Four years after Fukushima:
Are Nuclear Power Plants Safer?

Critical Review of the Updated National Action Plans (NAcP)

of the EU Stress Tests on Nuclear Power Plants

Bulgaria, Czech Republic, Hungary, Romania

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FOREWORD

The introduction intends to give a quick overview about the EU nuclear stress test in a bigger framework, before the main part of this *Critical Review of the updated National Action plans (NAcPs) on the Stress Tests for Bulgaria, Czech Republic, Hungary and Romania* analyses the past four year of the stress tests.

This paper evaluates each country by comparing the tasks set at the end of the stress tests in 2012 (National Action Plans) until the updated National Action Plans published in December 2014. Our study goes beyond checking the number of measures completed or rather not completed in the majority of cases. It combines the stress test findings with the current conditions of each plant on the individual site; also plans for completing the proposed stress test action later or for licensing life time extensions have been taken into account.

Another aspect, which was not discussed at the official discussions at ENSREG level and in its reports is the question whether the suggested measures are adequate to remedy the weaknesses found and agreed on by the Peer Review Assessments in 2012. Each country report in this paper also answers the question, whether the risk each nuclear power plant poses has been reduced substantially or whether severe accidents with large radioactive releases still can occur.

Transparency was a new and interesting approach introduced for the stress test exercise and each country report also summarizes the experiences made. Another new feature were the Peer Reviews, when experts nominated by EU countries recommended to other EU countries measures to improve the safety in their plants. We examined, whether the new approaches – Peer Review in nuclear safety and transparency – are useful and should be continued, which is the path which has been chosen for the newly revised EU directive on nuclear safety.

The *Overall Conclusions* at the end of this paper also include the rather non-traditional feature of an *Outlook*, providing an idea of the status and the next steps in nuclear safety in Europe.

The EU, ENSREG and WENRA declare themselves being the „leader in nuclear safety“. This study checks this claim against reality of the stress test results, after millions of hours of (wo)man power were spent on conducting them since the nuclear disaster at Fukushima in 2011.

We hope that this study - despite the thorough technical information - provides a useful and concise overview over an important topic. The findings of this paper should enable the reader to gain a bigger picture and comprehensive understanding of the risk nuclear power plants pose in Europe.

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1 INTRODUCTION

The March 2011multiple core melt accidents at the Fukushima Dai-ichi nuclear power plant proved that it was not justified to exclude highly unlikely accidents from happening as had been the accepted safety philosophy for decades.

Quickly the European Council concluded in March 2011 that the safety of all EU nuclear plants should be reviewed on the basis of a comprehensive and transparent risk and safety assessment: The EU stress tests were invented and the EU Nuclear Safety Regulators Group ENSREG took over this task.

However, already two months later the scope of the EU stress tests was reduced, the comprehensive approach exchanged for a limited one. Only (1) **External Hazards, (2) Loss of Safety Systems and (3) Management of Severe Accidents** were to be assessed.

The following steps were set up for this unique nuclear safety examination:

1. Operators of the NPPs prepared a self-evaluation of their plants until 31 October, 2011.
2. National regulator reviewed the operator reports until December 31, 2011.
3. Peer Review - experts nominated by each participating EU member state together reviewed the national reports, some NPP were also visited. This Peer Review delivered a report with recommendations on the three topics for each of the 17 countries on April 26, 2012.
4. Each national regulator set up a National Action Plan (NAcP) until December 2012 to outline the measures considered necessary
5. Review of each National Action Plan by other participating countries; stakeholders were able to submit questions (25 February to 20 March 2013)
6. Only very general presentation, no specific country specific shortcomings were explained at the ENSREG conference (11/12 June 2013)
7. Updated National Action Plans were presented until 31 December 2014 to explain the status of implementation or non-implementation of actions. Stakeholders could submit questions in the forerun to the Peer Review Workshop (8 January to 28 February 2015)
8. The 2nd ENSREG Post-Fukushima National Action Plans Workshop took place on 20-24 April 2015
9. ENSREG nuclear safety conference on June 28&29, 2015: Stress test declared being a success, while admitting at the same time, that the implementation of measures has not been finished by far nor is it secured for the future.

It is important to underline that the EU stress tests cannot be understood as a comprehensive safety check of the NPP in Europe, because very important factors were excluded:

- Ageing
- Safety culture
- Plant design

Important events which were excluded:

- Airplane crashes
- Fires
- Human failure

More detailed information on each step can be found in past reports as listed in the References. This report attempts to give a concise assessment of the outcome of the past four years of stress tests in four countries - Bulgaria, Czech Republic, Hungary and Romania – and provides a broader outlook on the safety situation at the individual plants.

2 CERNAVODA NPP, ROMANIA

Romania´s two reactors at the country´s only NPP site Cernavoda are located in Constanta County, about 2 km southeast of the Cernavoda town boundary, at 4 km southeast of Danube River. Cernavoda NPP comprises two Pressurised Heavy Water reactors (PHWR) of CANDU 6 design, which are the only units in Europe based on the CANDU (**CAN**adian**D**euterium **U**ranium) technology.

Cernavoda NPP is owned and operated by the National Company Nuclearelectrica (**S**ocietatea **N**ationala **N**uclearelectrica, SNN) [RNR 2011]. In 2014, unit 1 and 2 (650 MWe net capacity each) generated about 18.5 percent of Romania's electricity [PRIS 2015].

In 1980, the construction of five units at the Cernavoda site began. But the project was scaled back in the early 1990s to focus on unit 1, which was completed in 1996. The second unit was connected to the grid in August 2007.

In 2007, the Romanian Government announced **plans to complete Cernavoda units 3 and 4**. In October 2014 SNN designated China General Nuclear Power Group (CGN) as the "selected investor" for the project and the two companies signed a letter of intent to proceed. The units will be updated versions of the Candu 6, but not the full new design of the EC6 version, since the concrete structures are already built. Unit 3 and 4 are reported to be 53% and 30% complete, respectively. [WNA 2014a]

The operating time of 30 years for unit 1 and 2 will end in 2026 and 2037, respectively. Therefore the operator (SNN) intends to start a PLEX procedure for an extension of 20 years. This announcement causes concerns, because already today the design of CANDU 6 reactors is very outdated, for example external threats as airplane crash and other human impacts as terrorism are not considered in the design. Also ageing of the pressure tubes is an issue.

Material degradation of the pressure tubes is a persisting problem of existing CANDU plants. The pressure tubes are exposed to the neutron flux, with consequent weakening effects. Problems occurred with delayed hydride cracking as a result of deuterium-zirconium alloy reactions. Also, pressure tube fretting corrosion appears to be a generic flaw of the CANDU design. This degradation mechanism has been traced back to vibrations of the pressure tubes and could lead to a loss-of-coolant accident. Both ageing effects of the pressure tubes have already been observed at the Cernavoda-1 [JPG 2012].

CANDU reactors are designed to undergo refurbishment after approximately 25 years of operation, requiring a major outage to extend the operation time. However, refurbishment projects seem to be significantly more complicated than expected:

- The single-unit Point Lepreau (Canada), which began commercial operation in 1983, is the first CANDU 6 to undergo full refurbishment. Work began in March 2008 and involved the replacement of all 380 fuel channels, calandria tubes and feeder tubes. This work was originally expected to be completed in 16 months; however the program was set back when problems with seal tightness necessitated the removal and replacement of all the calandria tubes for a second time. Not early as at the end of 2012 (after about 4.5 years), the reactor received the permission to operate at full power again [WNN 2012b].
- At Unit 1 of the Wolsong NPP (South Korea) the refurbishment was completed in July 2011. The entire re-tubing outage took 28 month to complete, thus considerable longer as the above mentioned 16 month [WNN 2011a]. The reactor came back into operation in July 2011. However, Wolsong 1's operating licence expired in November 2012. The Nuclear Safety and Security Commission (NSSC) began a process of stress tests, checks and discussions which culminated in October 2014 with a conclusion by the Korea Institute of Nuclear Safety

that the unit is suitable for operation given certain engineering improvements over the long term – but only until November 2022. It restarted operation in June 2015. [WNN 2015a]

- Because major problems were encountered in the refurbishment projects at CANDU 6 reactors at Wolsong and Pont Lepreau the owner of the Canadian CANDU 6 reactor Gentilly-2 in 2012 decided to close its reactor after the planned operation time of 30 years. Hydro-Quebec explained that the decision was made for financial reasons, additionally the Fukushima accident in March 2011 contributed to concerns about lifetime extension [NW 11/10/2012].

2.1CRITICAL REVIEW OF THE UPDATED ROMANIAN NACP

Concerning the three topics of the stress tests: (1) External Hazards, (2) Loss of Safety Systems and (3) Management of Severe Accidents, the Romanian NAcP listed 33 measures, 13 of these measures were already implemented in 2013 [RNR 2012]. The implementation of improvement measures is clearly scheduled, and the end date of the process is December 2015.

At the end of 2014, 24 measures have already been implemented, eight measures are in progress and one measure is planned. [RNR 2014]

The following section inquires whether these hazards have been dealt with sufficiently or still an accident with a major release could occur.

NATURAL HAZARDS

Romania is **one of the most active earthquake regions in Europe**. In 2011, the stress tests revealed that this hazard was not adequately assessed and the plant might be threatened by earthquakes.

- The value for the exceedance probability (return period) associated to the Design Basis Earthquake (DBE) was found being considerably lower than the current European practices. Margins to cliff edge effects, weak points and plant behaviour under beyond design basis earthquake were not evaluated. The Peer Review Team criticized that seismic upgrading has not been considered. However, the Romanian regulator CNCAN insisted that the seismic margin assessment showed that in comparison with the original DBE (PGA = 0.2g), systems, structures and components (SSCs) which are part of the safe shutdown path after an earthquake are able to perform their safety function up to 0.4g, which has a frequency of 5E-5 events/year**. The Romanian regulator did not change its opinion that this margin is adequate, thus additional margins have not been quantified.**
However, the lack of seismic resistance of other safety relevant Systems, Structures and Components could threaten the safety of the plant.

Concerning earthquake protection, some limited actions have been performed:

- The seismic walk-downs and subsequent seismic robustness analyses done as part of the seismic margin assessment have identified the need for several actions. These have been included in the regular plant seismic housekeeping program and were to be done by 2014 (No. 6). *The activities consisted in strengthening of the supports of various equipment and reducing the likelihood of seismic interaction by improving anchorage of various cabinets and equipment.*
- The seismic robustness of the existing Class I and II batteries were improved. (No. 4)
- Taking into account the fact that the probability of large earthquakes is extremely high (recurrence intervals for the Vrancea seismic zone: 50y for Mw>7.4), the Peer Review criticised the absence of seismic level comparable to the SL-1 of IAEA leading to plant

shutdown and inspection.[1] In this regard, CNCAN has to establish adequate regulations. (No. 8)

The Cernavoda site elevation is about two meters higher than the calculated **Design Basis Flood** (DBF). During the stress test procedure the regulator assessed the existing margins as being adequate and no additional measures were required to protect the plant against **external flooding**. However, flooding turned out to be a neglected issue: the Peer Review Team criticised that the dangers connected with extreme flooding events have been analyzed insufficiently, because margins for flooding have been assessed with limited identification of cliff edge effects and weak points; and pointed out that for a number of safety significant equipment located underground the protection against flooding needs to be improved (so that protection does not rely solely on the elevation of the platforms). Some limited measures have been done:

- According to the NAcP, potential measures to improve protection against flooding have been identified. (No. 2) **However, it was not explained which measures have been performed.**
- In addition, sand bags have been made available on site to be used as temporary flood barriers, if required. (No. 3) **It is not appropriate that the sand bags are the only measure to protect specific weaknesses.**
- The Peer Review Team criticised the lack of routine inspections of the flood protection design features, such requirements were to be established by 2013. (No. 7)

The following measure is still in progress:

- Design modifications to replace selected doors with flood resistant doors and penetrations sealing in buildings containing safety related equipment in rooms below the plant platform level are to be performed by 2014. (No. 5) *According to the updated NAcP, about 50 flood resistant doors were installed, but activities to improve penetrations sealing of selected rooms are still in progress. New deadline is the end of 2015*.

The Peer Review Team pointed out, that there is only limited information about extreme weather conditions, information regarding the plant capability beyond the design basis and the identification of cliff-edge effects and weak points are lacking.

- Until now only the specific procedure, which is in place for extreme weather conditions in order to include the proactive actions for plant shutdown, was reviewed. (No. 1)

More detailed regulatory requirements on the protection of NPPs against **extreme external events**, taking account of the results of the "stress tests" Peer Reviews are to be elaborated by the end of 2014. (No. 9)
CNCAN has elaborated this regulation based on Issue T of the 2014 WENRA RHWG Safety Reference Levels. According to the updated NacP, these regulations are to be published by January 2015.
However, it is not explained, in which time schedule necessary improvements are to be required.

The Peer Review highlighted the need of further work for assessing margins to cliff-edge effects due to external events. It was recommended that CNCAN obtains good quality programmes from the operator SNA and ensures that the work is appropriately followed up. (No. 10) *This measure is only planned.* Thus, no target date for implementation is set. CNCAN stated that this work is depending on the development of a common methodology, at EU-level. It is stated that *no guidance has been yet provided by CNCAN to the licensee on how to perform this particular type of assessment if the aim of the cliff-edge analysis is not only to demonstrate sufficient margins but also to identify the ultimate failure point of safety-related structures and systems. A common methodology at EU-level, based on*

[1] According to the IAEA, two levels of ground motion hazard should be evaluated for each plant site: seismic level 1 (SL-1) and seismic level 2 (SL-2). SL-2 is associated with the most stringent safety requirements, while SL-1 corresponds to a less severe, more probable earthquake level [IAEA 2003].

a joint regulatory effort, would be welcome.
This is one of the examples showing that CNCAN is not fulfilling the tasks of a nuclear authority. CNCAN performance does not comply with international standards.

LOSS OF POWER SUPPLY AND HEAT REMOVAL

Because **Station Black-out (SBO)** scenarios, i.e. the complete **loss of power supply** situations were not considered in the design basis of the units, there is no adequate protection against this threat. As the stress test has shown, if SBO occurs at certain points during the refueling process, two spent fuel bundles would not be adequately cooled. Fuel damage would occur in about 1.4 hours and the fuel starts melting after approx. 1.9 hours. Fission products are supposedly being retained either within the pressure boundaries of the refuelling machine or in the spent fuel discharge room which is part of the containment extension.

In case SBO will be induced by an earthquake, fuel damage could occur already after 4 hours as a consequence of not being able to depressurize the steam generators (SGs). To avoid this scenario operator action in less than 2 hours is necessary (manual opening of the Main Steam Safety Valves (MSSV)) and in addition, in about 2.5 hours, the mobile DGs have to be available. Efforts to prevent the hazard are made:

- A provision of a facility to open the MSSVs manually after a station black-out (SBO) was implemented. (No. 12)
- Procurement and testing of mobile equipment (e.g. mobile diesel generators, mobile pumps, connections, etc.) were done. (No. 11)
- A provision of connection facilities required for refilling water by using fire fighters trucks and flexible conduits to supply the primary side of the heat exchangers and steam generators (SGs) under emergency conditions were implemented. (No. 13)
- Specific emergency operating procedures (EOPs) to cope with Station Blackout and Loss of Spent Fuel Pool Cooling events have been implemented. (No. 14)
- Special agreements were established with the local and national authorities involved in the emergency response in order to ensure that in case of a SBO coincident with loss of primary ultimate heat sink (UHS) the plant has absolute priority to grid re-connection and supply of light and heavy equipment and the necessary diesel fuel. (No. 18)
  However, instead of improving the power supply of the plant, the agreement means that other important consumers (e.g. hospitals, traffic systems, private households) are without power after, for example, a heavy storm.

This limited measure is still in progress:

- The option of charging the batteries or the installation of a supplementary uninterruptible power supply for the Secondary Control Area (SCA) is to be evaluated by 2015. (No. 15) *A few options to supply plants critical parameters from SCA, during severe accident, from a seismically qualified power supply, were analyzed and documented. The solution selected for implementation was to add a new power supply to SCA instrumentation panels from 100 kW mobile Diesels, which are already procured.*

All in all the envisaged measures consist mainly of mobile equipment. Thus the prevention of an accident relies on the quick and faultless response actions of the staff, instead of installing reliable technical equipment

Accident management provisions for events in the **spent fuel pools** (natural ventilation for vapours and steam evacuation, seismically qualified fire-water pipe for water make-up) were implemented. (No. 19)

Furthermore, improvement of the existing provisions to facilitate operator actions (water level and temperature monitoring from outside the building) were to be performed by 2014. (No. 20) *The necessary action has been completed. Water level gauges were installed outside the SFB building.* **Again, only portable devices will be used for water temperature measurement.**

SEVERE ACCIDENT MANAGEMENT

The stress tests revealed that regulatory requirements regarding **Severe Accident Management** (SAM) are not incorporated in the regulations. The Peer Review Team recommended that "CNCAN should finalize the incorporation of severe accident management requirements in the Romanian regulation and, if possible, some qualitative or quantitative safety objectives related to the protection of the population." *According to the NAcP* severe accident management (SAM) requirements shall be included in a regulation in 2013 (No. 27). *In January 2014, CNCAN issued a regulation on the response to transients, accidents and emergency situations at NPPs. This regulation includes requirements on severe accident management.*
However, the incorporation of safety objectives in the safety regulations is not mentioned in the updated NAcP of 2015.

Because of the lack of regulatory requirements, measures to cope with severe accidents were not implemented until 2011. The following measures have been implemented between 2012 and 2014:

- A containment filtered venting system was installed in 2013 (Unit 1), respectively in 2014 (Unit 2). (No. 22)
- The passive autocatalytic re-combiners (PARs) to prevent hydrogen explosions were to be implemented by 2013 at unit 2; implementation at unit 1 was completed in 2012 (No. 21).
- Additional instrumentation for SAM, e.g. hydrogen concentration monitoring in different areas of the reactor building was to be implemented by 2013. (No. 23)
- The completeness of event-based and symptom-based Emergency Operating Procedures (EOPs) for all accident situations was to be verified by 2013. (No. 26).
- Review of the Level 1 PSA and completion of the Level 2 PSA (to include spent fuel pool accidents) were to be performed by 2013. (No. 29)
- Necessary measures to improve the reliability of the communication system and the on-site emergency control centre were to be implemented by 2013. (No. 30)
- Training for severe accident scenarios was implemented. (No. 17) *Refreshment training will be performed periodically.*

The implementation of the following SAM measure is ongoing:

- Improvements to the reliability of existing instrumentation by qualification to severe accident (SA) conditions and extension of the measurement domain are to be performed by 2014 (Unit 1), respectively by 2015 (Unit 2) (No. 24)*The target date has been changed due to difficulties in procuring items qualified to the specifications issued by the licensee. Since 2013, the manufactures/suppliers have adapted to the demand for equipment qualified for SA conditions, as required post-Fukushima, so the licensee could identify suitable suppliers. The action is now in progress. The remaining activities will be implemented in 2015 and 2016 outages.*
- Design modification for water make-up to the calandria vessel and vault are to be implemented by 2013. (No. 25) According to the updated NAcP, only at Unit 1, the necessary modifications have been implemented. At Unit 2, the modification will be finalized during the outage, in 2015. This modification was delayed because the installation of a certain valve

requires plant shutdown state. (Compensatory actions are in place to ensure the function of water make-up can be performed, if required, even if the permanent modification is not yet completed.)
However, it is not justified to delay necessary improvements due to economic reasons.

- Severe Accident Management Guidelines (SAMGs) taking account of plant modifications and upgrades performed after Fukushima are to be reviewed by 2014. (No. 32) *The target date was moved to mid-2015, the revised SAMGs need to be submitted to the regulator for review.*
- Severe Accident Management Guidelines (SAMGs) have been validated through emergency exercises (No. 17). However, it is important to understand, that the scope of these SAMGs is not sufficient to meet the international state of the art. **In the opinion of both regulator and operator the SAMGs for power states would provide valuable guidance to respond to an accident that originated from a shutdown condition. To meet the international state of the art** SAMGs specific for shutdown states are to be developed by 2015. (No. 33) *This measure is in progress. A common technical basis developed by a CANDU Owner Group Joint Project has been used by CNE Cernavoda to extend the site specific SAMG application to shutdown state.*
- During the stress tests the habitability of the main control room (MCR) and the secondary control area (SCA) was assessed for various types of accidents and it is concluded, that the shift crews can perform their work either from the MCR or from the SCA without exceeding an integrated dose of 100 mSv in the seven days following an accident. However, the Peer Review Team criticized that the case of a total core melt accident associated to a containment failure (or voluntary venting) has not been assessed. Thus, the habitability of the MCR in the case of a total core melt accident associated to a containment failure (or voluntary venting) was to be analysed by 2014. (No. 28). *The target date was changed to mid-2015 due to delays in the procedure for contracting the necessary studies from external companies.*
  However, the implementation of necessary back-fitting measures will take additional years. Both operator and regulator missed the idea of the stress tests (to analyse core melt accidents and to find improvements to mitigate the consequences).
- The accident managements depends on mobile equipment. However, a location to store the important intervention equipment (mobile DGs, mobile pumps, fire-fighter engines, radiological emergency vehicles, heavy equipment to unblock roads, etc.) that is protected against all external hazards is lacking. A new seismically qualified location for the on-site emergency control centre and the fire fighters are to be established by 2015. (No. 31) *The target date was changed due to legal and administrative issues, related to transfer of property of the physical location to the end of 2017. (Until the completion of the action, equivalent measures have been implemented to ensure that all intervention equipment are protected from external hazards).*
- Concerning the conceptual preparations of solutions for post-accident contamination and the treatment of potentially large volumes of contaminated water, no schedule is set. CNCAN stated this issue is to be considered, taking account of developments in international guidelines on this matter. **However, the measure is not listed in the NacP, operator and regulator are monitoring the development in other countries before they start considering their own actions**

2.2 TRANSPARENCY

The NAcP – along with all EU stress test documents – is accessible on the regulator's website but only in English language.

The word "transparency" is not mentioned at all in the NAcP. In January 2015 CNCAN was invited by NGOs in Romania and Bulgaria to speak at a round table on nuclear safety, but did not manage to send a representative. The nuclear authority on the other hand did not hold a public meeting on nuclear safety with the public.

On behalf of the NGO TERRA Mileniul III the experience with transparency during the past period was characterized as trying to comply with existing laws, however does CNCAN as most Romanian authorities still provide lapidary answers without giving away usable information.

The CNCAN website is still kept in an unfriendly to users' format. Real involvement does not take place, since strategies are published only after their final adoption and the way they are presented is very rough. This site is no help when trying to find out about decision making processes. Therefore submitting an information request under the transparency law turned out to be the best option.

There is no direct reference to a section dedicated to the stress test, often the best method to find information on the website is using the search engine from the home page.

In general CNCAN does provide information via the mentioned channels however, the situation remains unsatisfactory.

2.3 DISCUSSION AND CONCLUSIONS

This analysis of four years of stress tests showed that seismic risk, flooding and extreme weather events have not been sufficiently addressed by the operator of the Cernavoda NPP. The Romanian Regulator CNCAN (National Commission for Nuclear Activities Control) did not to insist on the implementation of the measures, which the EU Peer Review Team had drawn up as necessary.

Romania is one of the most active earthquake regions in Europe. The Peer Review Team criticized that **seismic upgrading** has been not been considered and safety margins have not been quantified adequately. However according to the NAcP, the regulator CNCAN sticks to the opinion that the seismic margins are sufficient and further measures are not necessary. Thus, the regulator missed the idea of the stress tests. Although the probability of an earthquake exceeding the plant's design limit is low, the possibility of a severe earthquake persists, which could trigger a severe accident.

Only limited work has been done during the last four years to improve the protection against earthquake and flooding. But even worse: no substantial improvements are envisaged for the future.

The stress tests revealed that **flood protection is insufficient**. A number of safety significant equipment is located in underground rooms of the NPP, making the implementation of flood resistant doors and sealing of penetrations necessary; this should have been completed in 2014, but is now postponed to 2015. Instead of reliable technical measures, **sand bags** have been made available. However, it is not justified **to use only sand bags to prevent the NPP from being flooded and risking a severe accident.**

On extreme weather conditions like heavy winds, snow and rain and the plant´s capabilities to withstand their effect, the Peer Review Team found out, that only limited information is available.

Further work for assessing margins to cliff-edge effects due to external events (flooding, earthquake and extreme weather events) is necessary. The Peer Review highlighted that the operator SNA should provide programmes and CNCAN should ensure that the work is appropriately followed up. But CNCAN revised its responsibility and stated that this work is depending on the development of a common methodology, at EU-level. No date is given on when concrete measures will have been implemented.

More detailed regulatory requirements on the protection against extreme external events, taking account of the lessons learned from the Fukushima accident and of the results of the "Stress Tests" Peer Reviews are planned to be elaborated by the end of 2014. While not even the requirements exist, no deadlines for the implementation of necessary measures against extreme events which can occur any day, the plants are allowed to operate.

The Spent Fuel Pool (SFP) is located outside the containment, thus in case of a severe accident a major release of radioactive substances could be a dangerous consequence. However, only improvement of the existing provisions to facilitate operator actions to prevent a severe accident in the spent fuel pool (water level and temperature monitoring from outside the building) were performed in 2014.

Mobile equipment is presented as the solution to compensate deficiencies of the reactors and the spent fuel pools. Procurement and testing of mobile equipment were done. However, a location to store the mobile equipment protected against all external hazards is still lacking. **There can be no guarantee that the staff will be able to prevent a severe accident in a complex situation arising after an earthquake - with mobile equipment only.**

Cernavoda NPP is situated in an **area** highly **inadequate for** a **NPP**, because the region is **prone to earthquakes**. Nevertheless, currently the means of the severe accident management are not sufficient to prevent severe accidents or even to mitigate their consequences.

The stress tests revealed that regulatory requirements regarding **Severe Accident Management** (SAM) are not incorporated in the regulations, moreover qualitative or quantitative safety objectives related to the protection for the population in the regulatory requirements are lacking. SAM requirements have been included in the regulation since 2014, however the implementing of safety objectives are not mentioned in the updated NAcP.

Because of the lack of regulatory requirements, measures to cope with severe accidents were not implemented. A containment filtered venting system was installed in 2013/14. The implementation of other measure is ongoing. The analysis on a key issue, which was to be completed by 2014 is delayed: habitability of the main control room (MCR) in the case of a total core melt accident. However, the implementation of necessary back-fitting measures will take additional years**.**

The deadline for the implementation of necessary improvement measures is the end of 2015. According to the NAcP Peer Review, the schedule is ambitious and commendable. But on the other hand only limited measures are envisaged.

When trying to assess the overall safety situation, we need to take into account not only the information the stress tests provided, but incorporate the specific safety issues of the CANDU reactors: Units 1 and 2 of the Cernavoda NPP have been operating for only relatively short periods (since 1996 and 2007 respectively), but the reactors were designed in the 1970ies and thus the design is very outdated. Several design weaknesses of the reactor cannot be remedied – in particular the possibility of violent power excursion in case of loss of safety systems and the vulnerability against external hazards.

Besides earthquakes also **terror attacks** could cause a severe accident. A large amount of radioactivity can be released not only from the reactor core but also from the **spent fuel pool which is located outside the containment**.

Moreover, material degradation due to ageing effects of the pressure tubes are a persisting problem of existing CANDU plants and have already occurred at the Cernavoda-1 plant.

The operating time of Cernavoda 1 and 2 is 30 years, which will last until 2026 and 2037, respectively. The operator (SNN) stated in February 2012 that an extension of 20 years for unit 1 in 2023 and for unit 2 in 2030 is planned.

CANDU reactors are designed to undergo refurbishment after approximately 25 years of operation, requiring a major outage to extend the operation time. A refurbishment project at two units of this type (CANDU 6) that was performed during the last years experienced time and money overruns. The operator had to react by taking the third unit offline as soon as it had reached the designed operation time of 25 years.

The conclusions show that the risk of a severe accident with major radioactive releases to the environment is unjustifiably high: Cernavoda units 1 and 2 need to stop operation immediately – also because the regulator does not intend to require comprehensive back-fitting measures.

3 KOZLODUY NPP, BULGARIA

The Kozloduy NPP is located in the north-west of Bulgaria on the Danube River, 5 km to the east of the town of Kozloduy and 200 km to the north of Sofia. Originally, six reactors were in operation at the Kozloduy NPP site. Under commitments made by Bulgaria as part of its accession to the European Union, units 1 and 2 were shut down in 2002; units 3 and 4 followed in 2006 (Kozloduy 1 – 4 are WWER-440/230 reactors).

Kozloduy 5 and 6 (WWER-1000/V-320 reactors with a net capacity of 963 MW each), put into operation in 1988 and 1993 respectively, are the only reactors still operating in Bulgaria; Kozloduy NPP-Plc. is operating these units. In 2014, the Kozloduy NPP provided about 33.6 percent of the Bulgaria's electricity [PRIS 2015].

The units 5 and 6 of Kozloduy NPP are currently licensed to operate until 2017 and 2019 (30 years design life time). There are plans to **extend the operating lifetimes** by 20 years and reach a total of 50 years (until 2037 and 2039, respectively)**.**

In April 2012, the Kozloduy plant management signed a contract with a consortium consisting of Rosenergoatom and EDF to prepare the extension of the operation of units 5 and 6. Under that contract – worth 31.2 million lev ($21.3 million), the Russian and French state-owned companies will carry out modernisation work on the two reactors between 2014 and 2018. [NW 21/02/13]. The government is strongly committed to their life extension. [WNA 2015b]

A serious incident in 2006 caused by the control rods of unit 5 proved that back-fitting measures can result in new safety problems [JPG 2012]. Furthermore, this incident showed that the safety culture at Kozloduy NPP was not strong enough. Both factors are important issues regarding the need of comprehensive back-fitting and upgrading measures in the framework of lifetime extension.

In December 2012, the two-week IAEA safety review at Kozloduy (OSART Mission) pointed out further negative aspects the lack of safety culture is causing, when it summarized that "Analyses of the cause of events are not always performed in a thorough and timely manner to prevent the recurrence of events related to human performance" [IAEA 2012a]. According to the OSART Follow-up mission in June 2014, this issue has not been resolved. [IAEA 2014a]

3.1 CRITICAL REVIEW OF THE UPDATED BULGARIAN NACP

Concerning the three topics of the stress tests - (1) External Hazards, (2) Loss of Safety Systems and (3) Management of Severe Accidents - the Bulgarian National Action Plan (NAcP) in 2012 listed 32 measures to be implemented in order to remedy the weaknesses found. According to the ENSREG Report of 2015, 23 of these actions have been completed, eight are in progress (five of these are re-scheduled) and one is transformed into two new actions. [ENSREG RR-BG 2015] Some of the actions referred to in the NAcP are quite complex, actually covering several actions. Thus, 14 new actions are defined. [BNRA 2014].

However, this strictly formalistic evaluation did not even attempt to assess the nuclear safety level of the plant. The following section of this Review analyses whether the actions considered necessary in 2012 have been implemented and whether the current state of NPP Kozloduy is sufficiently robust to withstand the impacts of external events or whether a nuclear accident with enormous radioactive releases is still possible.

Three years ago, the Bulgarian National Action Plan announced that the implementation of all actions will be completed before the end of 2017. [BNRA 2012] However, some actions consist of studies only consequently the implementation of necessary back-fitting measure will take place several years after 2017.

NATURAL HAZARDS

Both the operator and the regulator continue ignoring the seismic hazards. According to the updated NAcP, the current seismic characteristics of the Kozloduy NPP site were reassessed in the period 1990-1992. Reassessment was completed against the IAEA safety standards. The seismic level of the **design basis earthquake** (DBE) is defined with a PGA of 0.2 g. However, according to the Rapporteurs´ Report of the ENSREG NAcPs Review workshop 2015 the value for the design basis earthquake (DBE) is outdated: stronger severe earthquakes are possible. The April 2015 report stated: *According to the recent seismic re-evaluation of the site, the maximum horizontal PGA is estimated as 0.22 g. The definition of the new DBE and the seismic stability analysis of the SSCs of Kozloduy NPP will be performed in connection with the ongoing PSR.* [ENSREG RR-BG 2015]
The Bulgarian side recognizes that the required earthquake resistance is not assured, however the only remedy agreed so far is that it will be assessed during the regular PSR (Periodic Safety Review). No information is provided when this assessment will be completed and how many more years the regulator will allow the operator for implementing the necessary back-fitting measures and whether the highest level of safety will be required or the cheapest solution.

To cope with **Beyond Design Basis Earthquakes** (DBE) or other **external events**, two mobile diesel generators (MDGs) (including provision for recharging one of the batteries of the safety systems by a mobile DG) were to be delivered by December 2013.[2] (A-1-1; C-1-1) To provide a more effective and interchangeable usage of these MDGs (one 6 kV MDG and two new 0.4 kV MDG) in case of loss of on-site and off-site power supply, the implementation of additional design solutions and activities is envisaged. This required the planning of four new measures:

- The implementation of provisions to connect the 6 kV MDG to the reliable power supply cabinet by November 2016. (FA-1-1-1)
- The implementation of provisions for charging the batteries of the safety systems by the 0.4 kV MDGs by November 2016. (FA-1-1-2)
- Seismic upgrade of the air passageways between the Auxiliary Building and the Reactor Building to ensure the access routes of the MDGs by November 2016. (FA-1-1-3)
- Bunker buildings for MDG sheltering are to be constructed by October 2015. (FA-1-1-4) According to the updated NAcP, these buildings will be located at three different spots at the plant site, suitable for transportation. The MDG buildings are designed with 50% margins regarding the DBE.

The site is located at the first non-flooded terrace of the Danube. The average height of the site elevation is about two meter above the calculated water level of the **Design Basis Flood** (DBF). However, in case of external flood corresponding to DBF the Bank Pumping Station (BPS) would be flooded. Thus, possibilities for protecting the equipment of the BPS were to be investigated by October 2012. (B-2-1) *According to the results of the conducted studies changes were made in the relevant instructions for the personnel at the bank pumping station in case of flooding hazard due to*

[2] Prior to the accident at the Fukushima Dai-ichi NPP only one 6 kV MDG was available at the site of Kozloduy NPP to supply the alternative SG feedwater pumps in case of total loss of power supply. Furthermore, provisions for direct connection of the 6 kV MDG to the reliable power supply cabinets of the safety systems did not exist at the time.

rising of the Danube River level.
However, obviously no permanent reliable protection will be installed instead the plant´s safety will fully depend the staff performing the correct actions

A measure to enhance the plant robustness in case of external flooding and to avoid secondary effects of beyond design basis flood of external sites was to be performed by November 2012. (B-1-1). **Again, this measure also consisted only in the development of an emergency response procedure for the operating personnel in case of damage of Zhelezni Vrata-1 and Zhelezni Vrata-2 Water Power Facilities.**

In December 2012, activities to improve the condition and the protective functions of the dike in the region of the Kozloduy valley have been initiated. These activities have been completed in December 2014. (B-3-1)

The scenarios for **Beyond Design Basis Flood** showed that some locations of the site could be flooded due to the limited sewage and drain system capacity; the Peer Review Team highlighted the relevance of back-fitting measures. However, the measures are still in progress:

- The modernisation of the sewage network and drain pump system were to be performed by October 2013. (B-2-3) However, this measure is still in progress. Due to problems with the equipment supply, the technical specification was revised and the final completion date was postponed to November 2015.
- Measures to protect the water intake of the plant sewage network in case of Kozloduy valley flooding were to be developed by October 2013. (B-2-2) *The selected concept is based on tanks with mobile pumps for sewage water retain. The provisions to prevent water penetration into the plant sewage are to be implemented by December 2016 (FB-2-2-1).* **However, again the measure depends on actions of the staff instead of installing permanent and reliable technical solutions.**

The stress tests revealed that a review of **extreme weather** hazards (e.g. heavy rains and strong winds) is necessary. Thus, an analysis of extreme weather conditions on the KNPP site, using probabilistic methods according to the IAEA methodology, and considering combinations of extreme weather conditions is to be performed by 2015. (E-1)*This measure is in progress*.

LOSS OF POWER SUPPLY AND HEAT REMOVAL

The main **ultimate heat sink** of the Kozloduy NPP is the Danube River. As the alternative heat sink connections to the existing "Shishmanov Val" dam are considered. The condition, efficiency and availability of the water supply system from the Shishamnov Val dam was to be assessed by May 2012. (C-2-1)
However, the updated NAcP does not include the results of this assessment. Most likely the alternative heat sink connection, which would deliver the alternate heat sink turned out to be infeasible, probably due to economic reasons.

Also another investigated alternative for heat removal was cancelled: Possible alternatives for residual heat removal in case of earthquake-induced loss of heat sink, using the Additional Emergency Feed Water System of units 3 and 4 were to be investigated by March 2013. (A-1-2) *The conclusions of the study are that the capacity of the systems will be insufficient. As a result this measure is not followed up by activities.*

The Peer Review Team pointed out that in **Station Black-out** (SBO) situations, when the heat removal from the reactor fails shortly after shut down, core melt will start soon – after only 7.5 hours. Thus, the time span for intervention measures is very short.

Technical means to provide direct injection of water to the spent fuel pool, reactor core, the steam generators (SG) and the containment by mobile fire protection equipment in extreme conditions were to be developed by December 2013. (D-2-4) *According to the updated NAcP, this measure is transformed into new measures field FD-2, separated for the different facilities – SFP, Reactor, SGs, Containment:*

- An additional pipeline to the spent fuel pool cooling system to allow cooling the spent fuel by mobile means is to be installed by November 2014. (FD-2-4-1) *Due to delay in the equipment supply, the deadline was extended to November 2015.*
- Feasibility study of direct water injection into the reactor core from an external source is to be performed by December 2016. (FD-2-4-2)
- Feasibility study of direct water supply to SGs from an external source is to be performed by June 2015. (FD-2-4-3)
- The part of the measure, associated with the analyses and studies on the possible means to supply water to the containment, is incorporated into Measure D-3-5 with the respective completion date.

In short: Only feasibility studies are planned, thus it is not sure that any improvements will be implemented and if so, whether they will be adequate and when they might be available.

The **accident management in shut-down states** was identified as a major weakness by the Peer Review Team. Several measures were done to improve the situation:

- The availability of at least one tank of the steam generator (SG) Emergency Feedwater System as an alternative for heat removal in shutdown mode is ensured since March 2012. (A-1-3)
- In order to enhance safety in shutdown states symptom-based emergency operating procedures (SEOPs) for a shut-down reactor mode with closed and open primary circuit were to be implemented (February 2012/ 2013). (D-2-1; D-2-2)
- To provide a possibility to make-up the primary circuit in reactor cold shutdown state and failure of the emergency DGs, the possibilities to power the motors of the valves at the hydro-accumulator connecting pipelines to the primary circuit from batteries were to be analyzed by December 2013. (C-2-3) *Analysis was conducted and the need for providing supply from batteries was proven. The newly implemented circuit ensures operational possibility for the staff to control the hydro-accumulator valves in case of loss of all AC power supply sources.*

However, these limited measures probably do not provide enough time for an effective core cooling if an accident occurs during shut-down states.

Power supply through the two new mobile DG for the cooling systems of the **spent fuel pool** (SFP), or for feeding the SFP had to be ensured by December 2013. (C-2-2) However, the design characteristics of the SFP exclude modes related to occurrence of criticality and drainage of the pools. **Thus, severe accidents in the spent fuel pools remain possible.**

SEVERE ACCIDENT MANAGEMENT

The stress tests revealed also the need for significant improvements of the **Severe Accident Management** (SAM). Only the following measures have been completed until now:

- The installed passive autocatalytic re-combiners (PARs) were designed for design basis accidents (DBAs) only. Thus, additional hydrogen recombiners, which are able to mitigate hydrogen explosion risks in severe accidents in the containment, were to be installed by December 2013 (unit 6), respectively by June 2014 (unit 5). (D-3-1)

- The ionization chamber channels located in the walls of the reactor vessel cavity are the most vulnerable paths - molten core can spread core outside the containment; plugging of these channels was to be conducted by December 2014. (D-3-3)
- Detectors for monitoring the temperature of the reactor vessel were to be installed (October 2012). (D-3-4)

The molten core stabilisation is one of the major issues of the reactor design (WWER-1000/V320). A study of the possibilities to localize (contain) the melt-through in case of severe accidents is to be finalized by December 2017. (D-3-5) *According to the updated NacP, the first stage of the measure results in the development of a summary report on the outcomes from the three workshops that have been conducted. These workshops were focused mainly on the IVR (In-Vessel Retention) strategy as an alternative to the ExVR (Ex-Vessel Retention) strategy. It is necessary at this stage to proceed with the efforts to analyze this issue within the international cooperation framework. As for now, no specific strategy to how further implement the measure has been chosen.* **However, the 2015 report stated that the technical realization is outside the scope of the updated NAP***.* **One of the most important issues of the Kozloduy NPP will be resolved, if ever, only several years´ time!**

The following SAM measures are also ongoing:

- The severe accident management guidelines (SAMGs) were to be implemented (October 2012). (D-2-3) However the scope of the SAMGs is not sufficient. The Peer Review Team asked for the development of SAMGs that fully cover shutdown states, including those with open reactor, and accidents in spent fuel pools. These SAMGs were to be developed by December 2014. (D-2-6) *However, this measure is still in progress, new deadline is July 2015.*
- A system for direct monitoring of water steam and oxygen in the containment was to be installed by June 2014. (D-3-2) However, according to the updated NacP, this measure is still in progress, because the previous time period was insufficient for completing the activities. Finalisation is envisaged for December 2016.
- The possible deterioration of working parameters due to a high contamination level and equipment failure on-site (incl. the impact on accessibility and functional availability of the main control room (MCR) and the auxiliary control panels) were to be analyzed by December 2014. (D-2-8). *The phenomena associated with the late phase of severe accidents and relocation of the molten core to the containment premises and Reactor Building were analyzed. It was identified that at a certain moment the MCR habitability criteria might be exceeded (fixed as 1 mSv/h) and then the operators shall move to the ECR to manage the accident. The four new measures were necessary:*:
    - Instructions on the evacuation of the MCR staff to the ECR upon reaching the dose limit of 1mSv/h have been added. (FD-2-8-3)
    - To prevent airborne release to the ECR in case of a severe accident by replacement of the corridor doors with gas tight ones have been done. (FD-2-8-4)
    - Prevention of airborne release to the MCR in a severe accident by implementation of a set of organizational and technical measures by December 2015. (FD-2-8-1)
    - SAMGs and electricity supply recovery procedures from MDG to ensure starting of the ventilation systems for recirculation and air filtration in the MCR are to be modified by November 2016. (FD-2-8-2)

- Organizational measures and technical means for management of simultaneous accidents with core melt/fuel damage on all facilities on-site are to be assessed by December 2015. (D-2-7)
- Possible damage on the regional road infrastructure surrounding the plant under the impact of extreme weather were to be assessed; and the reliability of routes ensuring accessibility to the plant site for machinery, supplies and personnel were to be evaluated by December 2014. (A-3-1) *As a result of the analysis Kozloduy NPP main road and the ring-road were repaired. An alternative access road was chosen, which is more robust toward earthquakes.*
- The on-site and off-site emergency plans (EPs), taking into account that the Emergency Control Rooms (ECR) might be inaccessible and providing alternative routes for evacuation, transport and access of staff are to be updated by December 2014. (D-1-1) *After the completion of the full-scale national exercise "PROTECTION 2014" developed on the basis of a scenario with severe accident occurring simultaneously on the two nuclear units, it was concluded that further change of the on-site emergency plan is not needed. But improvement of the off-site emergency plan is necessary andan alternative path for securing access to the power plant has been identified. The Road Infrastructure Agency has prepared a project for the reconstruction of an alternative road to the power plant. The related activities are implemented by the end of 2015 (EP-1-1).*
- The volume of the generated liquid radioactive waste in the containment in case of a severe accident and the adequacy of the available measures to prevent the release into the environment are to be assessed by December 2015. (D-3-6)
- An off-site Emergency Response Centre (ERC) is to be constructed by December 2016. (D-1-2). The off-site ECR of a bunker type is currently being designed. The building will be situated in the town of Kozloduy over an area of 2100 m² and specific complex underground part of about 1500 m². According to the updated NacP, the finalisation of the ECR is postponed to December 2017.
  However, the implementation of an off-site Emergency Response Centre is the necessary consequence of the fact that severe accidents with major releases are possible at the Kozloduy NPP. However there are no guarantees in place that the ECR will be realized in soon.

3.2 TRANSPARENCY

The NAcP of Bulgaria – along with all other reports in relation to the European stress test – is accessible through the home page of Bulgarian Nuclear Regulatory Authority (BNRA), both in English and in Bulgarian.

The nuclear energy law of Bulgaria stipulates the requirement for BNRA to openly and transparently communicate regulatory decisions and safety information to the public. To satisfy this, BNRA uses several channels and mechanisms, as web page, media, formal letters and Annual Report to provide all necessary information to the public. The law also requires the licensees to inform the public about possible radiation risks associated with the facilities and activities. [ENSREG RR-BG 2015]

According to the updated NAcP BNRA periodically organizes press conferences or briefings and BNRA representatives participate in TV and radio broadcasts. Additionally, BNRA organizes training seminars for the media, where public needs of information and its clearness are discussed. [BNRA 2014]

As the tone of this official explanation suggests, the prevailing approach is that the authority is the only one to know and decide about nuclear safety and thus provides information to the public about its activities. A real effort to enter an open discussion did not take place and the regulator is still trying to cover up the fact, that the operator is not willing to perform necessary steps.

3.3 DISCUSSION AND CONCLUSIONS

Concerning seismicity, not even the level of seismic hazards has been agreed on yet: While the Bulgarian side recognizes that the required earthquake resistance is not assured the only remedy agreed on consist of assessing this issue during the regular PSR (Periodic Safety Review). No information is provided on when the seismic assessment will be completed and how many more years the regulator will grant the operator for implementing the necessary backfitting measures and whether the highest level of safety will be required or the cheapest solution.

To sum up: Seismic resistance at NPP Kozloduj has not increased since Fukushima accident in 2011 until today.

In case of extreme flood some locations at the NPP could be flooded due to the limited sewage and drain system capacity. Instead of installing permanent and reliable technical solutions, the necessary intervention depends on actions of the staff.

The stress tests revealed that a review of **extreme weather** hazards like heavy rains and strong winds is necessary. However, today not even the analysis of the extreme weather hazards has been completed. **Results and possible improvements are likely to take several more years.**

To cope with Beyond Design Basis Earthquakes (DBE) or other external events, only two mobile diesel generators (MDGs) were to be delivered by December 2013.

The stress tests showed that during **Station Black-out** (SBO), after the plant lost external power supply, core melt will start already after a few hours. Currently, NPP Kozloduj uses the Danube River as the main ultimate heat sink. In search of the alternative heat sink as demanded by the stress tests, constructing connections to the existing "Shishmanov Val" dam have been considered. However, the Bulgarian side did not report on the results of this assessment. This option which would have delivered the alternate heat sink, turned out to be infeasible; probably due to economic reasons.

To sum up: The alternate ultimate heat sink needed to prevent severe accidents has not been installed until today. Still only feasibility studies to ensure the cooling of the fuel in the reactor core and the spent fuel pool are planned, thus it is not sure that any improvements will be implemented and if so, whether they will be adequate, and when they might start functioning.

The accident management in shut down states, when the reactors are not operating, was identified as a major weakness by the Peer Review Team. Some, but limited, measure have been done. **Measures to prevent accidents rely mainly on the correct performance of actions by the staff - the same is valid** for the spent fuel pools.

In 2011 the Stress Tests revealed that the NPP Kozloduj does not have sufficient Severe Accident Measures in place to contain the development of severe accidents, among them the inability to deal with the molten core to prevent a major release of radioactive substances. However, only the study about this important issue is to be performed by 2017. Currently not even the decision for the implementation of a measure has been taken, not even a possible measure for this reactor type was suggested. Any implementation, if it will take place at all, will take about ten more years.

The complete implementation of all actions is scheduled before the end of 2017. Only a few actions are already completed, the majority of actions are "in progress", and several actions are in a delay. Furthermore some actions consist of studies only and consequently the implementation of necessary back-fitting measure will take place several years after 2017. Transparency about the measures taken will be even lower than until now when the stress tests were ongoing. It is necessary to understand that the issues mentioned will be solved much later than the deadlines mentioned in the National Actions Plans suggest, because it is not always clear what the solution might be. It is important to understand, that it is not clear whether the solution which will be finally decided on will be sufficient at all.

The updated National Action Plan shows that the operator as well as the nuclear regulator are lacking a responsible attitude towards nuclear safety. They both underestimate the urgency to implement those measures or shut the plant down, at least until those measures are completed. Economic considerations may be the reason for this reluctance. Contrary to previous decades, even old nuclear power plants are hardly competitive on the European Electricity Markets with electricity prices which hit a historic low.

The status of the plants and the regulatory situation in addition to the unclear and unreliable deadlines for completing the stress test measures turns the planned power uprate and lifetime extensions into an unacceptably high nuclear risk. Kozloduy 5 and 6 have been operating for over 20 years; therefore ageing of materials becomes a safety issue. It has to be expected that ageing induced effects will increase in the next years. This could be a danger for the units, in particular because of the lack of appropriate safety culture.

To licence a Plant Life Time Extension (PLEX) as intended, i.e. increasing the originally designed lifetime of 30 years by 10 or 20 years entails high nuclear risk. The contrary is necessary: Since so little progress was achieved in the past four years and the stress tests are now understood as having been completed, we urge the nuclear regulator to order the reduction of the power output and the shut – down of the reactors. The European Commission, the EU member states and ENSREG need to follow through the task started in 2011 after the Fukushima disaster and insist on consequences as a result of the stress tests.

4 DUKOVANY NPP, CZECH REPUBLIC

The nuclear power plant Dukovany (EDU) is situated in the southwest of the city of Brno. Four WWER-440/V213 reactors are operating at the Dukovany NPP. The reactors were put into operation between 1985 and 1987. The licence holder (ČEZ, a.s.) has **valid permits 30 years of operation** for Unit 1 until **2015**, for Unit 2 and 3 until **2016** and for Unit 4 until 2017.

In 2014, the nuclear power plants in the Czech Republic, Dukovany and Temelin, provided about 35.8 percent of the Czech electricity demand [PRIS 2015].

In 2008, based on the invitation of the State Office for Nuclear Safety of the Czech Republic (SÚJB), an IAEA mission focussing on Safe Long Term Operation (SALTO) was performed to review the programs/activities concerning LTO and the control of the ageing of safety-related systems, structures and components (SSCs). The SALTO Follow-up IAEA mission took place in November 2011. It concluded that 16 of total 37 corrective measures remain unsolved. [CNS CZ 2013]

In November 2014, again the SALTO team reviewed the plant's organization and programs related to its long term operation, including human resources and knowledge management. The team identified again several areas where improvements are necessary including the following issues [IAEA 2014b]:

- Rather than limiting the plant's approach for the long-term operation to the 10-year licensing period, it should focus on the full time span;
- Coordination between key functions and partners for the long-term operation must ensure that relevant documents, data and knowledge are being systematically reviewed, archived and shared.

In 2009, ČEZ commenced its **Long-Term-Operation (LTO) project** to **extend** the operating lifetime of the Dukovany reactors **by 10 years** to 2025. The LTO project consists of about 230 sub-projects with total costs over CZK 14 billion (€ 560 million) between 2009 and 2015 [WNA 2015a].

Further lifetime extension of up to **60 years** is **under consideration**. According to SÚJB, safety improvement and equipment modernisation make it possible to consider operating Dukovany NPP until the year 2045 [CNS CZ 2013].

Nuclear safety re-assessment of the units that was performed within various international activities from 1992 – 1997 resulted in the Equipment Renovation Program (MORAVA[3]), established in 1998. Since 2009, the remaining modernisation measures from the Equipment Renovation Program MORAVA were relocated to the LTO Program, with the exception of I&C Refurbishment and Power Up-rate Projects which were realised simultaneously. Despite the efforts undertaken in the framework of the MORAVA program, not all IAEA safety findings identified in 1996 by the IAEA have been solved in 2013. Three safety issue of the category III, which are of high safety concern, and therefore – according to the IAEA – make immediate corrective actions necessary, were not resolved. These safety issues are the qualification of equipment, internal hazards due to high energy pipe breaks and seismic design. Also solving four safety findings of category II has not been completed.[4] [CNS CZ 2013]

In June 2007 WANO's peer review mission to review the safety of the nuclear power plant recognized 12 **areas where improvement was necessary**. The follow-up peer review mission in January 2009

[3] MORAVA = Modernisation - Reconstruction - Analyses – Validation

[4] 1) Steam generator safety and relief valves performance at low pressure, 2) Mitigation of fire effects; 3) I&C reliability; 4) Main control room ventilation system;

found that nine of these 12 issues were not fully completed. The following issue is of high importance regarding negative effects of ageing: Corrective actions identified and implemented in some cases do not correspond to the root causes of the events and were not always sufficient to prevent recurrence of the events. Another issue also highlighted by the WANO mission proves the lack of safety culture: The Essential Service Water (ESW) systems are affected by continuous appearance of leaks. However, there is no overall assessment of the condition of these systems. [CNS CZ 2010]

Between 2005 and 2008, the power generation at all four Dukovany units was increased by replacing the low-pressure turbines. This was the first part of a program to boost the gross output by 240 MWe by 2012. The 38 MWe uprates of units 3 and 4 were completed in May 2009 and December 2010 respectively – bringing their gross capacity to 500 MWe – using improved fuel, replacing the high-pressure turbine, refurbishing the generator, and I&C changes. A similar uprate of unit 1 was performed in November 2011 and for unit 2 in 2012 [WNA 2015a].The originally designed reactor power of 1375 MWth (440 MWe) was increased to 1444 MWth (500 MWe), which corresponds to a power uprate of 105%. A further power-uprate (108%) that aims to increase the reactor power to 1485 MWth (517 MWe)) is planned for 2016/2017 [CEZ 2013].

4.1 CRITICAL REVIEW OF THE UPDATED CZECH NACP

Concerning the three topics of the stress tests - (1) External Hazards, (2) Loss of Safety Systems and (3) Management of Severe Accidents - the NAcP of the Czech Republic defined 76 actions/activities for Dukovany and Temelín NPPs [SUJB 2012].

The ENSREG NAcP Peer Review Team criticized that in several cases it is not clear to which extent the NAcP is covering some of the ENSREG recommendations/findings (for example presence of hydrogen in unexpected places, ultimate heat sink, or the development/update of severe accident management guidelines). [ENSREG RR-CZ 2014]

The updated NAcP explains that many of the listed measures are already in an advanced stage of implementation since they have been proposed before the Fukushima events on the basis of Periodic Safety Report (PSR) results. This could be the reason why in some cases the context between ENSREG recommendation and the implementation activities is not easily understood. [SUJB 2014]

According to the updated NAcP, however, additional measures (Actions 77-84) which emerged from a detailed analysis of ENSREG documents made in the period from May to September 2013, have been added to the updated NAcP. The deadline to implement all necessary measures is the end of 2016. [SUJB 2014] However this is not the final date of the implementation of the necessary back-fittings. Those measures which consist of performing a study or analysis may result in the need to identify new measures.

NATURAL HAZARDS

The original level of the **design basis earthquake** (DBE) for Dukovany NPP is given as a peak ground acceleration (PGA_H = 0.06g) based on a Seismic Hazard Assessment (SHA) performed in 1985. In order to meet the minimum seismic design requirements according to the IAEA recommendation, the level has been set to 0.1g PGA_H in 1995. The decision followed an IAEA mission to the site [ENSREG CR-CZ 2012]

- However, the project of seismic upgrading to the current DBE (with PGA = 0.1g) is scheduled for completion by 2015, which is 20 years later. The Peer Review Team highlighted the importance of the on-going earthquake resistance qualifications and reinforcements to ensure that all the safety related structures, systems and components (SSCs) of the plant are resistant up to the level of at least 0.1 g PGA. [BMLFUW CZ 2014] According to the updated

NAcP, this project is still underway. Currently, only about 90% (including all technology) of the significant safety equipment complies with requirements and is seismically qualified. (Not all necessary measures are mentioned in the NAcP, because these measures are part of another program.)

Only the following measures regarding earthquakes are listed in the (updated) NAcP as finished:

- A seismic monitoring system was to be implemented by 2014. (No. 6)

The following measures regarding earthquakes are still in progress:

- The necessary reinforcement of the Fire Brigade Building is to be performed by 2015. (No. 3). In 2011, as a first measure storages of essential equipment in tents outside the fire brigade buildings have been implemented. The very low seismic resistance of the fire brigade buildings has been identified during the Stress Tests. Until then the operator argued that this issue is taken care of: „Considering the fact that occurrence of seismic event is not sudden … the fire equipment can be moved outside in time”). **This attitude shows that the hazard of an earthquake was not considered appropriately.**
- An assessment of the consequences of the seismic hazard for the site (e.g. destroyed infrastructure) was to be performed by 2012 (No. 45). **The measure is listed as completed, but only the assessment was done. Neither the scope of the required back-fitting measure nor the timeschedule for their implementation is mentioned.**
- The Peer Review Team highlighted also the need for increasing the plant's capabilities to cope with the indirect effects of an earthquake. The risk resulting from the seismic induced floods or fires were to be evaluated by 2014. (No. 4) **The measure is listed as completed but only the evaluation was made neither the scope of the required back-fitting measure nor the time schedule for the implementation is mentioned.** Furthermore, a seismic PSA including analysis of secondary effects with proposals for remedial measures is to be performed no earlier than in 2015. (No. 70) This analysis will probably identify additional necessary back-fitting measures.

On top of the very long implementation period for the necessary seismic upgrade program, almost no seismic safety margins exist and according to the updated NAcP it is not intended to change this situation: SUJB claimed in the **seismic margin assessment** during the stress tests procedure, that the seismic safety margin is defined by the difference between the hazard level originally determined for the site (1985, PGAH=0.06g) and the level of seismic upgrading (PGAH=0.1g). With respect to the overall assessment of the seismic margins of the plant the Stress Tests Country Report states that events "of the intensity > 7° MSK-64 (PGAH > 0.1g) might cause loss of the NPP safety function" even after the completion of the upgrading program. This indicates that the available safety margins might be small and no significant margins exist above 0.1g. [BMLFUW CZ 2014] The resistance for example of the cooling towers (ultimate heat sink) against earthquake loads has been estimated with 0.112g.

Czech geoscientists have prepared a new **seismic hazard assessment** for the Bohemian Massif, which is based on an updated geological and seismological database. The latter include recent paleoseismological data obtained from the Bohemian Massif and the Vienna Basin, which show that the magnitude of the strongest earthquakes that may occur in some regions around the site is significantly higher than previously assumed. New data further suggest that the Diendorf-Boskovice Fault at a distance of only 10km from the Dukovany site should be considered in seismic hazard assessment. The NPP Dukovany is currently being upgraded to 0.1g, which is the minimum design value suggested by IAEA. Seismic margins are expected to remain small even after the upgrade is completed. Reliable seismic hazard assessment therefore is of high safety relevance. [BMLFUW CZ 2014]

All in all it is not excluded that “beyond design earthquakes” can occur. It is a matter of fact that the plant is not able to cope with this situation.

Due to location of the plant several tens of meters above the closest rivers the plant sites are not endangered by **external flooding** caused by rivers, nevertheless flooding caused by extreme rainfall could result in a dangerous situation. The following measures were done:

- Flood protection of the Emergency Control Centre (ECC) was implemented in 2012. (No. 9)
- Sealing of entrances of cable ducts was to be performed by 2013. (No. 10)
- Sealing of entrances of diesel generator station was to be performed by 2013. (No. 11)

The Stress Tests procedure identified several safety relevant issues which may arise from **extreme weather conditions**. The Stress Tests revealed that several civil structures currently do not meet the design basis requirements with respect to wind and snow loads. Most important is the limited capability of the cooling towers in respect of strong wind. Furthermore, considerations for extreme snow loads show low or no margin for the generator halls, its collapse which might endanger the operability of the essential service water (ESW) system.

Also, the considerations for extreme low temperatures may be too simple, not taking into account the realistic related effects, e.g. Station Blackout. In 2012, the ENSREG Peer Review Team pointed out that some problems resulting from extremely low temperatures should be reconsidered (freezing of open water, pipelines, and congelation of diesel fuel). However, the results of the re-assessment of the possible impact of extremely low temperatures are not mentioned. It is even not mentioned whether this re-assessment has been done carefully

Some refined further analyses and verification of existing analyses are necessary. Currently, safety margins of external hazards are not sufficiently evaluated. Only based on the insufficient analyses the following measure were performed:

- Structure reinforcement against extreme climatic phenomena was to be implemented by 2014. (No. 1) However, both the NAcP and updated NAcP do not explain what kinds of measures have been done, thus the reliability could not be evaluated.
- The procedures for special handling of weather related hazards are not sufficient, some specific additions might be necessary to the emergency management procedures. Procedures for managing extreme conditions on the site (wind, temperature, snow and earthquake) were to be completed by 2013. (No. 7) However, as mentioned above, these procedures only rely on insufficient analyses.

LOSS OF POWER SUPPLY AND HEAT REMOVAL

The stress tests in 2011 revealed that in case of loss of off-site power and loss of the ordinary back-up AC power source, the main strategy to prevent a dangerous SBO situation would consist in recovering AC power via separate lines (alternate grid) from two hydroelectric power plants. However, the electrical connection lines between Dukovany NPP and the hydroelectric power plants are not protected against earthquake and thus will fail in case of an earthquake.

In the case of long-lasting SBO, there is a threat to the integrity of fuel in the reactor core and the spent fuel pool. Without available alternate AC power supply, the heat removal cannot be ensured. The NAcP proposed the implementation of alternative means for AC power supply for core cooling and heat removal. The following limited measures (provisions) have been done to remedy the dangerous situation and to prevent core melt accidents:

- To prevent SBO, off-site power connections are to be reinforced by 2013 and if necessary subsequent reinforcements are to be done by 2015. (No. 74) **The updated NAcP does not mention the results of the analysis of off-site power connections reinforcement. It does not mention whether any reinforcement is planned and if so what time schedule for the implementation of the measures is valid.**
- A new diesel generator (SBO-DG) for subsequent increasing of resistant against SBO scenario was to be provided by 2014. (No. 18) **No information is provided on the time needed to connect those SBO DGs to the essential safety systems and how robust they are in case of earthquakes or other external hazards.**
- Provision of alternative fuel filling for long-term operation of DG including providing of fuel sources were to be implemented by 2013. (No. 22)
- Provision of alternative mobile devices for alternative fluids pump and power supply were to be implemented by 2014. (No. 38) No further information is provided.
- Alternative supply of selected valves from mobile power supply sources was to be implemented by 2015. (No. 76) No further information is provided.

The **ultimate heat sink** for NPP Dukovany is the atmosphere via the cooling towers. The two units of Dukovany NPP are cooled by four wet cooling towers each, which serve as heat sink for both, service and essential service water systems. The cooling towers are not qualified as safety components. Thus as mentioned above they will get lost during strong wind and extreme earthquakes. The periodic safety review (PSR) as well as the stress tests identified the need of diverse ultimate heat sink possibilities.

- New ventilator towers for ensuring independent ultimate heat sink are to be implemented by 2016. (No. 33) Information on the robustness of the new ESW fan cooling towers with respect to earthquake and extreme weather events was not provided.

An alternative / diverse ultimate heat sink (e.g. cooling water supply through wells) has not been implemented at the Dukovany NPP, which could operate as back-up for the ultimate heat sink. It is explained that upon the unavailability of the cooling towers an alternative heat sink can be established by pumping water from fire trucks into the steam generators (SG). This water will evaporate in the secondary side of the SG and the steam will be released into the atmosphere (secondary feed & bleed). To improve this “solution” the following measures have been done:

- Purchase of one additional fire truck was initiated after Fukushima (three fire trucks were available in 2011) to have at least one fire truck ready for each unit. (No. 84)
- Connection points to inject water from fire brigade equipment were to be installed by 2012 (No. 13)
- Provision of back-up coolant supply into depressurised reactor and spent fuel pools with additional and sufficient sources of coolant was to be implemented by 2014. (No. 15)

However, many doubts concerning the reliability of the implemented measures remain: The cooling by the feed & bleed procedure claims the full availability of the fire-fighting equipment, which, however, is not safety qualified. The seismic margin of the feed & bleed cooling procedure therefore appears to be even lower than the seismic resistance of the cooling towers. It should be clarified whether there is any success path that ensures reactor cooling after a possible loss of the cooling towers that exclusively relies on safety-classified and seismically qualified SSCs. It should further be clarified that the amount of water, the flow rate, and the injection pressure that can be

sustained by the fire brigades is sufficient for cooling the reactor core and other consumers. [BMLFUW CZ 2014]

Next year again no real improvement will take place, only an additional pump, an "emergency feed-water pump" to inject water to the SG will be provided by 2015. (No. 17)

The fire trucks constitute the Czech response to the following ENSREG recommendation calling for "provisions for the bunkered of ´hardened´ systems to provide an additional level of protection ... designed to cope with a wide variety of extreme events including those beyond the design basis." **In case of an accident, instead of relying on some at least partly passive cooling systems, the prevention of a major radioactive release depends on the quick response of the fire brigade.**

The estimated time, which is available to recover the lost heat sink or to initiate external actions and restore core cooling before fuel damage will occur in the reactor core is about 10 hours (this time period can be prolonged by up to 20 hours using feeding the SGs from feed-water tanks by gravity). In shutdown conditions, the natural circulation would be lost and fuel damage starts (if the SGs feeding is not initiated) within 4 hours. The calculated time until the water starts to boil in the spent fuel pools (SFPs) is 2 hours, while the time available until the fuel un-coverage is 20 – 30 hours.

According to the updated NAcP, sufficient capacity and expertise of personnel for multi-unit accident and for the whole site affected was to be ensured by 2014. (No. 40) **However, regarding the amount of tasks and the limited time it is not credible that the staff will be able to prevent core melt accidents in four reactor cores as well in four spent fuel pools simultaneously after a severe external event like an earthquake.**

Another weakness of the approach using feeding the SG via fire trucks as ultimate heat sink is not appropriate as an alternative method of heat removal from other safety relevant systems which depend on the Essential Service Water (ESW). The loss of ESW will for example limit the ability to cool specific rooms, which in turn might result in the increase of room temperature and loss of vital I&C components within 60 minutes. This would lead to a loss of indications/parameters providing the status of the units, and loss of ability to control (some of the) safety equipment. Thus, provisions of heat removal from the key safety component and I&C system for long-term monitoring of key parameters during SBO were to be implemented by 2015. (No. 29 and No. 25) **However, only mobile fire-fighting pumps might be used for this purpose**. [BMLFUW CZ 2014]

The following limited measures are still in progress:

- Alternative measures to ensure recharging batteries and measures to extend batteries discharging time are to be implemented by 2016. (No. 20)
- Processing of guides for the use of alternative technical means by 2015. (No. 53)
- Periodic verification of the functionality and periodic practicing of using the alternative mobile devices is to be performed by 2015. (No. 42 and No. 43)

SEVERE ACCIDENT MANAGEMENT

The stress test revealed that the severe accident management (SAM) measures show a range of shortcomings. Several measures are necessary. However, not all of them are addressed: For some circumstances the SAM 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. In 2012, the Peer Review Team emphasised the need for additional investigations of the potential for re-criticality of the molten core, to see whether during or after an accident the already molten core could re-start chain reaction and turn into a major accident one more time. However, the issue of re-criticality is not explicitly mentioned in the NAcP or in the updated NAcP.

The following measures regarding the severe accident management (SAM) have been completed:

- The habitability of main and emergency control rooms (MCR/ECR) during severe accidents were to be ensured by 2015. (No. 31)
- Severe accident management guidelines (SAMGs) for accidents during shutdown conditions and in the spent fuel pools (SFP) were to be developed and implemented by 2014. (No. 56)
- System setup of training, exercises and training for SAM according to SAMGs, including possible multi-unit severe accident were to be done by 2014. (No. 55)
- Provision of back-up power supply telephone exchanges, communications, and lighting was to be implemented by 2014. (No. 34)
- Alternative means for internal and external communication, notification and warning of staff and population during loss of existing infrastructure are to be provided by 2013. (No. 57)

However, the following SAM measures designed to cope with core melt accident and to prevent major radioactive release are still in progress:

- Hydrogen reactions can lead to early containment failure, and to large, early releases of radioactive substances. No sufficient time is available for implementing off-site emergency measures, and the releases would lead to the contamination of large areas even in great distance. Thus, to prevent hydrogen explosions passive auto-catalytic recombiners (PARs) to reduce hydrogen concentration in case of severe accidents are to be installed by 2015. (No. 46)
- The implementation of the so-called in-vessel-retention of the molten core concept in case of core melt accident has been planned pre-Fukushima. An external reactor pressure vessel (RPV) cooling and thereby retention of the molten core inside RPV are to be implemented by 2015. (No. 48) The **In-Vessel Retention (IVR) concept** aims to ensure the integrity of the RPV during a severe accident. It is one of the most important modifications concerning the prevention of major radioactive releases during accidents. The measure requires a number of technical modifications. Since the cooling of the RPV from the outside is a complex procedure, extensive analyses and experiments have been performed at the CERES test facility to demonstrate the feasibility. Analyses of consequences of RPV failure and the preservation of containment integrity in case of a severe accident are on-going. Until now, only limited experimental analyses provided proof that this concept fulfils all the intended functions. Therefore, the ENSREG Peer Review Team recommended considering a failure of the reactor pressure vessel (RPV), despite the fact this is claimed to be very unlikely. **However, the evaluation of the consequences of RPV failure is not included in the NAcP. It has to be emphasised that the current severe accident management includes instructions for unfiltered release, which would lead to the emission of large amounts of radioactive products into the environment. But the implementation of a filtered venting system is not envisaged**.
- The probabilistic safety assessment (PSA) studies so far include only full power operation in Level 2. Thus an upgrade of the PSA 2 (including shut-down states) for the identification of plant vulnerabilities and the quantification of potential releases related of extreme external conditions is to be performed by 2015. (No. 69)
  A PSA is a very useful tool to identify vulnerabilities and for deciding on backfitting measures. It can be assumed that the PSA will identify the need for further back-fitting measures.

- Effectiveness of the accident management measures depend on the available information on the status of the facility. Currently, the measurements of the conditions of the spent fuel storage pool during accidents are only displayed in the MCR. They are neither available in the ECR, nor in the post-accident monitoring system (PAMS). Important measurements (e.g. spent fuel pool (SFP) condition) into post-accident monitoring system (PAMS) are to be included by 2015. (No. 27 and No. 32)
- Providing of alternative means of abnormal occurrence management during loss of primary control centres (Emergency Control Centre, Physical Protection Control Centre, Fire Protection Control Centre) was to be analysed by 2014. (No. 59) This measure is listed as finished, however, only the analyses are performed. The updated NAcP does not mention the results. It does not mention either, which measures are planned and which time schedule is set up for the implementation.
- Potential accident scenarios resulting in large volumes of contaminated water including definition of remedial measures are to be analysed by 2015. (No. 68)
  It does not explain whether implementing measures will be required and if so which time schedule will have to be fulfilled.

4.2 TRANSPARENCY

The NAcP and the updated NAcP are accessible on the regulator's website, though in English only.

Most countries published NAcP providing information which is often incomprehensible und incomplete. However the Czech report is even less useful when compared to other countries´ reports. In spite of ENSREG critique, the information of the updated NAcP 2014 continues being insufficient and incomprehensible.

At the same time the public is kept in the dark: The public received the following information by the operator: *„The stress test results for NPP Dukovany (...) confirmed the decisions taken to improve the original project as effective and correct. No situation was found, which requires immediate solutions. The NPP can cope with highly unlikely severe accidents (...).“*

Another ČEZ press release of May 2013 simply states: „ (...) *top-notch performance and maximum safety of the power plants* (…)”[5]

And still, only those two – SUJB and CEZ – negotiate in a closed procedure which safety measures to realize or postpone – which is a dangerous game.

4.3 DISCUSSION AND CONCLUSIONS

The stress test revealed that the Dukovany NPP is not prepared to withstand an accident caused by a natural hazard like an earthquake which obviously could affect all four units at the site.

The target date to implement the upgrades is end of 2016. However, this is not the final date of implementation of necessary back-fitting. Those measures which consist of performing an analysis may result in further measures.

In 2012, the Peer Review Team highlighted the **importance of the on-going earthquake reinforcements**, which is scheduled to be completed in 2015. But also after finishing the back-fitting measures, the protection will not be adequate. Further back-fitting will be probably be necessary

[5] http://www.cez.cz/en/cez-group/media/press-releases/4380.html

after the seismic PSA systematically analysed the threat including seismic induced flooding and fire, which is to be completed by 2015. Until now no prove was provided to confirm that the seismic hazard assessment is reliable. This means that four years of stress test led to a situation, when **“beyond design earthquakes” are possible and due to the limited seismic margins it is a fact that the plant is still not able to cope with such a situation.**

The stress tests have identified that the **considerations for extreme low temperatures may be too simple**, not taking into account the realistic related effects, e.g. Station Blackout. This example show that CEZ without SUJB intervening did not take the lessons from Fukushima and the idea of the EU stress tests seriously. Another example is the assessment of the plant´s ability to cope with a station blackout (SBO) by excluding external and internal hazards. It is not clarified whether these hazards have been re-assessed sufficiently and if so what the outcomes are.

The fact that SUJB did not take very idea of stress tests seriously led the Peer Review Team to formulating a number of recommendations; however the regulator did not follow them up adequately. For example, the issue of the potential for re-criticality of the molten core as recommended by the Peer Review Team was not mentioned.

The fire trucks constitute the Czech response to the following ENSREG recommendation calling for “provisions for the **bunkered or ´hardened´ systems** to provide an additional level of protection ... designed to cope with a wide variety of extreme events including those beyond the design basis.” To present the water supply with fire trucks as idea reveals a dangerous approach to safety culture, additional pumps and one new fire truck can only be called the improvement of insufficient measures. The scope of measures (e.g. providing of a new diesel generator and a new fire truck) implemented between 2013 and 2015 to remedy the dangerous situation and to prevent core melt accidents is limited.

One major weakness will persist at least for the next years: The **only heat sink at Dukovany NPP are the cooling towers** with their capabilities being endangered by strong wind and earthquakes. The solution chosen by the Czech side is the construction of new cooling towers, however again, information on their robustness is not provided. The new ventilator towers for ensuring an ultimate heat sink will not be implemented before 2016. The construction of the new cooling towers was necessary to provide an alternate heat sink which can cope with the natural hazards. However, a second heat sink is still lacking because the old cooling towers nor the fire truck can be seen as a reliable heat sink - the lack of an alternate Ultimate Heat sink persists. This is important because the time available to recover the lost heat sink before fuel damage occur in the core and spent fuel pools is only several hours.

The stress test revealed that the **severe accident management** (SAM) measures are **not sufficient**. Dukovany NPP has no means to cope with a core melt accident, thus **a severe accident with a major radioactive release could result**. An upgraded probabilistic safety analysis (PSA) Level 2 for the identification of plant vulnerabilities, which should have been the basis of the development of the severe accident management is still in progress.

An external reactor pressure vessel (RPV) cooling and thereby retention of the molten core inside the RPV is to be implemented by 2015. However, doubts about the reliability of the concept exist. Currently, the unfiltered release of large amounts of radioactive products into the environment is foreseen. The implementation of a filtered venting system to prevent overpressure of the containment in case of severe accidents is not envisaged.

Sufficient capacity of personnel for multi-unit accident should be available now, however this is hard to imagine regarding the plenty of measures to be performed e.g. after an external events, by the staff with mobile equipment.

The licensed operation time (30 years) of units 1 – 4 ends between 2015 and 2017. The Czech authorities are preparing to extend the operating time of the NPP Dukovany without any public debate or EIA procedure. In 2009, ČEZ commenced its Long-Term-Operation (LTO) project to extend the planned operating lifetime of the Dukovany reactors by 10 years to 2025. Further lifetime extension to 2045, which means an operation time of 60 years, is under consideration.

Material degradation and design weaknesses of the very old units can significantly aggravate the development of an accident caused by an earthquake or other external or internal events. In particular the essential service water system is prone to leaks and could fail unexpectedly.

Life time extension for the old dangerous plants means ageing becomes an increasing safety issue, faults cause by ageing could trigger accidents. Furthermore there are design weaknesses that cannot be remedied, e.g. the low protection against terror attacks.

Despite the modernisation programs, not all IAEA safety issue identified in 1996 have been solved in 2013. Another sign that both regulator and operator do not take sufficient care of the nuclear power plant: The follow-up WANO's peer review mission peer review mission in January 2009 noticed that nine of 12 issues of the WANO's peer review (June 2007) were not fully completed. Amongst other issues there are issues of high importance regarding resistance against natural hazards and negative effects of ageing. The Essential Service Water Systems (ESWS) are affected by continuous occurrences of leaks. However, an overall assessment of the condition of these systems is lacking. In general, corrective actions were not always sufficient to prevent recurrence of the events.

Moreover, the modernisation program includes significant power uprates which will lead to a further reduction of safety margins and accelerate ageing. The reactor power output has already been increased over the last years. A further power-uprate that aims to increase the reactor power to 108% of the designed rector power is planned for 2016/2017.

All in all, we recommend shutting down Dukovany NPP immediately.

The Czech side is not acting on behalf of people and environment, but is neglecting safety. At the same time, the Dukovany reactors increased their electric output because of economic reasons thereby increasing pressure on safety, using up safety margins. Currently those plants are reaching the end of the 30 year life time in 2015– prolongation is a serious hazard and need to be prevented. Dukovany reactors need to be shut-down immediately, to permit 10 or even 20 more years is utterly irresponsible.

The intentions however are going into a completely different direction, the "reasonably practicable" measures[6], designed to prevent severe accidents, for postulated severe accidents of the reactor core and in the spent fuel pool measures should serve to reduce impacts of severe accidents, as suggested by the WENRA Reference Level F (Design Extension for existing reactors). What exactly would have to be done will be subject to negotiations between nuclear regulator and operator, taking into account rather economics of the operator than safety aspects.

This situation needs much more attention by the politicians and the public; regular, transparent and understandable reporting as promised on European level has to be introduced. The four Dukovany reactors need to be shut-down; operating them without the upgrades recommended by the Stress Tests should be stopped by the regulator SUJB.

[6] Milan Sýkora, CEZ, Czech Republic, Annual Meeting on Nuclear Technology; Berlin, 5-7 May 2015

5 PAKS NPP, HUNGARY

In Hungary currently four WWER-440/V-213 reactors are operating at the Paks NPP, which is located 5 km south of the city centre of Paks, 114 km south of Budapest. Paks NPP is owned and operated by Paks Nuclear Power Plant Ltd, which is a subsidiary company of state-owned Hungarian Power Companies Ltd (Magyar VillamosMűvek, MVM) [HAEA 2011]. In 2014, Paks NPP provided 14.8 TWh or 53.6 percent of Hungary´s electricity [PRIS 2015].

The four units are placed in two building structures in a twin arrangement. The first grid connection of unit 1 was in 1982, unit 2, 3 and 4 followed in 1984 and 1986 and 1987, respectively. The original design lifetime was 30 years, so the four units would have reached the end of their operation times between 2012 and 2017.

The Hungarian Atomic Energy Authority (HAEA) is in charge of issuing the permission for operating the reactors beyond the design lifetime. Four years before applying for the license, the power plant had to create a program on lifetime extension of the units. The program was evaluated, and the program implementation oversight was in the hands of the nuclear regulator.

The Hungarian Atomic Energy Authority (HAEA) has approved the lifetime extension program (submitted in November 2008) for all four reactors. The Hungarian law prescribes that license applications have to be dealt with for each of the four units separately. The licensing process of the first unit started by the end of 2011, the decision of the authority was issued on 18th December 2012. The operating licence was prolonged until 31th December 2032. In November 2014 a 20-year licence extension for unit 2 was approved. The PLEX program implementation at Paks 3 – 4 is on-going. [WNA 2015c]

Hungary was the first case where an environmental impact assessment (EIA) was required for a plant lifetime extension. According to the Austrian Expert Statement on the EIA Report, several issues remain open, despite the comprehensive lifetime extension program. Several important topics are concerned: Seismic hazards and design, ageing management program, reactor pressure vessel integrity, negative effects of power uprate, confinement integrity and severe accident management [UBA 2012].

In Hungary several regulatory guidelines for ageing management and in-service inspection have been implemented. These requirements define the basic scope of the ageing management programme at Paks NPP. A comprehensive and systematic approach for ageing management has been implemented in Paks NPP –this applies certainly to the mechanical components, however no further information concerning ageing management of structures and I&C components has been presented [UBA 2012].

Between 2002 and 2009, the thermal capacity of the units was up-rated to reach 108% (1485 MWth), compared to the original value (1375 MWth), resulting in increased electric gross capacity to 500 MWe each unit. [WNA 2013b].

The Paks NPP is **planning** to add **two new units**. The EIA procedure for Paks 5&6 is ongoing.

5.1 CRITICAL REVIEW OF THE UDATED HUNGARIAN NACP

Concerning the topics 1 – 3, in the Hungarian National Action Plan (NAcP) 49 detailed actions are listed. The implementation of improvement measures is clearly scheduled with the specified timeframe to implement all the measures until the end of 2018 [HAEA 2012].

The updated NAcP includes no additional actions. Also no actions have been removed. Two actions have been modified (No. 2 new fire brigade barrack instead of reinforcement, No. 3 protection of demineralized water tanks instead of the reinforcement of the building). Delay is indicated in the case of four actions (No. 2: new fire brigade barrack, No. 11: Reinforcement of 400 kV and 120 kV substations, No. 48: Air-conditioning and power supply of Protected Command Centre, No. 49: Construction of a new Backup Command Centre).

NATURAL HAZARDS

The plant has not been originally designed to withstand **earthquake** loads, but due to the implementation of reinforcement and qualification measures the plant complies with the current seismic safety requirements. However during the stress tests, some weaknesses were identified, thus upgrading or fixing of Structures, Systems and Components (SSCs) is necessary. **According to the updated NacP, only three limited measures are completed:**

- Fixing of the non-process equipment and maintenance tools that could adversely impact process equipment during outages were to be provided by December 15, 2014. (No. 8).
- To cope with the simultaneous occurrence of an earthquake and rupture of the primary coolant circuit the existing symptom-based emergency operating procedures (EOPs) are to be re-assessed by December 15, 2013. (No. 10).
- In the frame of the reconstruction project of seismic instrumentation, the issue of automatic shutdown was to be revisited by 2012 (No. 9). *Currently no such system exists, which would initiate an automatic shutdown of the reactors for a given acceleration level of an earthquake. It is not envisaged to implement such a system. According to the updated NacP, an automatic shutdown is not justified, because this measure would increase the risk of station black out (SBO) and collapse of whole national system.*[7] **This statement shows that the operator doubts the reliability of the plant´s power supply system.**

According to the updated NacP, the following measures are still ongoing:

- A damage to the service building could lead to failure of the nearby common demineralised water storage tanks. The walls of the building need to be seismically qualified and, if necessary, reinforced or appropriate protection of the tanks by other means is to be provided by December 15, 2015. (No. 3) *A new analysis changed the technical content. Now the reinforcement of the building is decided. The new analysis, construction planning, and time needed for the public procurement procedure cause delay. The reason for the reinforcement of the building instead of new or reinforced demineralized water tank is the significant financial difference.* **However, the new analysis did not claim that the cheaper solution is the safer solution or at least as safe as the one chosen in the first place.**
- The building for the plant fire brigade is not qualified against earthquake loads, thus intervention to protect the personnel and equipment in the fire brigade headquarters is to be performed by December 15, 2015. (No. 2) *The measure will be delayed due to changes of technical content. Instead of reinforcement of the old building, a new one will be constructed. The task will be completed in 2017.*
- To avoid the flooding of the turbine hall or the cable tunnels, an automatic shutdown of the main condenser coolant pumps is to be provided. Furthermore, the consequences from the rupture of large diameter pipelines (main condenser cooling water system) which is not seismically qualified are to be investigated and the protection against a possible internal

[7] Note: in case of stronger earthquakes the reactors will stop automatically because of several other signals from protection systems.

flooding is to be improved if necessary by December 15, 2015. (No. 7) *The construction plans are finished, the public procurement procedure is in progress. Deadline can be met.*

- The filter structures of the Essential Service Water (ESW) system are not seismically qualified, so it is possible that heat removal fails in case of an earthquake. Thus, analyses are to be conducted to understand whether this lack jeopardises the ultimate heat sink function and, if necessary, the adequate exclusion measures are to be implemented by December 15, 2015. (No. 14) *The work has commenced. Deadline can be met.*
- The protection of the not seismically reinforced 400 kV and 120 kV sub-stations and the automatism switching are to be increased by December 15, 2014. (No. 11) *Construction is in progress. The delay is due to a transformer failure in 2014 which hindered implementation of the modification.*

A quantitative assessment revealed only narrow **seismic safety margins** – particularly soil liquefaction is a hazard. Soil liquefaction might occur in the acceleration ranges slightly exceeding the design basis, which can cause an uneven settlement of the buildings. The Peer Review Team highlighted the importance of the planned measures and advised the regulator to monitor the implementation.

- The underground lines and connections (pipelines, cables) at risk due to potential settlement of the main building caused by liquefaction are to be re-qualified and, if necessary, modified by December 15, 2017. (No. 4) *Seismic input data will be ready by the end of 2015 (see action No. 5). The technical solution is in the planning phase. The concept for management of small diameter pipelines is ready. The completion of the task may undergo delay because the appropriate technical solution for large diameter pipelines should be found; in addition a delay due to the public procurement procedure is also expected.*
- A state-of-the-art analysis for the assessment of the existing margins of earthquake-initiated building settlement and soil liquefaction phenomenon are to be performed by December 15, 2018. (No. 5) *The work is in progress, determination of settlement parameters will be completed by the end of 2015. Deadline can be met.*

According to the report of Austrian experts it is unclear whether active faults in the site vicinity are adequately considered in the **seismic hazard assessment** which is of utmost importance for the reliability of the assessments. The general existence of active faults in the region has recently been confirmed by studies. However, documents and materials supplied during the stress tests procedure are not sufficiently clear in describing whether these faults have been studied further or not. The topic appears particularly important with respect to the location of the plant in the vicinity (<5km) of faults which offset Quaternary sediments and therefore are to be classified as “capable” in the sense of IAEA. Some of the mapped faults parallel the Mid Hungarian Fault Zone, which has been identified as an active seismogenic source by investigations of Hungarian geoscientists. At this background a systematic assessment of Quaternary faults and the parameterization of slip history, youngest slip events, fault geometry and slip velocity is of utmost importance for the reliability of seismic hazard assessments. [BMLFUW HU 2014]

The level of the machine room, which houses the safety important Essential Service Water (ESW) system pumps, is below the water level of the Danube in case of the calculated **Design Basis Flood** (DBF)[8]. Thus, it is necessary to seal the penetrations of the machine room wall. The modification is to be performed by December 15, 2015. (No. 6) *According to the updated NacP, this modification is done*.

[8] In emergency situations, the ESW system supplies Emergency Diesel Generators (EDG), Emergency Core Cooling System (ECCS) and cooling of the Spent Fuel Pool (SFP) with cooling water; when the ESW system fails, only the fire water system could provide cooling water.

Regarding **extreme weather** events, the Peer Review Team highlighted the need for strengthening the protection (e.g. against extreme precipitation and snowmelt or lightning). During stress tests procedure numerical values of the safety margins of the extreme weather conditions were not available, because the evaluation of loads caused by weather impacts in frame of the last Periodic Safety Review (2008) is not in compliance with modern expectations. A new assessment was to be conducted by 2012. The Authority´s review is on-going. The following measure is also ongoing:

- A list of such system components important to safety which are endangered by lightning is to be compiled by December 15, 2015. Based on the list, reinforcement will be specified. (No. 13) *Supplementary repair of external lightning protection systems based on the revealed deficiencies is in progress. Modification of cable paths and shielding of relay tables have been commenced. Construction will be completed in 2015.*

Only one limited measure has been completed:

- The inspection and maintenance procedures to be applied in the situation of extreme low level of the Danube were not satisfactory. The missing instruction is to be developed by December 15, 2013. (No. 12).

LOSS OF POWER SUPPLY AND HEAT REMOVAL

At Paks NPP a station **black-out (SBO)** is always connected with the **loss of Ultimate Heat Sink** (UHS). If the UHS is unavailable, the heat removal via steam generator (SG) may be initiated (secondary feed & bleed). But without any countermeasures the SG would dry-up within 4.5 hours, and core damage may occur in about 10 hours after the loss of power.[9]

Without electrical power supply the circulation of the cooling water stops in the Spent Fuel Pool (SPF). Boiling of the water could start after 4 hours already; damage to the cladding of the fuel assemblies may start after about 19 hours.

To enhance the opportunities of onsite and off-site AC power supply, the possible cross-links shall be studied and the concluding modifications shall be carried out for providing safety electrical power supply from any operable Emergency Diesel Generator in any unit to the safety consumers of any other unit (including the necessary procedures) by 15.12.2015. (No. 26 and No. 27) *Major part of the works took place in 2014, it will be completed in 2015.*
However, the Peer Review Team warned: "The possibilities of interconnection of existing equipment are beneficial. However, they might also lead to loss of separation. Such improvements or modifications should be prepared carefully. Before the implementation, separation issues should be investigated." The problem is if all trains could be cross connected, then the short circuit might disable several trains. [BMLFUW HU 2014]

Several means are necessary. Only some measures to prevent station black-out situation or providing alternate cooling and heat sink have been completed:

- The fuel storage capacity of the diesel generators (DG) was to be increased by March 15, 2014. (No. 22) *Completed 6 months before the deadline.*
- The black-start capability (start-up from own diesel generator) for the Liter gas turbine was to be created by December 15, 2014. (No. 25) *Completed 17 months before the deadline.*
- The ENSREG Peer Review Report states that in addition to the cooling with essential service water (ESW), the Emergency Diesel Generators (EDGs) could be cooled by the fire hydrant and the connecting point is easily accessible to achieve cooling quickly. In the current design,

[9] In case the SBO occurs during at power operation

ESW is used for the cooling of the diesel generators. With a loss of ESW, EDGs become inoperable. [BMLFUW HU 2014] The water supply from the fire water system to the ESWS through the technology cooling water system is to be solved by December 15, 2015. (No. 20) *The work has been completed in 2014.* **However, the time duration of establishing the cooling connection, after the ESW system is lost, is not mentioned. Thus, the feasibility of this measure in an accident situation could not be assessed.**

- The equipment necessary for the cooling water supply to at least one Emergency Diesel Generator (EDG) of each unit from the fire water system (so as the EDG can be started and operated in case of loss of the ESW system) is to be provided by December 15, 2015. (No. 21)
- The available inventory of the stored demineralised water in all operation states was to be maximized (deadline March 15, 2014) (No. 15).

These measures providing alternate cooling and heat sink are still in progress:

- Access to the connection point of the auxiliary emergency feed-water system in accident conditions is to be improved, new connection points are to be established on the demineralised water tanks by December 15, 2015. (No. 16)
- The supply mode of borated water inventories to the containment, including setting of boron concentration and storage, is to be regulated by December 15, 2018. (No. 17)
- Power-operated filters of the ESW system are to be established by December 15, 2015. (No. 23)
- As an alternate source of water (in a case the ESW system is lost) Paks NPP made 9 water wells 30 meters deep, that are located at the banks of Danube. However, at present, as the pumps are powered by plants' normal power supply this option is not available to be used as **ultimate heat sink** if the external electric power supply is lost. A provision of appropriate electrical power supply (diesel generator) that enables the bank filtered well plant to supply water to the ESWS via the existing connections in accident situations is to be established by December 15, 2015. (No. 18) **However, it is not mentioned against which external events the wells and the associated equipment can withstand and thus whether the ultimate heat sink will be available after an external event.**
- The accessibility of the water reserve available in the closed segment of the discharge water canal for the earthquake resistant fire water pump station is to be solved by December 15, 2018. (No. 19)

SEVERE ACCIDENT MANAGEMENT

The program for development and implementation of hardware measures for **Severe Accident Management** and of SAMGs started before the Fukushima accident. In 2011, it was completed at unit 1. HAEA requires the modifications necessary for the management of severe accidents to be completed prior to the expiry of the original design lifetime (30 years) for each unit.

In case of core melt accident, the goal is to **stabilize the molten core** within the reactor pressure vessel (RPV) by flooding the reactor cavity and external cooling of the vessel. The respective modifications were to be implemented by December 13, 2014 (No. 31).
This so-called **In-Vessel Retention (IVR) concept** aims to ensure the integrity of the RPV during a severe accident. It is one of the most important modifications concerning the prevention of major radioactive releases during accidents. The measure requires a number of technical modifications. Since the cooling of the RPV from the outside is a complex procedure, extensive analyses and experiments have been performed at the CERES test facility to demonstrate the feasibility. Analyses of consequences of RPV failure and the preservation of containment integrity in case of a severe

accident are on-going. Until now, only limited experimental analyses provided proof that this concept fulfils all the intended functions. Therefore the ENSREG Peer Review Team recommended considering a failure of the reactor pressure vessel (RPV), despite the fact this is claimed to be very unlikely. **However, the evaluation of the consequences of RPV failure is not included in the NAcP**.

The units are not equipped with a **filtered containment venting system**, and it is not planned to install such a system. HAEA requires the implementation of suitable measures to prevent over-pressurisation of the containment to avoid the release of radioactive material by December 15, 2018. (No.30)
After flooding of the reactor cavity to stabilize the molten core inside the reactor pressure vessel, the evaporation of coolant will gradually increase pressure in the containment. If there is no pressure reduction, the containment might fail due to over-pressurization after several days. To avoid this, either filtered venting or additional measures to assure long-term containment cooling by the containment sprinklers could be introduced. The method selected for containment overpressure protection at the Paks NPP is the installation of an active system for containment cooling, to enable the use of the containment spray in case of severe accidents. [BMLFUW HU 2014]
After the first review of the NAcP, **ENSREG pointed out that it is a challenge for the authority to verify whether the external containment cooling solution is suitable to cope with the containment over-pressurization phenomena and that the modifications will not impair any existing safety functions** and satisfy the nuclear safety principles. After the second workshop in 2015, the ENSREG Peer Review Team repeated this warning. [ENSREG RR-HU 2015]

It must be noted that this measure can only be adequate in case of successful In-vessel Retention of the molten core. Without cooling and stabilization of the molten core inside the reactor vessel, containment failure and thus a major release of radioactive substance appears likely. Given the importance of the issue, the deadline (2018) is very late!

To prevent hydrogen explosions in case of a severe accident, the following measures have been performed:

- A Hydrogen Monitoring System as part of the severe accident instrumentation for units 3 and 4 is to be installed by December 15, 2013 (installation for units 1 and 2 is already completed). (No. 29) *Severe accident modifications were completed at all units.*
- Distributions of the presence of hydrogen in unexpected places were to be performed by December 2012. The need for further action to avoid hydrogen explosion will be defined according to the result of the analysis. (No. 41) *According to the calculation results inflammable concentrations may occur, which can lead to turbulent burning.* **However neither the necessary back-fitting measures nor the time schedule for their implementation are mentioned.**

As a result of the EU Stress Tests, following Severe Accident Management (SAM) hardware provisions have to be improved:

- Today, additionally to the safety related electrical power supply system, one 300 kW severe accident diesel generator (DG) is available for each unit. These DGs are installed on trailers and are capable to supply electrical power to the instrumentation, monitoring and intervention systems, which are needed for mitigating the consequences of the severe accident. However, these DGs are not capable of supplying electrical power to safety supply systems and to the essential service water (ESW) pumps, therefore in order to manage accident situations the establishment of an additional, diverse diesel generator is planned. Appropriately protected independent severe accident diesel generators (DGs) are to be installed by December 15, 2018. (No. 24)

- For the construction of an external water supply route to the auxiliary emergency feed-water system, the necessary equipment is to be purchased by December 15, 2016. (No. 33)
- A new water supply route to the spent fuel pools designed against external hazards and connected in the courtyard by flexible means is to be constructed by December 15, 2018. (No. 32) At present, if the main SFP cooling/makeup system is lost, there will be no possibility to refill the SFP except from the inside. These areas might be subject to radiation and/or steam/heat due to evaporation of the water in SFP.
- Because the plant is not fully prepared to manage liquid radioactive wastes generated in large quantities during a severe accident, procedures for management of such large volume of contaminated water are to be developed by December 15, 2015. (No. 42) *The examinations were completed. A separate procedure is being prepared. The task will be completed by deadline.*

The on-site organisation and management of accidents and events, especially **of multi-unit accidents**, including severe damage to the infrastructure has to be improved. The following measures are necessary:

- For simultaneous management of severe accidents occurring on more than one (or even all) unit, the physical arrangement and instrumentation at the PCC are to be extended by December 15, 2018. (No. 36)
- A software-based severe accident simulator is to be established by December 15, 2017; the training and exercise of multi-unit emergencies can take place after the implementation of that action. (No. 38) *The simulator is in test operation already.*
- The number of staff is to be determined; procedures for personnel and equipment provisions are to be developed by December 15, 2017. (No. 37)
- A SAMG to manage severe accident situation simultaneously taking place in the reactor and the spent fuel pool is to be developed by December 15, 2018. (No. 34) *The task depends on other tasks (No. 17, No. 18, No. 33, No. 35). The compliance with the deadline also depends thereon.*
- A nuclear emergency response centre resistant to beyond design earthquake is to be established by December 15, 2018. (No. 47)
- Air-conditioning of the Protected Command Centre (PCC) is to be improved by December 15, 2015. (No. 48) The task can be carried out after the necessary reinforcement of the PCC against design basis earthquakes so the completion will be significantly delayed.
- A Backup Command Centre (BCC) equivalent with the PCC is to be established by December 15, 2016. (No. 49) The BCC will be constructed together with the new Counter-terrorist Centre about 5-6 km from the plant on a little hill. A delay is probable due to public procurement procedures.
- Informatics mirror storage computers are to be installed both at the PCC and the BCC by December 15, 2016. (No. 40)
- The radio communication is to be assessed in the case of permanent loss of electric power and earthquakes and the necessary actions are to be performed by December 15, 2018. (No. 39)
- A transportation vehicle providing adequate radiation protection under severe radiation conditions is to be purchased by December 15, 2018. (No. 44) *Implementation is in progress, it could be completed in 2015.*

5.2 TRANSPARENCY

The Hungarian Atomic Energy Authority published the Hungarian National Action Plan on its website in Hungarian and on the ENSREG website in English. [HAEA 2014].

In accordance with Article 8 (4) d) of the Atomic Act: "*The organization supervising the use of atomic energy ... shall inform the public on the safety of the use of atomic energy, nuclear security, its own activities, its major decisions and their substantiation, as well as on the applied safety, security and safeguards requirements via publishing the relevant information on its website.*"

The HAEA, on its website, continuously informed the public about the situation evolving in Japan and its consequences. The authority made available all relevant information on the preparation for, and execution of, the targeted safety re-assessment (TSR) in framework of the EU stress tests as well as on the extraordinary review made by the IAEA.

The interested parties can continuously follow the events on the website of the HAEA, since the major news is released thereon by the authority. Additionally, a "Bulletin" is published every six months, which includes information that may satisfy professional needs as well; Bulletins are sent in printed format to wider scope of people and organizations.

Another communication channel is the HAEA newsletter, through which the authority provides information on the major events every three months; the part targeted at the general public is available at the HAEA website. The HAEA, according to law, annually reports its activity to the Hungarian Parliament. This report is discussed within the relevant committees of the Parliament, which finally endorse it.

According to the Hungarian NGO Energy Klub, the transparency level concerning the stress test of the Paks NPP is still lower than would be necessary. The nuclear regulator HAEA provides information only in irregular intervals on its own initiative on the matter, and that information is inexpressive. The website of the HAEA does not contain specific pages dedicated to the stress test, and the timeline of the hits that are provided by the search engine of the website is confused. However, HAEA answers in details to the questions raised in official letters asking for information.

According to the updated NAcP, the outcomes of the analyses of the Fukushima Daiichi accident have not revealed such deficiency, which requires any change in the area of openness, transparency and communication. [HAEA 2014]

5.3 DISCUSSION AND CONCLUSIONS NPP PAKS

When trying to assess the overall safety situation, we need to take into account not only the information the stress tests provided, but incorporate the specific safety issues at the site and of the reactors at this site.

The original Paks NPP was not designed to withstand seismic loads. A large effort was undertaken to upgrade the plant to the level of the design basis earthquake defined in the course of an updated seismic hazard assessment. While it remains a fact, that Paks NPP underwent comprehensive reinforcement and qualification programs, further upgrading of Structures, Systems and Components (SSCs) is necessary. According to the National Action Plan of 2012, the further upgrading should be completed by 2015. However, one important measure is delayed - and the measure which has been chosen in the first place was replaced by a cheaper solution.

The seismic issue need to be taken very seriously, because the quantitative assessment revealed that only narrow seismic safety margins available. The most pressing unsolved seismic issue is the

potential for soil liquefaction, as it could act as an important initiator for the simultaneous failure of several safety systems.

Soil liquefaction might occur in the acceleration ranges slightly exceeding the design basis, which can cause an uneven settlement of the buildings. It is to assume that underground pipelines and cables could fail in this case. However, modifications are performed **no earlier than 2017**. Moreover, a state-of-the-art analysis for the assessment of the existing margins of earthquake-initiated building settlement and soil liquefaction phenomenon are not finished before2018.

According to Austrian experts it is unclear whether active faults in the site vicinity are adequately considered in the seismic hazard assessment which is of utmost importance for the reliability of the assessments. It could turn out that the current protection against earthquakes is utterly insufficient. However, to assess the hazard, the current situation needs to be considered: regardless of its low probability, an earthquake can occur any day from now on over the next ten years.

Not all measure to reduce the likelihood of major radioactive releases at Paks have been implemented, because they are not yet recognized by the nuclear regulator as possible, e.g. the failure of the reactor pressure vessel**.**

Without countermeasures, loss of electrical power supply and heat removal triggered by an external hazard result in core damage after approx. 10 hours. The damage of the fuel in the Spent Fuel Pools starts after about 19 hours, the boiling of water already after 4 hours. Thus the intervention time is quite short regarding the complex situation after an earthquake.

The implementation of hardware measures for Severe Accident Management (SAM) and Severe Accident Management Guidelines (SAMGs) had started before the Fukushima accident happened. The original program was completed for unit 1 in 2011, and is now completed for units 2 – 4. The regulator HAEA required these modifications to be implemented prior to the lifetime extension.

The most important SAM issue is the **external cooling of the reactor pressure vessel (RPV)** by flooding the reactor cavity to prevent RPV failure. The calculations of this in-vessel retention (IVR) concept were only justified in the frame of limited experimental analyses. The Peer Review Team recommended considering a failure of RPV, despite the fact the Hungarian regulator claims a failure of this utterly new measure as being highly unlikely. However, in the NacP the evaluation of the consequences of RPV failure is not required by HAEA. Furthermore, it is not assured that the external containment cooling solution suited to cope with the containment over-pressurization phenomena and that the modifications will not impair existing safety functions.

During the (slow) increase of pressure caused by steam produced during the external cooling of RPV, the unfiltered release through the stack could be necessary to avoid containment failure. However, the **installation of a filtered venting system is not planned**. Instead an active containment cooling system should be introduced, but no earlier than 2018. Moreover the envisaged specific containment cooling is only adequate if reliable in-vessel retention can be guaranteed, but this is not completely proven yet as mentioned above.

In response to the stress tests, further studies and measures are necessary to remedy deficiencies that the stress tests have revealed. The topics to be resolved concern e.g. water supply to the spent fuel pools, multi-unit accidents, on-site emergency preparedness etc. Despite the fact this are of high safety importance this measures are not pre-conditions for the approval of lifetime extension.

Overall assessment and the aspect of life time extension (PLEX)

The deadline for the implementation of all measures is not earlier than 2018, creating two additional problems: This well-documented dangerous situation will persist for more than 7 years after the Fukushima accident and furthermore, the finalization of these measures is out of the

scope of the stress tests procedure, which means out of the scope of the international assessment procedure which created a certain level of transparency.

All four units are supposed to be in operation for additional 20 years. Unit 1 and 2 have received the operation licence for extended operation already. Ageing is an issue at all units of Paks NPP, because their design operation time is exceeded or almost over. In addition, the power uprates which were performed during the last years accelerated the ageing process. Degradation effects of safety-related systems and components could significantly aggravate the development of an accident or even trigger a severe accident.

To remedy all design weaknesses (in particular wall thickness of the reactor building and location of the Spent Fuel Pool) of the outdated WWER 440/V213 reactor type is not possible. Taking into account the existing risk of terrorism, it is irresponsible to operate a nuclear power plant with such a high vulnerability to external attacks.

The combination of design weaknesses, ageing impacts and the seismic hazards revealed by the stress tests show that the Paks NPP life-time extension would pose an irresponsibly high nuclear risk. The four units at Paks should be shut-down immediately.

6 CONCLUSIONS

Nuclear safety of the EU nuclear power plants and nuclear safety concepts were to be thoroughly revisited after the Fukushima disaster on March 11 2011. The EU Council set out to respond to this "new experience" of Fukushima by conducting the stress tests and promising that the results would lead to higher safety.

Increased Safety?

After having evaluated the past four years of the EU stress test we are trying to provide a concise overview over what has happened and how this fits into the general trend of nuclear safety development in Europe. There were roughly three options the operators and nuclear authorities chose to deal with the shortcomings the stress tests had revealed:

- A quick response, but without any guarantee that the measures are sufficient (e.g. Cernavoda NPP, Romania).
- A comprehensive evaluation of possible hazards and protections measures, which will take more than ten years (e.g. France).
- Business-as-usual (e.g. Dukovany, Czech Republic). The idea of the stress tests is more or less ignored. Instead the already on-going measures are listed, major hardware improvement avoided.

However, none of those options has increased the nuclear safety to an acceptable level - in no country. The very obvious solution – permanent shut down – needs to be considered and is in several cases the only safe option.

Response to Fukushima: Mobile Equipment

Especially problematic is the fact that mobile equipment is presented as the solution to compensate deficiencies of the reactors and the spent fuel pools. ENSREG highlighted as good practice the use of an additional layer of safety systems fully independent from the normal safety systems, located in areas well protected against external events, e.g. bunkered systems or hardened core of safety systems.

However, the operators instead are heavily relying on the new magic solution to severe deficiencies at the plants due to design or the site: mobile equipment, which is easy to plan and store in the plant and therefore a cheaper solution than the implementation of comprehensive measures. But under severe accident conditions, it is very unlikely that the proposed mobile equipment can be put to work as quickly as necessary; to rely to such a large extent on manual actions is irresponsible in regard of the consequences of a severe accident [BECKER 2013].

Another advantage of those easy solutions is also that the plants do not have to stop producing electricity. All over Europe the regulators are content with the measures being implemented during the regular outages or during normal operation.Many plants would have to undergo long outages while serious upgrades are implemented at the plants, causing enormous costs. If investment is rather avoided or if the plant cannot be upgraded, there is only one responsible solution: permanent shut down, which for several NPP is the only safe option. This applies in particular to those plants where significant improvements cannot be achieved by the planned deployment of mobile equipment only or by having plants on the grid in the current status for many more years while evaluations and assessment are under preparation and again later back-fittings would start.

Upgrades of old plants and life extension (PLEX)

Limited back-fitting measures do not significantly improve the safety level because they cannot compensate the increasing threat of hazards (e.g. by climate change) and of ageing effects. Furthermore, the experiences show that back-fitting measures could cause new faults (e.g. because of defective mounting, forgotten scrap etc.).

Comprehensive plant modifications which would actually improve the safety level are technically impossible due to design weaknesses or would be done only in exchange for prolonged operation times, at the same time carrying the risks of aging plants as mentioned above.

Currently PLEX – life time extension – is the only means available to nuclear power plant operators to keep their market share, because new built is impossible for a wide range of reasons. While until a few years ago, the operation of old NPP was very profitable, the very low electricity prices turned the operation of nuclear power plants into a difficult business with very tight profits. Operators, e.g. CEZ in the case of Dukovany, made clear, that any new safety requirement that would be agreed on EU level could endanger the economics of the plant[10].

Outlook: Development of Nuclear Safety Regulation in the EU in the upcoming months

Revised EU nuclear safety directive

The Council adopted the revised directive 2014/87/EURATOM on July 8 2014[11]. While EU members have three years´ time (until 15th August 2017) to transpose the directive into their national legislation, the EU Commission started to prepare guidance concerning the question of the more concrete implementation. One of the elements which had been introduced by the stress test into the regulatory framework was the **Peer Review Approach** and later incorporated in the revised directive. Every six years ENSREG (European Nuclear Safety Regulators Group) will organizes this: In the first step the national regulators need to decide on a **common nuclear safety topic**, then prepare a report on the situation in their country; then they will peer review each other´s reports. The first topic will be suggested by WENRA to the EU Commission in July 2015, so that it can start in 2017. The results of these peer reviews will be made public and some concrete technical recommendations and appropriate follow-up measures will be taken.

Our paper at hand arrived at the conclusion, that the Peer Review is certainly able to deliver added value, because national regulators have to argue their results and methods with their colleagues and publish those. Now, four years later we can also clearly describe the weakness of this new tool, which is the follow-up on national levels. It is still up to the national regulators to take up the recommendations made and order the licensees, the operators of the nuclear power plants in their country, to implement adequate measures. We hope, that ENSREG and the EU Commission will improve this situation, both concerning the follow-up of the stress tests and the safety directive.

[10] Petr Štulc, ČEZ, at the seminar „Energetické Třebíčsko" in the Czech Parliament in Prague, November 25 2014

[11] http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32014L0087&from=EN

At the same time the EU directive uses the term of '**reasonably practicable'**, which could open the way to safety levels much lower than the „highest level of nuclear safety standards" or „Best Practice" or „Best-Available-Technology", which should be applied in safety standards.

Transparency and Peer Reviews

Transparency was a new and interesting approach the stress test exercise made us of, for each country this report summarizes the experiences made. Another new feature the stress test introduced into the safety assessment were the Peer Reviews, when experts nominated by EU countries recommended to other EU countries measures to improve the safety in their plants. We examined, whether the new approaches – Peer Review in nuclear safety and transparency - are useful and should be continued, which is the path chosen for the newly revised EU directive on nuclear safety.

ENSREG certainly put more emphasis on transparency and involvement of independent experts, civil society and the public when setting up the stress test rules, thereby recognizing the role of transparency in safety culture. Our paper at hand summarized the experiences made per country. We saw that the idea pushed on the European level by ENSREG was not fully embraced on national level. Contrary to announcements made in the beginning, national regulators did not change much their traditional approaches. In many countries we observed the following problems:

- national reports only in English on the national regulator´s website
- written information requests were answered strictly in line with the law, not even attempting to make the answer comprehensible
- no open discussions with the public took place with a few exceptions
- reports, including the latest Updated National Action reports, are compiled in such a manner, that it is not possible to compare the original recommendation with the measures implemented or not implemented until now
- nuclear regulators still rather try to cover up the nuclear safety deficits instead of openly discussing them

An example is Romania, where the Stress Tests proved to be useful in pointing out that seismic risk, flooding and extreme weather events have not been sufficiently addressed in Romania. Even now, the Romanian Regulator CNCAN (National Commission for Nuclear Activities Control) does not to insist on the implementation of the measures, which the EU Peer Review Team has drawn up as necessary. A serious problem for the nuclear safety in Romania is the fact, that CNCAN regulatory performance is insufficient and does not comply with international standards. Public scrutiny was not sufficiently strong to prevent this situation. Currently, no information is available on the implementation of the Stress Test results. It would be necessary that CNCAN would resume issuing regular, transparent and understandable reports as was announced on European level during the Stress Tests. CNCAN either ensures that the operator fully and timely implements all measures or orders the plant to be taken offline.

At the same time the topic of nuclear safety is a very complex one and not only the general public, but also the expert organizations and independent observers have a hard time having an overview and deeper understanding. Therefore it is important that the national regulators via ENSREG adopt at a new type of safety culture and see that public control is essential and only possible if the regulators actively support this development.

A key issue, which was unclear two years ago, was how comprehensively the ENSREG´s peer review of the national action plan will be conducted. This could have been seen as an opportunity to force the nuclear regulators to formulate mandatory requirements which need to be fulfilled in a rather stringent time schedule; in contrast to the years or even decades currently planned in many countries. This could make operators decide to shut down old and unsafe nuclear power plants NPP instead of investing into extensive modernization measures. However, at the end of the stress test procedure it is clear that ENSREG has not intervened in any case. The peer review of the updated NAcP was more or less a formal review rather than an evaluation of the remaining risks. **The summary report of the ENSREG workshop of April 2015 only highlighted good practice and did not mention the grave problems at many plants.** [BECKER 2015]

Inspite of tons of papers, millions of working hours we have to see that no lessons have been learned from the accident at Fukushima: At all European nuclear power plants severe accidents can occur – any time.

7 REFERENCES

BECKER 2013: Critical Review of the National Action Plan (NAcP); EU Stress Test performed on Nuclear Power Plants; Study commissioned by Greenpeace; Oda Becker, Patricia Lorenz; Wien, Hannover, April 2013

BECKER 2015: Critical Review of the updated National Action Plan (NAcP); EU Stress Test performed on Nuclear Power Plants; Study commissioned by Greenpeace; Oda Becker, Patricia Lorenz; Wien, Hannover, April 2013

BMLFUW CZ 2014: Stress tests Follow-Up Actions; Issue Paper for the Czech Republic; Authors: Kurt Decker, Helmut Hirsch, Bojan Tomic; Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management; Prepared by the Order of the BMLUFW; Report Final Version Vienna; 20-01-2014

BMLFUW HU 2014: Stress tests Follow-Up Actions; Issue Paper for Hungary; Authors: Kurt Decker, Helmut Hirsch, Bojan Tomic; Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management; Prepared by the Order of the BMLUFW; Report Final Version Vienna; 20-01-2014

BNRA 2012: Bulgarian Nuclear Regulatory Agency (BNRA): National Action Plan of Bulgaria, European Stress Tests Kozloduy NPP; December 2012

BNRA 2014: Bulgarian Nuclear Regulatory Agency (BNRA): Updated National Action Plan of Bulgaria, European Stress Tests Kozloduy NPP; December 2014

CEZ 2013: Czech Republic National Report; AlešKarásek (ČEZ), JiříPliska (I&C ENERGO); IAEA Technical Working Group on Nuclear Power Plant Instrumentation and Control; 22-24 May 2013

CNS CZ 2010: Czech Republic National Report under the Convention on Nuclear Safety (CNS); 2010

CNS CZ 2013: Czech Republic National Report under the Convention on Nuclear Safety (CNS); 2010

ENSREG 2011: Declaration of ENSREG on EU Stress Tests Specifications. Published 31 May 2011

ENSREG 2013: European Nuclear Safety Regulators Group: ENSREG Nation Action Plans Workshop; Summary Report; 10 June 2013; http://www.ensreg.eu/node/1343

ENSREG CR-CZ 2012: ENSREG Peer Review Country Report –Czech Republic; Stress tests performed on European Nuclear power plants; 2012

ENSREG RR-BG 2015: Rapporteur’s report – Bulgaria, ENSREG National Action Plans Workshop, 2015

ENSREG RR-CZ 2015: Rapporteur’s report – Czech Republic, ENSREG National Action Plans Workshop, 2015

ENSREG RR-HU 2015: Rapporteur’s report – Hungary, ENSREG National Action Plans Workshop, 2015

ENSREG RR-RO 2015: Rapporteur’s report – Romania, ENSREG National Action Plans Workshop, 2015

HAEA 2011: Hungarian Atomic Energy Authority (HAEA): National Report of Hungary on the Targeted Safety Re-assessment of Paks Nuclear Power Plant; December 2011

HAEA 2012: Hungarian Atomic Energy Authority (HAEA): National Action Plan of Hungary on the Implementation actions decided upon the lessons learned from the Fukushima Daiichi accident; December 2012

HAEA 2014: Hungarian Atomic Energy Authority (HAEA): National Action Plan of Hungary on the Implementation actions decided upon the lessons learned from the Fukushima Daiichi accident; December 2014

IAEA 2003: International Atomic Energy Agency (IAEA): Seismic design and qualification for nuclear power plants, Safety Guide; IAEA Safety Standard Series; NS-G-1.6; Vienna, 2003

IAEA 2012a: International Atomic Energy Agency (IAEA): IAEA Leads Operational Safety Mission to Kozloduy Nuclear Power Plant; Press Release 2012/32; http://www.iaea.org/newscenter/pressreleases/2012/prn201232.html

IAEA 2014a: International Atomic Energy Agency (IAEA): REPORT of the OPERATIONAL SAFETY REVIEW TEAM(OSART) to the KOZLODUY NUCLEAR POWER PLANT BULGARIA 26 November to 13 December 2012; FOLLOW UP MISSION to the KOZLODUY NUCLEAR POWER PLANT BULGARIA 23 – 27 June 2014; http://www.kznpp.org/uf//bezopasna_eksploataciq_okolna_sreda/OSART_NEW/Kozloduy%20FU%20Mission%20report%20final_en.pdf

IAEA 2014b: International Atomic Energy Agency (IAEA): IAEA Concludes Safety Review at Dukovany Nuclear Power Plant in Czech Republic; 27 November 2014; https://www.iaea.org/newscenter/pressreleases/iaea-concludes-safety-review-dukovany-nuclear-power-plant-czech-republic

JPG 2012: Joint Project Group: Stress Tests & Vulnerability Assessment; Recommendations and Experience of the Joint Project Group; 2012; www.joint-project.org/upload/file/JointProjectGroup2012_Brochure_StressTests_VulnerabilityAssessment.pdf

NW 11/10/12: The McGraw-Hill Companies: Nucleonics Week 53; October 11, 2012

NW 21/02/13: The McGraw-Hill Companies: Nucleonics Week 54, February 21, 2013

PRIS 2015: IAEA Power Reactor Information System (PRIS): The Database on Nuclear Power Reactors; www.iaea.org/PRIS/home.aspx; 2015

RNR 2011: Romania National Commission for Nuclear Activities Control: National Report on the Implementation of the Stress Tests, December 2011

RNR 2012: Romania National Commission for Nuclear Activities Control: Romanian National Action Plan post-Fukushima, December 2012

RNR 2014: Romania National Commission for Nuclear Activities Control: Romanian National Action Plan post-Fukushima, December 2014

SUJB 2012: Post Fukushima, National Action Plan (NAcP) on Strengthening Nuclear Safety of Nuclear Facilities in the Czech Republic; State Office for Nuclear Safety (SUJB); December 2012

SUJB 2014: Post Fukushima, National Action Plan (NAcP) on Strengthening Nuclear Safety of Nuclear Facilities in the Czech Republic; State Office for Nuclear Safety (SUJB); December 2014

UBA 2012: Umweltbundesamt: Roadmap of Paks NPP Lifetime Extension (LTE) – Summary of Current Status and Open Questions of the Bilateral Meetings between Austria and Hungary. Becker, Oda; Brettner, Mathias; Decker, Kurt; Hirsch, Helmut; Indradiningrat, Adhipati Y.; Reports, Band 0402; Wien, 2012; www.umweltbundesamt.at/fileadmin/site/publikationen/REP0402.pdf

WENISCH 2012a: Wenisch, A.; Becker, O. Lorenz, P.: Critical Review of the EU Stress Test performed on Nuclear Power Plants; commissioned by Greenpeace, Wien, Hannover, May 2012

WNA 2014a: World Nuclear Association: Nuclear Power in Romania, updated October 2014; http://www.world-nuclear.org/info/Country-Profiles/Countries-O-S/Romania/

WNA 2015a: World Nuclear Association: Nuclear Power in Czech Republic, updated June 2015; http://www.world-nuclear.org/info/Country-Profiles/Countries-A-F/Czech-Republic/

WNA 2015b: World Nuclear Association: Nuclear Power in Bulgaria, updated April 2015; http://www.world-nuclear.org/info/Country-Profiles/Countries-A-F/Bulgaria/

WNA 2015c: World Nuclear Association: Nuclear Power in Hungary, updated April 2015; http://www.world-nuclear.org/info/Country-Profiles/Countries-G-N/Hungary/

WNN 2011a: World Nuclear News (WNN): Korean CANDU restarts after refurbishment; 29 July 2011, www.world-nuclear-news.org/C_Korean_Candu_restarts_after_refurbishment_2907114.html

WNN 2012b: World Nuclear News (WNN): Point Lepreau heads for full power; 05 November 2012. www.world-nuclear-news.org/RS-Point_Lepreau_heads_for_full_power-0511124.html

WNN 2013b: World Nuclear News (WNN): New lease of life for Paks; 08 January 2013, http://www.world-nuclear-news.org/RS_New_lease_of_life_for_Paks_0801131.html

WNN 2015a: World nuclear news: Wolsong 1 resumes operation following licence extension; 24 June 2015; http://www.world-nuclear-news.org/C-Wolsong-1-resumes-operation-following-licence-extension-2406154.html