome of international missions to the NPPs. The conclusions were reviewed by the regulatory body.

Opportunities for further improvement of robustness and safety features of NPPs identified during stress tests are described in detail; proposals/measures are clearly and separately listed for Dukovany and Temelin. Potential measures will be subject to further analyses; proposal of specific design modification has to be approved by the regulator in advance.

Many of the actions to increase the robustness of the plants have been implemented and some are at concept level.

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 Design Basis Earthquake (DBE)

2.1.1.1 Regulatory basis for safety assessment and regulatory oversight

The basic legislative procedures and requirements to ensure nuclear safety in the Czech Republic are governed by Act No. 18/1997 Coll., on the Peaceful Use of Nuclear Energy and Ionizing Radiation (the Atomic Energy Act).

Specific requirements for nuclear facilities with respect to external risks are described in Regulation No. 195/1999 Coll. of SÚJB (Requirements on Nuclear Installations for the Assurance of Nuclear Safety, Radiation Protection and Emergency Preparedness). The regulation refers to natural events such as earthquakes, windstorms and floods stating that: "The most severe natural phenomena or events that have been historically reported for the site and its surroundings, extrapolated with a sufficient margin for the limited accuracy (uncertainties) in values and in time" need to be considered for the design of nuclear installations, which is in compliance with relevant WENRA reference level.

During the country visit it was confirmed that for external events the current licencing practices are consistent with IAEA guidance. The current Earthquake assessment level is defined equivalent to the probilability of 10^{-4} per year.

The modifications of the legal requirements – including those related to seismic safety – are expected to be implemented in the next two years.

2.1.1.2 Derivation of DBE

NPP Dukovany. The original level of the DBE for the NPP is given as a peak ground acceleration PGAH (peak horizontal ground acceleration) = 0.06g for the safety level SL2 (10,000 years recurrence interval, 95% non-exceedence probability) and PGAH = 0.05g corresponding to I=6° MSK (Medvedev-Sponheuer-Karnik) for SL1 (105 years recurrence interval, 90% non-exceedence probability). The original Seismic Hazard Assessment (SHA) was performed in 1985. In order to meet the minimum seismic design requirements suggested by IAEA, the level has been set to 0.10g PGAH and 0.067g PGAV (peak vertical ground acceleration) in 1995. The decision followed an IAEA mission to the site.

NPP Temelin. The DBE for SL2 (termed MDE, Maximum Design Earthquake) is defined by peak ground accelerations PGAH = 0.10g and PGAV = 0.07g, which are comparable to I=7°MSK (10,000 years recurrence interval, 95% non-exceedence probability). SL1 (referred to as DE, Design Earthquake) is given by PGAH = 0.05g and PGAV = 0.035g (comparable to I=6°MSK, 100 years recurrence interval).

The first SHA was carried out in 1979 leading to MDE=6°MSK / PGAH = 0.06g and DE = 5°MSK / PGAH = 0.025g. These values were upgraded to the current ones following an IAEA mission in 1995 in order to conform to the minimum SL2 level suggested by IAEA.

2.1.1.3 Main requirements applied to this specific area

The general requirements for nuclear facilities with respect to earthquake hazards are described in Regulation No. 195/1999 Coll. of the SÚJB. Assessments of the DBE for both NPP sites are given by peak ground accelerations (PGA) for the return period of 100 years (SL1 or DE) and a non-exceedence probability of 90%. SL2 (MDE) is defined by peak horizontal and vertical ground accelerations for 10,000 years return period and non-exceedence probability of 95%.

2.1.1.4 Technical background for requirement, safety assessment and regulatory oversight

The original DBE for both sites (Dukovany and Temelin) was derived from a comparison of different approaches including deterministic and probabilistic assessments, which account for different source zone models, a non-zonation model and a model that included faults as "seismogenic structures"which uses a subjective expert judgement which was not validated. During the country visit it was explained that the hazard is being re-evaluated using modern standards. However, the results are still to be validated.

2.1.1.5 Periodic safety reviews

Periodic safety reviews (PSR) of the Czech nuclear facilities are performed at 10-years intervals. Among other safety aspects the reviews evaluate to what extent the original design basis remains in effect.

The last national PSR at Dukovany was carried out in 2006 and 2007. In addition, the report mentions an IAEA mission, which led to the upgrade of the DBE to 0.10g in 1995. The same mission apparently led to the upgrading of the DBE for the NPP Temelin. In Temelin a PSR was carried out in 2008 and 2009 resulting in the identification of various measures to increase the resilience of the plant design against the consequences of severe accidents.

Both plants underwent an international evaluation process by IAEA in the framework of a program focusing on WWERs (1991-1997).

2.1.1.6 Conclusions on adequacy of design basis

NPP Dukovany. SUJB concluded that the similar results obtained for the SL2 design basis using four different SHA approaches sufficiently supports the adequacy of the DBE.
NPP Temelin**.** The National report concluded that the peak ground accelerations derived by the SHA for the site are adequate and that there are no tectonic structures within the Czech Republic that would be able to generate strong earthquakes at the sites. During the country visit it was explained that current standards and related research will be considered in the updating of the SHA. The low site seismicity is supported by seismic data obtained by a local monitoring network.

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

NPP Dukovany. SUJB states an upgrade of the SL2 level from PGA=0.06g to PGA=0.10g was carried out to meet international requirements. Currently the resistance of significant safety equipment and civil structures is being increased to 0.1g, the value of peak ground acceleration, in all units. During the country visit it was explained that all of safety systems and majority of buildings have been upgraded. The remaining work is be to be completed by 2015, the end of the current PSR period.
NPP Temelin. The regulator finds the current state of the facilities of the NPP to be in accordance with the design requirements. SUJB implemented a number of regular activities (walkdowns etc.) in order to check that the current state of the facilities of the NPP is in accordance with the design requirements.

2.1.2 Assessment of robustness of plants beyond the design basis

2.1.2.1 Approach used for safety margins assessment

NPP Dukovany. Systems, structures and components (SSC) and civil structures relevant for seismic resistance (classified to category “S”) are assessed by type tests, calculations or indirect evaluation on the basis of operational experience. Some details about testing methods and the estimated robustness of classified SSC and civil structures were given during the country visit. Resilience of the spent fuel pools (BSVP), containment and civil structures on the containment boundary are assessed as follows: “After full completion of the design regarding the Dukovany NPP seismic upgrading, the basic safety functions will be preserved up to the level of the ground acceleration (PGAH) of 0.10g”.
NPP Temelin. Buildings, SSCs and service systems that are required for achieving a safe shutdown state were analysed by experiment, calculation or indirect assessment. Safety margins for selected SSCs are quantified by calculations of their fragility expressed as the value of bedrock acceleration related to a likelihood of failure <5% (HCLPF, High Confidence of Low Probability Failure).

2.1.2.2 Main results on safety margins and cliff edge effects

NPP Dukovany. SUJB claims a margin as the difference between the original hazard values of the site (PGA=0.06g) and the design basis assessment of seismic upgrading (PGA_{SL2}=0.10g). Nevertheless the utility is evaluating the margins beyond 0,1g PGA. During the country visit information was provided on HCLPF values for some of the civil structures that ranged from 0.112g for cooling towers to 0.19g for the vent stack. During the plant visit it was explained that SSCs of safety classified systems reach resistance values between 0,11g and 0,169g. The upper resistance limits for circulation cooling water is given as 0.112g, based on the capability of the cooling towers. It is recommended that SUJB should consider ensuring enhanced capability for this function is developed. This is also discussed in chapter 3.

NPP Temelin. According to SUJB, the seismic resilience of buildings and selected parts of the NPP proved that relevant safety systems and structures significantly exceed the value of MDE (I=7°MSK / PGAH = 0.10g). Data are provided for a selected list of safety-relevant SSC showing that calculated

HCLPF exceed the MDE (SL2) value of 0.10g. Fulfilment of the safety functions could be threatened at acceleration values exceeding PGAH = 0.15g.

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

The seismic monitoring system around Temelin NPP is a strong safety feature. For Dukovany NPP there have been many enhancements to the plants in line with increased seismic requirements arising from the PSR process, although it is noted that completion is not programmed until 2015.
Improvements are identified in the area of the ongoing SHA to confirm or re-assess current DBE levels at the background of new geological, paleoseismological and geodetic data obtained from the Bohemian Massif.

2.1.2.4 Possible measures to increase robustness

For the **NPP Dukovany** SUJB's report includes a statement that the project of seismic upgrading (to the current DBE with PGAH = 0.10g) will be completed by 2015.
The PSR for the **NPP Temelin** identified a range of measures to increase the resilience of the plant design against the consequences of severe accidents. The timelines for implementation are set to 2015 and 2018.

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

For both sites SUJB's report refers to a seismic probabilistic safety assessment as work in progress (the report is completed but not reviewed yet by the Regulator).
Further measures proposed:
- Reinforce and/or qualify the fire brigade quarters for earthquake resistance.
- completion of the seismic upgrade program at Dukovany NPP

2.1.3 Peer review conclusions and recommendations specific to this area

The original DBE assessments was performed in agreement with the technical requirements at that time (80^{th}). During the PSR process a re-evaluation against 0,1g PGA for Dukovany NPP, in line with IAEA guidance has been introduced. During the country visit it was explained that work has been carried out to evaluate the seismic hazard using modern methods taking account of recent paleoseismological and geodetic data. This SHA is still to be validated and it is recommended that SUJB considers the implications during the PSR process.
The upgrade program for Dukovany NPP is scheduled to be completed in 2015. It is recommended that SUJB should continue to monitor the ongoing earthquake resistance qualifications and reinforcements for the Dukovany NPP to ensure that all the safety related SSCs of the plant are resistant for at least 0.1 g PGA.
It is also recommended that the proposed reinforcement should continue to be monitored by the national regulator.
It is recommended that SUJB should consider how to monitor resolution of:
- actions to increase the plant's capabilities to cope with the indirect effects of an earthquake and other external events
- low seismic margins for cooling towers serving as heat sink for the ESW
- low seismic capability for fire brigade building

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

2.2.1 Design Basis Flooding (DBF)

2.2.1.1 Regulatory basis for safety assessment and regulatory oversight

The regulations refer to natural events such as earthquakes, windstorms and floods state that: "The most severe natural phenomena or events that have been historically reported for the site and its

surroundings, extrapolated with a sufficient margin for the limited accuracy (uncertainties) in values and in time" need to be considered for the design of nuclear installations.
SUJB states that WENRA Reference Levels will be implemented in the legally binding legislation in 2013. It is noted that the actual evaluations take into account the 10^{-4} per year recurrence frequencies.

2.2.1.2 Derivation of DBF

NPP Dukovany: It is claimed in the report that the Dukovany NPP location is not endangered by natural or specific floods. This claim is convincingly supported by the description of the plant site elevation and the elevations of the nearby rivers, dams and reservoirs (~ 80 m below the plant site).
NPP Temelin: As described in the report, all the natural and artificial water bodies are more than 100 m below the elevation of the plant site, thus physically the only potential for flooding is the extreme rainfall. The expected highest 15 minutes rainfall corresponds 88 mm, once in 10,000 years, which even without any drainage is unable to cause significant effects. Due to the morphology of the terrain even the natural drainage removes most of the excess water.
In the evaluation of the design basis for flooding all the upstream reservoirs, the small water flows nearby and the groundwater, as well as the effect of torrential rain, were taken into account.

2.2.1.3 Main requirements applied to this specific area

The main requirement is that the SSCs necessary for safe shutdown of the plant need to remain operational after any possible flood situation.

2.2.1.4 Technical background for requirement, safety assessment and regulatory oversight

The flooding is practically excluded on the basis of general morphological and geographical considerations; no detailed analyses are referred in the report. It is stated that: all the civil structures located in the Dukovany NPP premises are safely protected by means of the altitude level of the premises and a similar statement holds for the Temelin site. It is also stated that any extreme rainfall can be handled without the assumption of the drainage system – just by the site morphology – at both sites.

2.2.1.5 Conclusions on adequacy of design basis

As only the storm precipitation is the possible cause of any flooding on the sites, the effectiveness of the drainage system is evaluated, though it is shown that even draining the maximum possible flood is not a concern. The walkdown reviews confirmed the situation.

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

Due to location of the plants several tens of meters above the closest rivers the plant sites are well protected against flood conditions.

2.2.2 Assessment of robustness of plants beyond the design basis

2.2.2.1 Approach used for safety margins assessment

Direct comparison of the elevation of safety SSCs to the possible maximum flooding is made due to the highest precipitation for 10,000 years. Due to site morphology, even such an extreme precipitation is drained from the sites simply by the surface slopes.

2.2.2.2 Main results on safety margins and cliff edge effects

The margins against flooding are extremely high; no cliff-edge effect is identified.

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

The effects of floods might cause problems only with managing the consequences of floods owing to deteriorated access to the Dukovany NPP location, threat to persons restricted possibility to use the emergency shelters located under the level of site grade as a result of extensive floods and damage to the infrastructure in the Dukovany NPP surrounding environment.

2.2.2.4 Possible measures to increase robustness

For both sites: some modifications to emergency procedures and analyses regarding the usability of the shelters under flooding conditions are foreseen.
For the Temelin site: increasing the protection of the diesel fuel pumps against the effects of flooding and also an alternative shelter is to be set up for the emergency response organization when the dedicated emergency response centre is damaged due to some external hazard.

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

No additional further studies are foreseen about flooding.

2.2.3 Peer review conclusions and recommendations specific to this area

Convincing information is provided that the flooding from external water courses is “inherently ruled out” and the possible maximum flooding due to extreme rainfall is limited due to the morphological characteristics of the sites. At the same time there is a proposed measure for the Temelin site that the resilience of the emergency diesel generators should be increased, with a reference to the latest PSR.

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

2.3.1 Design Basis Extreme Weather

2.3.1.1 Regulatory basis for safety assessment and regulatory oversight

The regulations refer to natural events such as earthquakes, windstorms and floods stating that: “The most severe natural phenomena or events that have been historically reported for the site and its surroundings, extrapolated with a sufficient margin for the limited accuracy (uncertainties) in values and in time” need to be considered for the design of nuclear installations.
SUJB states that WENRA Reference Levels will be implemented in the legally binding legislation in 2013.
It is noted that the actual evaluations take into account the 10^{-4} per year recurrence frequencies.

2.3.1.2 Derivation of extreme weather loads

The meteorological parameters (rain, wind, snow and max/min temperatures) for 100 and 10,000 years were determined according to the IAEA NS-G-3.4 guidance with use of the Gumbel distribution. The 100 year extreme values are regarded as “design basis” parameters, while the 10,000 year values as “extreme design basis load”. The 10,000 year recurrence values are used as design basis for safety relevant SSCs, while the 100 year values for the other SSCs.
The occurrence, the effects and loads due to lightning is not discussed in the National report. In the course of topical review presentation it was clarified that the safety relevant buildings are qualified according to Czech standards for lightning protection.

2.3.1.3 Main requirements applied to this specific area

The main requirements are derived from the satisfaction of basic safety functions.

2.3.1.4 Technical background for requirement, safety assessment and regulatory oversight

Some deterministic analyses are referred in relation to loads due to high wind or to extreme load due to snow coverage; otherwise mainly expert judgements are applied.

There is a reference to the Dukovany PSR in relation to ensuring separation of safety systems from systems for normal operation used for ultimate heat sink because of the inadequate capability of the cooling towers in regard to extreme wind. Possibilities include using separate cooling towers or sprinkler pools for ESW heat sink. It is recommended that the SUJB considers how to ensure that this issue is effectively resolved and appropriate improvements incorporated.The PSR of Temelín plant did not discover any similar shortcoming since there a separate heat sink for residual heat removal is installed by the original design.

2.3.1.5 Conclusions on adequacy of design basis

As it is described in 2.3.1.2, the design basis is established on the 100 year recurrence values for non safety SSCs and the 10,000 year recurrence values are applied for safety SSCs.

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

It is claimed in the report that design basis is satisfied by referring to the PSR results. The reviewers see no point to question the statement.

2.3.2 Assessment of robustness of plants beyond the design basis

2.3.2.1 Approach used for safety margins assessment

The exceedence of 10,000 years recurrence values are considered for beyond design basis estimations, mostly by engineering judgement approaches. Also some particular combinations of meteorological effects were considered.

2.3.2.2 Main results on safety margins and cliff edge effects

The considerations for extreme snow loads show low or no margin for the generator hall, which might endanger the operability of the essential service water system. The considerations for extreme low temperatures may be too simple, not taking into account the realistic related effects, e.g. station black-out. No explicit cliff-edge effects are identified.

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

The civil structures seem to be robust for the weather effects except for the cooling towers. The other main field for possible improvements is in the organizational area (procedures, staffing, analyses).

2.3.2.4 Possible measures to increase robustness

In the stress test process it has been identified that the procedures for special handling of weather related threats need to be elaborated and some specific additions might be necessary to the emergency management procedures. The organizational arrangements to ensure the necessary staff in case of lasting extreme weather conditions have to be elaborated. Some buildings and civil structures not having direct nuclear safety significance need to be analyzed for their resistance to extreme loads due to meteorological effects. Some refined further analyses and verification of current analyses are deemed to be necessary. The cooling towers at Dukovany appear to have a limited capability in respect of strong wind and the PSR identifes the need to consider diverse ultimate heat sink possibilities by using separate cooling towers or sprinkler pools for ESW heat sink

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

The diversification of the ultimate heat sink for ESW system.

2.3.3 Peer review conclusions and recommendations specific to this area

In the stress test process it has been identified that the procedures for special handling of weather related threats need to be elaborated and some specific additions might be necessary to the emergency management procedures. The organizational arrangements to ensure the necessary staff in case of lasting extreme weather conditions have to be elaborated. The considerations for extreme low temperatures may be too simple, not taking into account the realistic related effects, e.g. station black-out. Some refined further analyses and verification of current analyses are judged to be necessary. The elaboration of diverse connection to the ultimate heat sink and the load analyses of specific civil structures are already in progress and it is recommended that the SUJB should ensure that the question of diverse ultimate heat sink is resolved effectively.

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

Offsite power supplies for Dukovany NPP are represented in page 55, for Temelin NPP in page 194 of the national report. According to the information supplied, the grid connections of Czech NPPs are adequately reliable.

In all units of NPP Dukovany and Temelin for the case of a Loss of Off-Site Power (LOOP) event, three redundant safety classified diesel generators start, each one assigned to its respective safety division (SZN1, SZN2, SZN3).

Dukovany has additionally two subdivisions (called SZN 4.1 and SZN 4.2) per unit, not fully qualified as safety system, assigned to BS divisions SZN1 and SZN2, respectively, supplied from non-interruptible battery / rectifier / inverter sets.

In Temelin there are two additional diesel generators (classified as safety related and shared between the two units) assigned to divisions SZN4 and SZN5, equivalent to those mentioned for the Dukovany NPP. They have the capability of being connected to BS divisions SZN1 and SZN3, in both units.

The diesel fuel reserve of the safety function (BS) diesel generators is adequately considered in the report; also DGs have more than 72 hours autonomy in relation with lubrication oil needs, and availability in the sites.

The cooling of safety systems is guaranteed with the water pumped by the essential water system (TVD or ESW).

Czech NPPs adequately cover the 72 hours time for diesel operation considered in the ENSREG guidance. Resilience of the BS diesel generators has been increased. Additional protection against heavy rain has been implemented.

The report describes that for the case of an SBO event in Temelin the common diesel generators or hydro power plants are considered as alternative AC power sources in existing procedures, none of these sources is seismically qualified. Diesel generators are started automatically within 10 seconds time period if voltage drops on 6 kV busbars. Hydro power plants have connection times between 30 and 60 minutes. These times are in accordance with some foreign regulations (US R.G. 1.155 considers 60 minutes), and seem acceptable. Periodic exercises are being performed. Capacity of either one diesel generator or hydro power plant is sufficient to cope with SBO at both units in Temelin. In Dukovany the arrangement is similar. At this moment no additional SBO diesels are installed in both NPPs, but there are plans to purchase them.

Batteries capacity has been addressed in the report. The battery duration should exceed the required time to connect mobile generators, and/or to perform other actions to fight against a complete loss of DC and SBO event. This is addressed later in the subchapter 3.2.2 of this report.

3.1.1 Regulatory basis for safety assessment and regulatory oversight

Sections 1.3 and 1.7 of the national report give a picture of the nuclear safety regulations, and the regulatory process, existing in the Czech Republic. References to sections of Regulation No. 195/199 are very illustrative. International WWER evaluation within IAEA (section I.5) and other international missions (section I.6) provide good support.

The basic national legislative acts and licensing requirements to ensure nuclear safety are described in the report. The regulatory basis (requirements, guidance, and licence conditions) for safety assessment of beyond design basis accidents and accident management is described. It is stated that the IAEA safety standards for severe accident management are considered in the review and amendment of the regulatory requirements.

The national report indicates that safety assessment and regulatory oversight are in agreement with international scope of these activities, referred to design basis events assessments.

3.1.2 Main requirement applied to this specific area

The main and specific requirements to the design of nuclear facilities are included in Regulation No. 195/1999 Coll. of the SÚJB, on the Requirements on Nuclear Installations for the Assurance of Nuclear Safety, Radiation Protection and Emergency Preparedness. With respect to the external risks, the regulation defines the requirements in terms of the protection against events caused by natural conditions or human activity outside of the nuclear installation. The specific technical requirements related to the design of systems for residual heat removal, emergency core cooling, power supply, redundant power supply systems, and the emergency power sources are quoted in the report.

3.1.3 Technical background for requirement, safety assessment and regulatory oversight

The Czech licensee performs comprehensive and systematic safety evaluation before a nuclear installation construction, commissioning and throughout its whole service life. The evaluation is documented and regularly updated at prescribed intervals to reflect operational experience and significant new scientific and technological information related to nuclear safety and, in compliance with the Act, assessed by the responsible regulatory body.

The specific requirements with respect to the beyond design basis accidents (BDBA) have been included in SÚJB Regulatory Guide on the Requirements for Nuclear Installation Project BN-JB-1.0. It has been clarified during the country visit, that most of the requirements in this manual are in line with the IAEA Safety Standard NS-R-1 (SSR 2/1): Safety of Nuclear Power Plants: Design (2012). According to the quoted provisions severe beyond design basis events shall be selected using a combination of engineering judgment and probabilistic methods to determine those events for which reasonably practicable preventive or mitigative technical and organizational measures can be identified.

The technical background in Czech Republic is basically deterministic. The use of Level 1 and Level 2 PSA is addressed in Sections II.1.1.4 and III.1.3 of the report. PSA is mainly contemplated as a complementary tool. It is stated that the concept of “Living PSA” is being used, what suggests that there is a provision to incorporate the operational experience into new PSA analysis.

3.1.4 Compliance of plants with current requirements

In general there is no evidence in the report indicating that the plants are not in compliance with the current legal requirements, however it is noted that at Dukovany NPP currently there is no diverse ultimate heat sink. In addition the cooling towers which are part of the essential service water system (ESW) are not specified as safety class components.

3.2 Assessment of robustness of plants

According to the Czech authority SUJB, the stress test should be understood as a complementary assessment of the existing safety margins against beyond design basis events performed in addition to the standard licensing safety assessment against the legally binding requirements and to the periodic safety review.

The robustness of the Czech NPPs is based on the concept of defence-in-depth, with resilience against LOOP situations, redundancy of diesel generators, autonomy of such diesel generators, switching between various busbars and diesel generators on-site and the alternative power supply from hydro power plants.

Mobile equipment will be made available, according to the provisions contained in the report; increase of the robustness with such means is clearly convenient, as mentioned in the report.

3.2.1 Approach used for safety margins assessment

The assessment of the safety margins in terms of time available to possible cliff-edge effects in events with LOOP, SBO, UHS and combination of them is performed using deterministic approach and engineering judgement. In many cases the time to perform specific restoration actions is practically validated with implementation of emergency exercises.
It can be concluded from the report that the incidence of common mode failures has been considered by the utility and in the assessment by the regulatory authority, though there is a dependency on the TVD system. Czech NPP strategy is clearly based on keeping the continuity of the power supply, with equipment adequately reliable. In case of a complete loss of AC sources existing on site and alternate AC off-site sources (hydro power plants), mobile generators or diesel pumps are apparently needed in a short time interval.

3.2.2 Main results on safety margins and cliff edge effects

Assessments of the loss of safety functions are performed and documented in the report in two consecutive chapters.

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

Description of the design solutions against LOOP has been made for both plants in a sufficient level of detail that allows the review to understand the design provisions. A design solution for LOOP[1] is to transfer the plant to the house load operation; if it is not possible, the plant safety buses are powered from the emergency diesel generators (EDG) and batteries. Each train of the emergency power supply system is capable of ensuring safe shutdown state in all design basis accidents. In case of loss of off-site power, signals for startup of the diesel generators are actuated independently for each EDG.

The only limiting factor for the long-term status of the loss of external sources would be the reserve of diesel fuel and lubrication oil for the EDGs.
For the Dukovany plant it is estimated that for each safety EDG, there is a reserve of stored diesel fuel for a minimum of **6 to 7 days** of operation, without the necessity for an external delivery. Considering the fact that for long-term operation only one of the 3 redundant EDGs per unit would be needed, it is concluded that there is fuel available for **18 to 21 days**.
The evaluation of the time constrains of the design of Temelin NPP to cope with LOOP shows that the real amount of the diesel fuel in the standard and reserve tanks would allow at least 56 hours of operation of all three EDGs (3x100%) at nominal load of about 5 MW, or about **7 days** of operation of a single EDG. This time period can be prolonged to about **10 days** considering the fact that according to the EOPs the actual EDG load would be between 2.5 and 3 MW. Additional diesel oil tanks are present on site.

- ***Station Blackout (SBO)***

In case of loss of off-site power and loss of the ordinary back-up AC power source, the main strategy at Dukovany plant is to recover AC power via separate lines (alternate grid) from two hydroelectric power plants, which have black-start capability, however the electrical connection lines between Dukovany NPP and the hydroelectric power plants are not seismically qualified. The identified possibilities to provide power supply are associated with restoration either from internal or from external sources, and are under the condition of operability of the external grid 400 kV and 110 kV line sections following a seismic event. As far as the current plant design does not include other dedicated provisions against simultaneous loss of off-site power and loss of the ordinary back-up AC power source (e.g. diverse or mobile generators), it is proposed to increase the plant robustness by implementation of alternative means for AC power supply for core cooling and heat removal.
The provisions at Temelin NPP against loss of off-site power and loss of the ordinary back-up AC power include two additional diesel generators (not diversified), which are common for both units and are intended to supply safety related systems. Arrangements for external diverse power sources include setting up connections with a nearby hydropower plants and hydro alternators, however the electrical connection lines between Temelin NPP and the hydroelectric power plants are not seismically qualified.

[1] All power supply lines (main and backup) are considered lost.

In case all AC power sources are lost, the accumulator battery can supply DC/AC power to the consumers, for which uninterruptible supply shall be supplied. All the units of both plants are equipped with 3 accumulator battery sets, each of them being capable to implement the designated monitoring and control functions (redundancy 3x100%).
The capacity of the accumulator battery sets of Dukovany uninteruptable power supply SZN1, 2 and 3 is 1500 Ah. According to the design, the discharge time of accumulator batteries with the maximum conservative load is at least 2 hours. Procedures have been developed to reduce the less important loads and saving of DC capacity. The real depletion time may be much longer than two hours. Based on the fact that battery depletion is an important cliff edge effect, further improvements are under consideration. It is recommended, that the regulator considers how to ensure this is resolved effectively.
Temelin NPP is equipped with 3x1600 Ah batteries for power supply of safety systems and 2x2400 Ah batteries for safety related consumers. The discharge time for these batteries is also at least 2 hours.
Currently, recharging of the accumulator batteries during SBO is not provided. If the power supply can't be restored within 2 hours, the operating personnel will lose the information on plant parameters and hence this is the first cliff-edge effect in case of SBO. For that purpose an improvement measure is proposed for ensuring an alternative source for battery recharging.
According to the report, the heat removal at Dukovany plant may be ensured in natural circulation mode for a period of about 20 hours after the SBO. This time may be prolonged with another 3 to12 days by applying of various strategies for heat removal on the primary or secondary side. In shutdown conditions, the natural circulation would be lost if the SteamGenerators SGs)feeding is not initiated within 4 hours.

Secondary side Feed&bleed strategies are particularly important. Safety related instrumentation is available during the autonomy time for the batteries. Operator actions related to secondary feed&bleed are important. For Dukovany and Temelin NPP the National Report mentions that manually operable valves exist for so called *PSA valves*[2], such valves seems useful to relief steam from SGs to atmosphere.

According to the analyses performed for Temelin NPP, a core outlet temperature of 650 degrees would be reached in SBO on full power after **2.5 – 3.5 hours**, while in shut down mode and mid-loop operation – after **30 min** (according to the answered questions). During the country visit the licencee announced that it eliminates the mid-loop mode of operation from the regular outage schedule.

- ***Spent fuel pools***

Several alternative ways for feeding the pools are proposed in the report, no one of which been included in the EOPs so far. Calculated times available until the boiling start in the spent fuel pools and until the fuel uncoverage in case of SBO initially were not provided in the report for the plants. During the Topical Review meeting it was explained that for both plants the conservatively calculated time until the start of boiling in the SFP is 2 hours, while the time available until the fuel uncoverage is 20-30 hours.

- ***Loss of Ultimate heat sink***

The design provisions for heat removal and ultimate heat sink have been described in the report for both plants.

In Dukovany NPP there are 4 wet cooling towers for twin units, which serve as heat sink for service water and also for essential service water (TVD) systems. Cooling towers are not qualified as safety components. This issue was recognized during the last periodic safety review in 2009, and is being addressed by the project "Separation of safety systems from operational systems" (No. 5983). As it was discussed during the country visit, this safety improvement project is currently in design phase; the hardware modification is scheduled from 2015 to 2017. It is recommended, that the regulator considers how to ensure this is resolved effectively.
Regarding the loss of primary UHS at Dukovany site it is noted that according to the results of conservative analysis (only half CČSI and CČSII pumping stations considered, minimum level in the

[2] From Czech National Report: PSA Valves – "Přepouštěcí stanice do atmosféry", "Steam bypass station to atmosphere"

cooling towers) there is a reserve of approximately 26 days for production and adding daily water, and about 39 days for the residual heat removal (operation of essential water system (TVD) pumps) from the disconnected reactor without adding raw water into essential water system TVD. It is concluded that for this case the function of heat transfer into the ultimate heat sink is not threatened in terms of safety.

As alternative heat sink of Dukovany plant it is proposed to pump water from fire trucks into SG through the so called super emergency feedwater system. This water will be evaporated in the secondary side of the steam generator and the steam will be released into the atmosphere (secondary feed&bleed). In addition it is stated that this technology is not adapted for ensuring alternative methods of heat removal from TVD consumer appliances. Connections to inject water from fire brigade equipment are already available at Dukovany, and are planned to be installed in Temelin. The partner country reported, that at this moment in Dukovany NPP 3 fire trucks are available, which can be used to feed the steam generators. Purchase of one more fire truck was initiated after Fukushima to have at least one fire truck for each unit. In Temelin NPP enough fire trucks are present, however no water connection points are available on relevant systems of the units. Safety improvement measure was decided by the licensee to resolve this issue. It was clarified during the country visit, that the first phase of system modification will be realized in 2012, and the full implementation is planned in 2013. SUJB should consider to follow up the implementation.

The external actions foreseen to prevent fuel degradation in case of loss of the primary ultimate heat sink and the alternate heat sink have been defined, however the time available to recover a lost heat sink or to initiate external actions and restore core cooling before fuel damage was not provided in the national report. The margins in case of simultaneous total loss of UHS seem not clearly presented in the report.

During the Topical Review meeting and the country visit the above mentioned issues were discussed in details. The Partner country informed that the time available to recover the lost heat sink before fuel damage in the worst case for Temelin is 2,5 hours for SBO, LUHS being bounded by SBO. The time frame of the same scenario in Dukovany is more than 10 hours (this time period can be prolonged upto 20 hours using feeding the steam generators from feedwater tanks by gravity). There are different hardware modifications foreseen to enlarge coping times.

- ***Loss of primary UHS with SBO***

For this combination of events, the bounding scenario is SBO. The external provisions foreseen to prevent fuel degradation, including mobile equipment such as fire trucks, are specified in the report.

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

The strong safety features as well as the areas for safety improvement have been identified in the report for both plants.

The report states that the stress test assessment results show the existence of safety and time margins and the robustness of both NPPs against extreme external events. There are previously adopted decisions (derived from PSR) to implement measures leading to the increase of robustness of the original NPP designs that corroborate the stress tests results. No issue requiring immediate intervention has been found in the NPPs. Despite the above mentioned statements, the stress tests identified opportunities for further enhancement of the robustness of both NPPs against the loss of UHS with and without SBO, especially in areas such as diversification of UHS, developing of procedures and alternative heat removal.

3.2.4 Possible measures to increase robustness

- ***LOOP, SBO***

After our review of Section IV.3.4 of the National report and discussion in topical peer review phase, we consider that all important issues are adequately addressed (with the comment included in paragraph 3.2.2 before).

Likely, the approach for the actions to Dukovany and Temelin should be almost identical, apparently both designs are similar.

- ***UHS***

- Specific possible safety improvements for **Dukovany NPP** related to the loss of UHS:Implement diverse (to the cooling tower) UHS means
- Develop a procedure for the loss of UHS and ESW systems in all 4 units
- Develop a procedure for the refilling of steam generators using fire fighting equipments
- Filling an open reactor and spent fuel pool (SFP) by gravity drainage from bubbler trays
- Removal of heat from the coolant in the SFP by means of coolant replenishment and its accumulation in emergency cooling water tanks (TH-system)
- Extensive damage mitigation guidelines for the use of alternative means

Specific possible safety improvements for **Temelín NPP** related to the loss of UHS:

- Install new hook up points for fire trucks
- Develop a procedure for the loss of UHS and ESW systems in both units
- Extensive damage mitigation guidelines for the use of alternative means
- Alternative replenishment of water to steam generator/SFP/primary circuit (with unsealed primary circuit)
- Analysis of heat removal from I&C systems following a loss of ESW

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

The measures, including further studies which had been already decided or implemented by operators are mentioned in the report.

The potential measures presented in 3.2.4B will be subject to further analyses as regards their efficiency. Technical measures concerning modifications to the current NPP design will be subject of feasibility studies including a proposal of specific design modifications which is to be approved before implementation by SÚJB. Those measures included in 3.1.4B are already in the process of implementation.

3.3 Peer review conclusions and recommendations specific to this area

Our conclusion from the peer review is that the Czech report is generally satisfactory, and in agreement with ENSREG guidance. Some of the possible safety improvements mentioned in the report seem important and should be promptly implemented.

In general there is redundancy and diversity in the electric and cooling capabilities to ensure safety functions, however additional alternate heat sink has not be implemented in Dukovany NPP. Besides that there are plans to increase system robustness to cope with SBO and LUHS. SUJB should follow the diversification of ultimate heat sink in Dukovany and the application of means and procedures to improve battery discharge time and makeup of steam generators.

It is recommended, that the SUJB consider how to monitor the licensee in respect:

- to ensure that the new safety related equipment has beyond design basis capability for hazards.
- to increase the plant robustness by implementation of alternative means for AC power supply for core cooling and heat removal
- to improve the battery depletion time and implement battery recharging
- to provide additional fire truck (Dukovany NPP)
- to install hook up points for steam generator water make-up at Temelin NPP

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 current nuclear legislation of the Czech Republic bases on the Atomic Energy Act no. 18/1997 on the peaceful utilisation of nuclear energy and its implementing regulations. The report also describes the main legislative and regulatory provisions that define main phases of the licensing process for nuclear installations and the scope of main safety justification documents needed for each licensing phase. More specifically main regulatory requirements addressing:

- emergency preparedness,
- beyond design basis accidents, and
- severe accident management,

are discussed in the national report, and the relevant specific local regulations are listed. In a very general understanding, the national report includes statements confirming compliance of the regulations in each of the above fields to applicable IAEA standards.

4.1.2 Main requirements applied to this specific area

It seems that the national legislation and national requirements for emergency preparedness are in general in compliance to the specifications of the IAEA safety standards GS-R-2, “Preparedness and Response for Nuclear and Radiation Emergencies” and GS-G-2.1, “Arrangements for Preparedness for Nuclear and Radiation Emergencies”. The addressed requirements for beyond design basis accidents (BDBA) are currently provided in the Manual of the SÚJB – on the Requirements for Nuclear Installation Project BN-JB-1.0. This document seems to be in accordance with IAEA safety manual NS-R-1, addresses events of the “extended design conditions” type, and declares specific requirements for BDBA. The existing severe accidents management guidelines (SAMGs) are based on the experience and philosophy of Westinghouse. The requirements on the accident management are currently summarized in the SÚJB guides (Requirements on the Implementation of EOP and SAMG-type Operating Instructions, BN–JB–1.11).

4.1.3 Technical background for requirement, safety assessment and regulatory oversight

Main instruments for the regulatory overview are the results and outcomes of the Periodic Safety Reviews (PSRs), of the permanently updated PSAs as well as of training. The results of the PSRs serve as a basis for measures, requirements and safety assessment.

In general, the severe accident management program at the NPPs is supported analytically. The analytical support is based on PSA and deterministic approach, which means that the accident scenarios with high probability that lead to severe accidents are selected and these are then deterministically analyzed using integral computer codes.

4.1.4 Periodic safety reviews (regularly and/or recently reviewed)

There is a practice of PSR of NPPs at 10-year intervals in the Czech Republic. The results of a PSR present a set of measures for maintaining or upgrading safety level to achieve compliance with current safety requirements for the whole period of NPPs operation until the next PSR or until the end of the plant lifetime. The last PSR for Dukovany was carried out after 20 years of beginning of operation, in the period from 1/2006 to 6/2007. The last PSR for Temelin was carried out in 2008 and 2009.The national report includes sufficient information about the results from the last PSRs of both NPPs.

4.1.5 Compliance of plants with current requirements (national requirements, WENRA Reference Levels)

The national SAMG concept is requested by SÚJB as well as the implementation of all WENRA reference levels. It will be legally binding in the amended Atomic act in 2013 and its decrees.
The WENRA requirements for “Emergency Operating Procedures and Severe Accident Management Guidelines” seem to be fulfilled except for the SAMGs for managing accidents at shutdown modes, and accidents in spent fuel pool, which have not been elaborated yet (to be implemented by 2014). The severe accident management is based on a symptom-oriented approach following the format of the EOPs. Certain criteria are defined for transition from EOPs to SAMGs. The transition to SAM Guidelines takes place when the reactor core is damaged. In this case, the EOPs are terminated and a transition to SAMGs is performed.

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

Information on the organization and arrangements of the licensees to manage accidents are described in detail and schemes are used to illustrate organizational structures.

The NPP operation is performed by the personnel in shift, sufficient in number and qualification, for all operational modes and accident conditions in the Unit. In case of severe accidents, the responsibility for support management activities is shifted to the Technical Support Centre (TSC) on site and for accident management to the emergency board, which is located in the emergency control centre also on the NPP site. In such a situation the personnel of the affected Unit perform the activities based on the instructions, which are included in the SAMGs. During the implementation of SAMGs the operational control over the personnel of the affected Unit(s) is taken by the emergency board officer, who remains the leader of the operating staff. The present management organization appears to be well structured and adequate to cope with different levels of severity in case of accident including a severe accident. There is still room for improvement of the plant personnel responsibilities for accident management in case of accident situations, including severe accidents at one or more units (e.g. plant staffing for multi-units, radiological conditions for staff, etc).

Dependence on the functions of other reactors on the same site:

There are four Units at Dukovany and two Units at Temelin site. For normal operating conditions the reactors are fully technologically independent; still nevertheless a series of auxiliary and supporting systems and the cooling basins spraying system at Temelin site are mutually used. The presence of several Units provides disadvantages but also advantages due to possible use of means from neighbouring Units. Each unit has independent power supply from external and internal sources. Under station blackout (SBO) it is possible to use power sources of the neighbour unit for supplying power to affected unit. This is only possible if the neighbouring unit is not affected by SBO and if the power infrastructure on site is not destroyed.

4.2.1.2 Procedures and guidelines for accident management

At present, the following sets of procedures are available at both Temelin and Dukovany NPPs for coping with BDBA and severe accidents:

- symptom-based EOPs for power operation modes,
- symptom-based EOPs for shutdown modes that cover as well the cases of threats to the heat removal from the spent fuel pools (SDEOPs),
- manuals for technical support centre,
- SAMGs (excluding shut down).

The SAM Guidelines are based on the SAM safety functions and are focused on the recovery of the heat removal from the reactor core, keeping the containment integrity as a last barrier against the release of radioactive products into the environment. If the core damage is identified, the EOPs are terminated and transition to SAMGs occurs, in particular, in following cases:

- ATWS (Anticipated Transients without Scram)
- Loss of core cooling
- Total station blackout

After transition to SAMGs is performed, a return to EOPs is not allowed. The SAM approach was developed and the SAM was designed to cope with accidents at all power operation states. Accidents during shutdown states and occurring at the SFP are not addressed in the existing SAMGs, but will be available by 2014. It is recommended that SUJB monitor the implementation.

4.2.1.3 Hardware provisions for severe accident management

For application of the SAMG, i.e. to allow the execution of SAM measures or to improve their mitigation effects, technical plant modifications have to be implemented. These modifications to a large extent are based on PSR findings. These hardware improvements are accompanied with suggested measures concerning regulation, organization and staff.

Modifications to enhance hardware provisions for severe accident, which have been proposed by the licensee are subdivided into short (2013) and medium term (2015) and still are under consideration, and only partly under implementation. The implementation will last for the next 4 years. The schedule (plan) for implementation of measures is to be approved by regulator authority in the nearest future.

- **Hydrogen:**

Regarding the hydrogen management, the existing hydrogen removal system at both sites is intended for DBAs only. Currently, it is under consideration to modify the hydrogen management system- to be used under SA conditions, by installation of PARs. Analyses were performed for the whole amount of zirconium in the core..

- **Power supply and instrumentation:**

According to the design, in case of SBO the power supply from external source has to be restored within 2 h. It can be assumed that nearly all of the severe accident measures relying on power supply would be no longer available in case of SBO longer than 2 h. If the high voltage lines are not available for longer than 2 h this could lead to very severe accident conditions.

At all units there is no special power supply for the instrumentation for monitoring under severe accident conditions. The power supply and the relevant instrumentation tools, intended for DBA have not been qualified for severe accidents conditions. But both plants still have post accident monitoring systems, with all instrumentation qualified for harsh post accident conditions and a sufficient range.

- **Mobile devices:**

The SAM measures do not include the use of mobile devices and non-technological means from external sources during DBA, BDBA and severe accidents, except for supplementary water that might be supplied by mobile pumps of the local fire rescue unit at Dukovany NPP. The use of mobile means e.g. pumps or electric generators from the NPP fire brigade, was not foreseen in the original design but is planned to be integrated in the SAMG by 2014.

- **Systems for depressurization:**

There is a number of technical means already provided by the original plant design:

- Pressurizer safety valves (to prevent pressure vessel melt-through under high pressure);
- System for emergency gas evacuation from the primary circuit;
- Steam generators safety valves or Steam dump to atmosphere (for primary circuit cooldown to reduce the primary pressure)
- Normal injection into the pressurizer;

Depressurization via the steam generators safety valves at Dukovany NPP is under implementation. This issue was clarified during the country visit. However, the survivability of existing equipment and their qualification for serve accident conditions has to be addressed.

- **Containment venting:**

The SAMGs include protective and preventive measures to ensure the containment integrity at the NPP. Therefore the SAMGs also contain instructions for using ventilation systems, which were not originally intended for venting. The approach to use them as a preventive measure to reduce the containment pressure is not justified, because it would lead to release of radioactive products into the environment. A filtered venting system would limit an excessive containment pressure build-up resulting from accumulation of non-condensable gases and decay heat, generated inside the containment in long-term, allowing to avoid containment overpressure in case of a severe accident. The issue is depending on the selected strategy for molten corium stabilization as well as the strategy to prevent overpressure of the containment in case of severe accidents different for both sites. A request to maintain filtered containment venting system from the SUJB is still open.

- **Coolability of molten core:**

The present design of the WWER-1000/V320 containment and the reactor cavity are such that any water supplied to the containment through the spray system or other means would not reach the reactor cavity. Thus, there is no opportunity for direct flooding the melt pool in the cavity. The SAMGs contain also instructions for flooding the containment with water. This could provide protection to the containment in case the core debris from the RPV reaches the containment. In general, the core melt coolability, stabilization and termination of severe accidents is still an open issue for the Temelin NPP. For Dukovany NPP, in-vessel-retention of the molten core has been planned pre-Fukushima and is at present in the stage of implementation. The implementation schedule has been discussed during the country visit and found acceptable and should be implemented by 2015.

- **Re-criticality**

The normal procedure is to feed borated water into the reactor coolant system. For some circumtances the SAMGs at both sites (Temelin and Dukovany) include the strategies allowing injection of non-borated water into the reactor as a last possibility to cool the fuel or debris at in-vessel phase of severe accident progression. As it has been clarified during the country visit the possibility of re-criticality has been considered by the NPPs and has been excluded based on certain qualitative considerations, although no dedicated detailed analyses have been performed. It is recommended that regulatory authority considers the need of requesting additional investigations of the potential for re-criticality for the correspondent SAM strategies.

- **Control rooms:**

The main control rooms (MCR) and the emergency control rooms (ECR) are equipped with emergency filtered ventilation systems and are shielded and protected sufficiently against radiation. The habitability of the MCR and ECR in case of containment failure during a severe accident has not been analysed.

Finally, it is recognized that not all systems used under SAM are designed to withstand earthquakes.

It is recommended that the seismic resistance of the systems used for severe accident management should be further analysed.

4.2.1.4 Accident management for events in the spent fuel pools

In the Units WWER-440/213 at the Dukovany site the spent fuel pool is located outside the containment in the reactor hall. Analyses of the fuel damage accident progression in the spent fuel pool covering the shutdown state of the plant are planned for 2012. SAMGs for severe accidents in the spent fuel pool are not prepared yet. The hydrogen issue in the reactor hall is assessed to be not critical, and the failure of the cooling in both pools would probably not lead to such concentration of hydrogen in the reactor hall, which would achieve the hydrogen burning limits.

With respect to spreading of radioactive substances from an accidental spent fuel pool to the reactor hall, which is common for both units, and the neighbouring containment (if it is open to the reactor hall) necessary actions have to be taken:

- to stop reactor hall ventilation system
- to evacuate personnel
- to stop the ventilation of the containment (if it is open to reactor hall).

The exact measures depend on operation modes of the affected and the neighbouring Unit. The measurements of the spent fuel storage pool during accidents are only displayed in the MCR. They are neither available in the ECR, nor in post accident monitoring system (PAMS).

At the WWER-1000 Units at the Temelin site the spent fuel pool (SFP) is located inside containment. Analyses of events involving spent fuel damage in the SFP have not been performed yet. SAMGs for accidents, which could lead to melting of the fuel in the SFP have not been elaborated yet. To prevent or mitigate the consequences of the fuel damage in the SFP, a continuous water supply from different systems is foreseen in order to remove the residual heat from the pool. The time period until the top of the spent fuel in the SFP is uncovered has been identified as a "cliff-edge" effect. The timeframe was presented during the country visit. The time span until the spent fuel is damaged in case of the loss of cooling in the SFP, as a result of SBO, was also presented during the country visit. In case of loss of cooling of spent fuel, actions for evacuation of the personnel from the containment and isolation of the containment are included in the emergency procedures, if the accident occurs during the plant shutdown mode. The analysis results show that if the cooling of the pool fails, the time delay to boiling is in the range of several hours to several dozens of hours. General analyses for hydrogen management for the SFP were presented during the country visit. The hydrogen management for SFP accidents is still under consideration. SAM instrumentation measurements, required for obtaining information on the SFP status are available. A system for monitoring of the temperature and water level in the SFP is connected to PAMS.

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

It was mentioned, that for multi units events may not be enough manpower and technical resources available on site (e. g. fire brigade); futher analysis is needed. For multi unit events further analysis are planned. In case of severe accidents there are several negative factors that may occur on both sites:

- restricted access to the site,
- loss of communication,
- high local dose rates, radioactive contamination,
- impact on MCR and ECR habitability, restrictions for local actions in other premises,
- feasibility and efficiency of SAM under external hazards,
- loss of power supply,
- instrumentation failures,
- risks from surrounding technical installations.

However, there is no information about possible arrangement of alternative means, such as air transportation (helicopters), which might be used in case of destroyed buildings, infrastructure and damaged communications. A possible coordination with the state administration (local fire rescue Unit, army etc.) is mentioned only. In case of a long-term loss of on-site and off-site power (SBO), the internal telephone centres on-site and off-site will not be operable, which will make the recovery of the off-site power supply more complicated.

Additionally there is no heavy-duty equipment on both sites to clear debris but it can be provided through the integrated rescue system of the NPP, if the infrastructure is broken down. The licensees are planning additional training and strengthen the TSC group for multi unit events.

In case of severe accidents the decision making process is supported by technical support centre personnel and plant control initially is carried out by control room personnel. The TSC provides information for plant status evaluation and decision making to support the staff in the control room by sufficient information and control capabilities for plant control. TSC is located in the emergency control centre (ECC), which takes responsibility for SAM in case of severe accident. In accidents when the offsite or emergency power supply is available, the ECC is ensured for at least 72 hours without external support. It has filtered ventilation system and a possibility for isolation from outside. However, it does not have sufficient local power supply equipment (DGs) that would ensure its long-term operation under SBO. This has been identified as a weak point during stress tests, and NPPs intention to implement additional power supply from external DG has been confirmed during the country visit. It has been also recognized for Temelin that ECC provides control capabilities for plant operation by the operating staff using components of non safety systems if the accessibility and habitability of the main and emergency control room is lost. It is also recognized for both sites, that it might be not possible to use ECC and TSC under severe external hazards such as earthquakes or floods. The habitability of the MCR and ECR in case of severe accident has not been analysed yet, correspondent analyses are planned. If the ECC is for some case not habitable any more there are off-site crisis centres available.

As it has been already mentioned, nearly all severe accident management measures are dependent on AC power by relying on battery back-up power, local manual operations, diesel generators, pumps etc. If the power supply in both Units is lost, the shift personnel could also be overloaded by activities related to restoring the power supply. This means that the capacity of the personnel on-site would not be sufficient to cope with the multi-Unit accidents. Further measures are forseen.

4.2.2 Margins, cliff edge effects and areas for improvements

4.2.2.1 Strong points, good practices

It should be mentioned as a strong point if the proposed mobile diesel generators to reload the batteries and to keep some severe accident measurements functional, are implemented.
Also, establishing practice on regular update of PSA Level 1 and requesting the operator to reflect the up-to-date state of the plants in the PSA models can be commended.
The proposal by the regulatory authority to establish common (regional) emergency response arrangements for several neighbour countries operating similar reactors is appreciable and should be discussed with the relevant neighbouring countries.
Proposal to increase the amount of coolant (water) on-site also can be indicated as a reasonable measure for increasing robustness of the plant response.

4.2.2.2 Weak points, deficiencies (areas for improvements)

Until now it is not clear which measures, of those under consideration will actually be selected for implementation. For several crucial issues (e.g. hydrogen management, corium cooling at Temelin NPP) evaluations are on-going or being started; it is open where they will lead.
NPP Dukovany: In the area of abilities to manage severe accidents opportunities were identified to increase the safety. This concerns administrative solutions, personnel area as well as hardware.
The key proposed measures include:

- improvement of the crisis plans and SAM documentation (e.g., providing SAMG for shutdown states and spent fuel pool accidents),
- completion of off-site places for their use as alternative location for SAM team,
- enhancement of the staff training in SAM field,
- additional technical measures (ensuring access to facilities, alternative communication means, etc).
- improved capability of buildings for storage of mobile equipment including fire trucks and fire fighters

Until now standard ventilation systems are considered for venting the containment. This system is not designed for severe accident conditions. Until now it is not decided if additional filtered venting system is needed for the WWER 440 units to prevent overpressure of the containment in case of severe accidents; futher analysis is needed.
Also sufficient amount of recombiners to reduce hydrogen concentration in case of serve accidents in the containment are not installed.
NPP Temelin: Failure of the reactor pressure vessel (RPV) during severe accident due to the fuel damage is a major factor in terms of negative processes in the containment.
Next important threshold in accident progression would be reaching a pressure value sufficient for challenging the integrity of the containment as a result of overpressure especially because there is no filtered venting system installed.
To manage severe accidents there are still opportunities to increase the safety. This concerns administrative solutions, personnel area as well as hardware. The key proposed measures by the regulatory authority include:

- improvement of the crisis plans and SAM documentation (e.g., providing SAMG for shutdown states and spent fuel pool accidents),
- enhancement of the staff training in SAM field,
- additional technical measures (ensuring access to facilities, alternative communication means, etc).

A filtered venting system to protect the containment against loss of integrity and to reduce significantly the releases of radioactivity to the environment is not in place.

4.2.3 Possible measures to increase robustness

4.2.3.1 Upgrading of the plants since the original design

With the IAEA extra budgetary program all Units at Dukovany and Temelin sites have been backfitted. All measures from the extra budgetary program regarding the category 3 and 2 issues have been implemented. Some of backfitting measures of category 1 are still not implemented. Some severe accident mitigation measures have been implemented in the NPPs in the Czech Republic before Fukushima. These measures are based on regulatory requirements and utility commitments.

4.2.3.2 Ongoing upgrading programmes in the area of accident management

The ongoing upgrading program for potential safety improvements measures is still under implementation and it is expected that all measures are implemented until 2015.

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

4.2.4.1 Upgrading programmes initiated/accelerated after Fukushima

The SÚJB requested to develop a number of feasibility studies and specific design modifications for implementation of measures related to the severe accident management. Topics to be studied in more detail include the following accident management issues:

- A feasibility study of the possibility of implementation of a filtered venting system (FVS) at the Temelin NPP to protect the containment against loss of integrity and to reduce significantly the releases of radioactivity to the environment has to be performed. The filtered venting system would limit a long-term containment over pressurization resulting from accumulation of non-condensable gases and decay heat, generated inside the containment in case of a severe accident.
- Regarding the hydrogen management, the existing hydrogen reduction system is designed for design basis accidents. A project was already initiated and is currently in progress on investigating the installation of a hydrogen reduction system (PARs) in the containment with extended capabilities for severe accidents.
- Additional technical measures to ensure the non-technological support functions such as ability to access buildings, accessibility of the fire extinguishing equipment and accessibility and habitability of the emergency control centre, shelters etc. Alternative measures to ensure long-term functionality of the communication means of the emergency response system as well as the communication with the external centres.
- Completion of procedures/guidelines for management of the selected accident conditions, e.g. SAMGs for managing severe accidents due to reactor core damage or spent fuel damage in the SFP at shutdown modes. Organizational measures, e.g. elaboration of crisis plans to ensure the accessibility of the location of the emergency control centres and thus to improve the coordination of the accident management activities, the communication and warning of the personnel on duty, etc.

Because of short geographical distance SÚJB proposed the idea to establish a common VVER emergency support centre for common emergency response for Dukovany, Bohunice, Mochovce and Paks for severe accidents. Such a centre would be a reasonable measure to increase the emergency preparedness for severe accident management by off-site means of the concerned NPPs.

4.2.4.2 Further studies envisaged

Additional measures for further improvement have been mentioned as a kind of preliminary list for consideration by the regulatory authority:

- Alternative replenishment of water into the containment sump

- Implementation of hydrogen removal system in the containment for SA
- Localization of core melt outside the reactor pressure vessel
- Verification of equipment functioning in beyond design operating conditions
- Analysis of radiation situation at MCR/ECR during a SA
- Process “shutdown SAMG” (damage to fuel during an open reactor / in the spent fuel pool)
- guidelines for the use of alternative means
- Staffing of the emergency response organization by qualified and well-trained personnel
- Capability of emergency response organization functioning outside the emergency control center
- Draw up agreements with external bodies (integrated rescue system, army) and nearby NPPs.

4.2.4.3 Decisions regarding future operation of plants

- Special arrangements for shift turnover in case of extensive infrastructure damage in the surrounding region.
- Setting up alternate emergency centres.
- Develop Plant Damage Mitigation Guidelines.
- Arrangements to ensure alternative means for ensuring long term external communication.

4.3 Peer review conclusions and recommendations specific to this area

The National Report of the Czech Republic is well structured and fits the guidance provided in the ENSREG stress tests specifications. Information supplied is consistent with the guidance provided by ENSREG.
No critical results, seriously threatening the NPP safety and requiring immediate intervention, have been identified during stress tests activities by the regulatory authority.
As a result of the stress tests several measures to increase the safety level of the NPPs were identified and will be analysed and implemented in the future. Although the exact list of actions, priorities and schedule of implementation of these measures are still being finalized by the licensee and the regulatory authority, some of them have been clearly specified in the national report. In particular, the following measures have to be implemented:

- development of SAMGs for shutdown modes including open reactor and SFP accidents;
- alternative containment sump water make up (Temelin)
- selection and implementation of appropriate solution for protecting containment from the overpressure loads;
- providing mobile (portable) equipment for ensuring feasibility of the SAM actions;
- further analyses of the impacts from the infrastructure damages, multiple Unit accidents etc on the SAM and emergency response provisions..
- increase robustness of storage building structures for mobile devices including fire trucks, or relocation of equipment
- ex-vessel cooling at Dukovany NPP
- cooling of molten core is still an open issue for Temelin NPP
- installation of additional recombiners sufficient for severe accident conditions at Temelin and Dukovany NPPs

A filtered venting system to protect the containment against loss of integrity and to reduce significantly the releases of radioactivity to the environment should be analysed in order to determine any appropriate modifications for all units at Temelin NPP and for all units at Dukovany NPP. The current system is not designed for severe accident conditions. The filtered venting system would limit a long-term containment over pressurization resulting from accumulation of non-condensable gases and decay heat, generated inside the containment in case of a severe accident.

Implementation of the measures identified during stress tests and recommended during peer review of the national report will ensure robustness of the SAM arrangements of the Dukovany and Temelin NPPs.

Accidents during shutdown states and occurring at the SFP are not addressed in the existing SAMGs, but will be available by 2014. It is recommended that SUJB considers how to monitor the implementation.

List of acronyms

BDBA	Beyond Design Basis Accidents
BS	Category Of Safety Systems
DBE	Design Base Earthquake
DBF	Design basis flood
DG(s)	Diesel Generator(s)
ECR	Emergency Control Room
EDG	Emergency Diesel Generators
ENSREG	European Nuclear Safety Regulators Group
EOP	Emergency Operating Procedures
ESW (TVD)	Essential Service Water (Technická voda důležitá)
FVS	Filtered Venting System
HCLPF	High Confidence of Low Probability Failure
IAEA	International Atomic Energy Agency
LOOP	Loss of off-site power
MCR	Main Control Room
MDE	Maximum Design Earthquake
NPP	Nuclear Power Plant
PAMS	Post Accident Monitoring System
PARs	Hydrogen Reduction System
PGA	Peak Ground Accelerations
PGAH	Peak Horizontal Ground Acceleration
PGAV	Peak Vertical Ground Acceleration
PSA	Probabilistic Safety Analysis
PSR	Periodic Safety Review
RPV	Reactor Pressure Vessel
SAM	Severe Accident Managment
SAMG	Severe Accident Management Guidelines
SBO	Station Blackout
SFP	Spent Fuel Pool
SG(s)	Steam Generator(s)
SHA	Seismic Hazard Assessment
SSCs	Structures, Systems and Components
SÚJB	State Office for Nuclear Safety of the Czech Republic
SZN	Systém zajištěného napájení Secured power supply
TSC	Technical Support Centre
UHS	Ultimate Heat Sink
WANO	World Association of Nuclear Operators
WENRA	Western European Nuclear Regulator Association
WWER	Water-Water Energetic Reactor (VVER)