Stress Tests & Vulnerability Assessment

Recommendations and Experience of the Joint Project Group

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The Joint Project Group

About us

The Joint Project is an ongoing co-operation of NGOs and research institutions on safe and sustainable energy issues with a focus on antinuclear activities in Central and Eastern Europe supported by the Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management.

Each year a main topic of particular relevance for the anti-nuclear/sustainable energy work in Europe and some additional anti-nuclear topics are identified. The members work on these topics within:

- **one transnational Joint Project**
  which is co-ordinated by the Austrian Institute of Ecology, an Austrian independent research organization.

- **national projects**
  which are coordinated by the Hungarian Environmental Partnership Foundation (HEPF). HEPF is a not-for-profit, politically independent organization promoting environmental improvement and awareness among civil society and the general public.

More information about our activities can be found under:

- **http://www.joint-project.org/**

Members of the Working group

The joint working group consists of members from Austria, Bulgaria, Czech Republic, Hungary and Romania. Current members of the working group are:

- Calla (CZ) http://www.calla.cz
- South Bohemian Mothers (CZ) http://www.jihoceskematky.cz
- Energiaklub (HU) http://www.energiaklub.hu
- Za Zemiata (BG) http://www.zazemiata.org
- Foundation for Environment and Agriculture – agroecofund (BG)
- Terra Mileniul III (RO) http://www.terraiii.ngo.ro
- HEPF http://okotars.hu/en
- Austrian Institute of Ecology (AT) http://www.ecology.at/

This brochure – the Joint Project 2011/2012 on stress tests and vulnerability assessment

After the accident in Fukushima, nuclear safety as topic in anti-nuclear work has gained importance within the Joint Project countries. Therefore, nuclear safety and in particular the activities of the European stress tests were chosen to be the main focus of the Joint Project 2011/2012 as well as the common theme of the national projects.

This brochure describes:

A) Vulnerability Assessment

A critical review of the EU Nuclear Stress Tests in Bulgaria, Hungary, Romania and Ukraine is presented in chapter 1.

- The review details the main weaknesses identified within the stress tests.

- Important shortcomings not mentioned in the stress tests reports are also discussed.

These evaluations do not claim to be exhaustive, but the findings contribute to a more comprehensive understanding of safety and risk of nuclear power plants in Europe.

B) Transparency of the stress tests

In chapter 2 the experience of the Joint Project NGOs concerning transparency of the stress tests is presented. The information is not meant to be an evaluation of the transparency of the stress tests in general – such an evaluation is not possible within the scope of this brochure. The evaluation aims to show activities concerning stress tests and how they were conceived by the JP NGOs. Some recommendations for improvement are given.

C) Safety focus

Within the main topic "nuclear safety" of the Joint Project 2011/2012 the NGOs of each JP country selected a special safety relevant topic, which is/was of particular interest in their country:

- Bulgaria: The short story of Belene NPP – The victory – Key points of the campaign against the nuclear power plant

- Romania: Risks of the CANDU reactor design

- Czech Republic: Results of the conference "Power Plant Load Testing: Safety Inspection or Propaganda?"

- Slovakia: Safety deficits of the NPP Mochovce

These safety relevant issues are discussed in separate sections within the brochure at hand**.**

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1 Vulnerability Assessment

1.1 Introduction

In March 2011, the core melt accidents at the Fukushima Daiichi 1 nuclear power plant (NPP) showed the world that the nuclear industry cannot prevent severe accidents from happening. The accidents in Japan proved that highly unlikely accidents cannot be excluded. The Fukushima accident confirmed the mistrust towards nuclear power among the Japanese but also European citizens.

In reaction to the devastating nuclear disaster in Japan 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 ("stress tests"). The EU Nuclear Safety Regulators Group – ENSREG took over the task to provide a "targeted reassessment of the safety margins of nuclear power plants", thus examining whether the safety margins which were used in the licensing of NPPs are sufficient to cover unexpected events. It is important to understand that the stress tests could not take into account all key safety issues such as the capability to prevent accidents - the scope of the stress tests defined by ENSREG didn´t promise to deliver a comprehensive risk and safety assessment. According to some observers the stress tests were mainly set up to improve the confidence in the safety of European NPPs. Nevertheless, the stress tests provided some interesting findings concerning safety:

Within this chapter, the safety of the nuclear power plants in Bulgaria, Hungary, Romania and the Ukraine is assessed. This assessment was financed by the grassroots foundation Germany and the Vienna Ombudsoffice for Environmental Protection (Wiener Umweltanwaltschaft) and was conducted within the Joint Project 2011 which is supported by the Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management. The assessment is also available separately under the title "Critical Review of EU Nuclear Stress Tests in Bulgaria, Hungary, Romania and Ukraine" – authors: Oda Becker, Patricia Lorenz, Andrea Wallner.

The introduction contains an overview of the content and procedure of the stress tests. This "Critical Review of the Stress Tests" is based on the national stress tests reports written by the national nuclear safety authorities and on the Peer review country reports attached to the Peer review report - Stress tests performed on European nuclear power plants written by the Peer review Teams, the Peer Review Board respectively, and endorsed by ENSREG [ENSREG 2012a, ENSREG 2012c]. It continues by listing the main weaknesses as identified by operators, national regulator and Peer review team and a selected range of the suggested remedial measures. Important shortcomings not mentioned in the stress tests reports are also discussed. These evaluations do not claim to be exhaustive, but the findings contribute to a more comprehensive understanding of safety and risk of nuclear power plants in Europe.[1]

[1] The evaluations are based on the study "Critical Review of the EU Stress Test performed on Nuclear Power Plants" published in May 2012 [WENISCH 2012a].

1.2 The EU Stress Tests

1.2.1 Accident Risk

The operation of nuclear power plants is inevitably connected with the residual risk of a major nuclear accident (BDBA, Beyond Design Basis Accident). Absolute nuclear safety does not exist. The expression "a nuclear plant is safe" only means that the level of residual risk is presumed to be "acceptable". Combinations of failure – technical and human – cannot be assessed and excluded in advance. In spite of this, common understanding tends to believe that tests can make nuclear power plants safe. A sound safety assessment can only help to reduce the nuclear risks [RENNEBERG 2011].

1.2.2 Aims

The EU stress tests were defined as a targeted reassessment of the safety margins of nuclear power plants and developed by ENSREG, including the European Commission, in the light of the events which occurred at the Fukushima Daiichi NPP.

Their aim was to assess whether the safety margins which were used in the licensing of nuclear power plants are sufficient to cover unexpected events. The stress tests were to draw the important lessons from the accident at Fukushima NPP that e.g. two natural disasters can hit at the same time and leave the NPP without any electrical power supply.

An overview of the stress tests is available under:

- http://www.ensreg.eu/EU-Stress-Tests (here all reports are/will be available)
- http://ec.europa.eu/energy/nuclear/safety/stress_tests_en.htm

1.2.3 Procedure

Definition of scope and modalities

In March 2011, the European Council (following an extraordinary meeting of Ministers, regulators and industry held on March 15) concluded that in the light of the Fukushima accident in Japan, the safety of all EU nuclear plants should be reviewed based on a comprehensive and transparent risk assessment (stress test). ENSREG and the European Commission were invited to develop the scope and modalities of these tests in a coordinated framework with involvement of member states, making use of available expertise, like e.g. WENRA (network of nuclear Regulators). WENRA started working on the scope and methodology – the final WENRA proposal on scope/modalities for the stress tests was submitted to ENSREG May 7, 2011. On May 25, 2011 ENSREG published the scope and modalities for the risk and safety assessments of EU nuclear power plants (NPPs). The document determined the concept, methodology and time schedule.

All EU Member States operating nuclear power plants – plus Lithuania – and some neighbouring countries that have accepted to be part of the process (Ukraine, Switzerland) performed the stress tests on a voluntary basis.

The ***first phase*** of the EU stress tests started in June 2011 – the ***operators*** of the NPPs prepared a ***self-evaluation*** of their plants. According to Annex I of the "Declaration of ENSREG" national regulators initiated this process by sending requirements to the licensees (operators) on June 1, 2011, at the latest. Licensees had to provide a progress report to the regulators by August 15, 2011 and a final report by October 31, 2011.

In the ***second phase*** the ***national authorities reviewed*** the progress and final reports submitted by the operators. The progress report had to be handed over by the regulators to the EU Commission until Sept. 15, 2011 – all final national reports were handed over to the EU Commission by December 31, 2011.

The European Commission presented a progress report to the European Council for the meeting scheduled on December 9, 2011. This Interim report was published on November 24, 2011.

Then the ***third phase*** started: the ***peer review***, which was conducted by experts nominated by the national states to review the national reports. Under the leadership of ENSREG, requirements on content and structure of the reports and the peer reviews were developed. The requirements were agreed at a meeting on October 11, 2011. During the peer review, teams reviewed the national reports in a desktop research. Each country was visited by one expert team.

The technical scope of the peer reviews comprises:

- Compliance of the national reports to the stress test specifications
- Safety improvements should be highlighted
- Suitable standard/best practices of margins to hazard and fault conditions

The peer review process comprised:

- Horizontal = topical reviews as well as
- Vertical = country specific peer reviews
    1. Earthquake, flooding and other external events
    2. Loss of power, loss of UHS and combination of loss of power + loss of Ultimate Heat Sink (UHS)
    3. Severe accident management issues
- As the final step, an ENSREG Summary Report prepared under supervision of peer review Board will be issued.

The results of topical reviews fed the country reviews with inputs, the country reviews provide an opportunity for follow-up discussions on the relevant issues.

The Peer review was completed with a main report that includes final conclusions and recommendations at European level regarding the three topical parts and 17 country reports including country-specific conclusions and recommendations. The report was endorsed and published by ENSREG on April 26, 2012.

The European Commission presented the ENSREG report in June 2012 to the European Council.

The EU Commission did not see the Council mandate for stress tests fulfilled and demanded further testing; six additional plant visits were undertaken, those follow-up reports were published in late October 2012.[2] To implement the stress tests findings, an ***ENSREG action plan*** (published 1 August 2012) has been developed to track implementation of the recommendations. in line with this action plan each national regulator will generate a country-specific action plan and publish it by the end of 2012. In October 2012 ENSREG published a compilation of Peer review recommendations and suggestions to assist the review of national action plans by national regulators [ENSREG 2012b]. Also in October 2012, the European Commission published a "Technical summary on the implementation of comprehensive risk and safety assessments of nuclear power plants in the European Union (Commission Staff Working Document)" [EC 2012]. All reports, including the licensee reports have been made available on the ENSREG website.

1.2.4 Content

The reassessment of the safety margins of NPPs within the EU stress tests consisted of:

- an evaluation of the response of a nuclear power plant when facing different extreme situations (earthquakes, floods and extreme weather events, and the combination of events). In these extreme situations sequential loss of the lines of defence was assumed in a deterministic approach, the probability of this loss is not taken into account).
- as well as the plant's capabilities to cope with consequences of loss of power including Station Black-out (SBO) and loss of heat removal via Ultimate Heat Sink (UHS). Safety reserves (margins) should also be assessed as well as Severe Accident Management (SAM).

The design basis of many European NPPs was determined many decades ago. Not all operators have reassessed the seismic hazards in compliance with state-of-the-art-methodologies. Any major effects to be expected from an earthquake would be related to the vibrations induced in the Systems, Structure and Components (SSCs). This can cause the lost of safety relevant SSC directly or indirectly (internal flooding due to pipe-breaks or fires due to release of flammable substances). Station Black-out (SBO) cannot be excluded even if the electricity supply has a high redundancy but the switchyard (cables, connections or the switches) are not seismically qualified.

At many NPP sites the ***flood threat*** has increased in recent decades for several reasons (e.g. climate change and reduction of natural flood plains). But still appropriate safety margins rarely exist. Fukushima highlighted the need for better flood protection. Large, destructive floods are now expected to happen more frequently. The presence of water in many areas of the plant may be a common cause of failure for safety related systems. The dynamic effect of the water can be damaging to the structure and the foundations of the plant. Flooding of a NPP could result in the total loss of electric power and/or loss of heat removal supply and so trigger a severe accident. Flooding may also affect the communication and

[2] http://www.ensreg.eu/node/520, accessed on November 12 2012

transport networks around the plant site and can contribute to the dispersion of radioactive material to the environment.

The frequency and the intensity of ***extreme weather events*** are expected to increase. Changes (e.g. of heavy rainfall) have been observed already. Many design standards of NPPs were based on an understanding of a climate system that is now decades out of date. Thus, the protections of the NPPs are probably not sufficient to prevent disaster. Sometimes, what is being thought to be a "worst case" scenario is not really the worst case. Extreme weather events can aggravate or even initiate an accident.

Total loss of electrical power – ***Station Black-out (SBO)*** – and ***loss of Ultimate Heat Sink (UHS)*** scenarios could result in severe accidents. All NPPs need electric power supply, particularly for the instrumentation and safety systems, even when they are shut down. Typically an NPP has three or more transmission line to the electric grid. Natural hazards (e.g. heavy storms, earthquake, flooding) can lead to multiple damage of the transmission lines, and hence to loss of off-site power. Every NPP has Emergency Power Supplies, which are often diesel-driven. These generators provide power to emergency pumps, valves, fans, and other components that are required to prevent core melt. If the Emergency Diesel Generators (EDG) fail, the situation at the plant becomes critical.[3]

NPPs also need an Ultimate Heat Sink (UHS) to remove heat from the primary cooling circuit and other vital systems necessary to avoid a severe accident. Usually, the Ultimate Heat Sink is a river or the sea. The Ultimate Heat Sink (UHS) removes heat from the (primary) cooling circuit and other vital systems necessary to avoid a severe accident. If the UHS gets lost, fuel damage can occur in the reactor core and/ or Spent Fuel Pool quite rapidly. One important new feature of the stress tests is the evaluation of the so called "cliff edge effects".[4] Of high importance in this context is the time until critical situations, particularly core melt arise.

Severe Accident Management (SAM) to mitigate the consequences of a severe accident, especially regarding Spent Fuel Pools and multi-unit accidents is an issue in all countries. However, the development and implementation of SAM guides, measures, equipment as well as organization and training of personnel is in very different state in the countries. The means for maintaining containment integrity should in particular include prevention of damaging hydrogen explosions (as it happened in Fukushima), and means of addressing long-term containment over-pressurization[5], such as filtered venting.

[3] There are also batteries that supply direct current in case of an emergency; however, the batteries cannot provide electricity for large components such as pumps and have only very limited capacity (few hours).

[4] A cliff edge effect describes a qualitative degradation of the plant's safety conditions (comparable to walking on a cliff and the next step fall down).

[5] When the reactor core has melted through the reactor pressure vessel and residual heat removal has failed, pressure in the containment rises.

1.2.5 Shortcomings

Limited scope[6]

- Besides natural hazards, other external or internal events can initiate a severe accident, for example an airplane crash, an internal fire, a human failure or combinations of those events.
- Particularly an airplane crash has to be considered as a relevant safety issue, because several plants have reactor buildings that are insufficiently robust to protect the containment and the reactor system against the impact of an airplane. An airplane crash (deliberate or accidental) could cause an accident with a containment failure or bypass and lead to a large and early radioactive emission into the atmosphere. The EC technical document on the stress tests stated that the stress tests have to a considerable extent covered the indirect effects of airplane crashes through the work undertaken on Station Black-out and loss of plant cooling [EC 2012]. But this is not true, because the effects of mechanical impacts and fires are not considered. Furthermore, the EC document conceals that the stress tests reveal that SBO situations mostly rely on perfect functioning of Severe Accident Management. However, they are not often is not implemented or not sufficient.
- The operating European NPPs differ in age and therefore in design. At none of those NPPs, the defence-in-depth concept[7] applied is complying with state-of-the-art requirements. Naturally it is better to try and prevent accidents from happening rather than dealing with the consequences of an accident. In spite of this, the capability of accident prevention was only partly under review in the stress tests. One important issue the stress tests do not review is the quality of systems and components (e.g. material of reactor vessel, pipes and valves).
- Weaknesses of the safety management or the safety culture could also cause faults that trigger or aggravate accident situations.
- Ageing induced degradation effects of safety-related systems and components can significantly aggravate the development of an accident caused by an external event. Ageing related incidents have also the potential to trigger a severe accident. Incidents could also be caused by ageing indirectly: If old components are replaced, new faults because of defective mounting are possible.

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[6] 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" (stress tests). The EU Nuclear Safety Regulators Group – ENSREG – took over the task to provide a "targeted reassessment of the safety margins of nuclear power plants. One of the reasons of this limitation in the defined scope of the stress tests was the lack of time provided to the ENSREG. This is a reason for the shortcomings the stress tests have compared to the original idea of a "comprehensive and transparent risk and safety assessment".

[7] The first level of defence provides a safe operation within the defined operational data specifications. The second level of defence serves for those cases when the operational specification data are exceeded. In those cases systems are needed to lead the reactor back into the allowed range of operational limits. If this second level fails and the reactor might get out of control, the most important the third level of defence is needed. This third level of defence consists of safety systems that must be able to shut down the reactor and to cool the fuel. If this third level fails, only the fourth level of defence, which consists mainly of accident management, should prevent a core melt accident with major radioactive releases.

- The stress tests take for granted that all the Structures, Systems and Components (SSC) assessed are in place and in perfect condition and functioning flawlessly, but the operational experience shows that this is not the case in reality.

Lack of criteria

- The stress tests specifications lack the definition of the safety level to be reached to continue plant operation, to make back-fitting necessary or to require shut down. The German Reactor Safety Commission, for example, has defined four levels of robustness in the frame of the German stress test. The basic level is chosen as a level that must be fulfilled by all operating plants. Each of the three levels of robustness defines a specific larger kind of safety-margin.

Involved experts

- Almost none of the experts involved in the stress tests are really "independent". The operators´ reports are the most important basis for the final national report and the assessment of the safety of the plant. For obvious reasons the operators cannot be considered independent: it is in their interest to demonstrate that a plant does not require costly back-fitting measures.
- The nuclear authority published the national stress tests reports. In the past the members of a nuclear authority and their technical support organisations legitimated the operation of the power plants under their supervision and they informed the public that the plants were operating safely. Conducting the stress tests makes them review their own practice and their own statements about safety and about acceptable risks.
- The EU Commission does not have the technical experts necessary to assess the safety of NPPs. The EU 27 nuclear regulators formed ENSREG, who provide technical guidance on nuclear safety. With the exception of the members nominated by countries without commercial nuclear power programmes, the ENSREG peer review teams[8] consisted mostly of employees of the nuclear authorities. It is not common practice or to be expected that colleagues would criticize each other within an official process which is additionally public in some parts.

Peer review process

- The complexity of data, of calculation methods, of assumptions about the safety parameters and their interdependence within the complex system of a NPP is extremely high. Despite the fact that a considerable effort was made, in terms of human and financial resources to analyse the safety of all NPPs of the EU-17 in the short time of about three month, taking into account the immense workload and the limited number of experienced experts able to review the assessments, it was not possible to perform a very well-founded peer review process.

[8] The Peer Review teams were composed of nuclear safety experts from EU Member States, Switzerland, Ukraine and the EU Commission, with observers from third countries (Croatia, Japan USA,) and the IAEA.

1.2.6 Conclusions

Considering the limited scope of the stress tests, the lack of defined assessment criteria, and the interests of the experts involved, the stress tests cannot confirm or guarantee safety of the plants in the EU or the other two states who fully participated, Switzerland and Ukraine. They will hardly fulfil the political intention, which was to demonstrate to the public that the plants are operating safely.

The outcomes of the stress tests consist only of recommendations for "further improvements". ENSREG stress tests did not assess the current safety level of the European nuclear power plants, but the potential increase of the safety level in the next decade.

Nevertheless the stress tests revealed a number of shortcomings regarding the plants´ capability to withstand several external hazards and the possible consequences of these events.

Until now ENSREG has not defined or even recommended any time schedule for implementation of the required measures or prioritization of these measures. ENSREG does not have a regulatory mandate. To define, require and monitor the implementation of safety improvements stays in the competence of the national regulatory authorities, who are members of ENSREG.

The most important phase of the stress test will start at the beginning of the year 2013. The national regulators agreed to develop national action plans to remedy the identified shortcomings by the end of 2012. No clarity was achieved yet on the question of how comprehensively the following peer review process will be conducted.

This might be seen as an opportunity to force the nuclear authorities to formulate mandatory requirements, which need to be fulfilled in a rather short time schedule; in contrast to the years or even decades usually applied. This could make operators decide to stop operation for economic reasons and shut down the NPP. In cases when NPPs with out-dated reactor design cannot reach an acceptable safety level and/or the probability of a natural hazard is relatively high, the operation time should be limited and safety upgrading measures implemented in a very strict time schedule. The regulators should not approve lifetime extensions.

Until now, ENSREG does not assess, but only describe the shortcomings of the NPPs. The country stress tests reports do not formulate any overall conclusions – not even if a specific NPP has shortcomings similar to those at Fukushima NPP [ENSREG 2012a]. However, this is insufficient to use as basis for deciding on the future of an NPP. A comprehensive assessment taking into account all facts is necessary for the politicians and the public to decide about the risk for people and environment.

Currently it seems that even the oldest plants with severe deficiencies in the defence-in depth concept will apply for life time extension. The stress tests do not provide sufficient information about the reliability of plant safety measures to prevent postulated failures of the safety systems; a second part is necessary to assess accident prevention capability. The WENRA safety objectives for new reactors can be applied as a minimal safety level for this assessment.

1.3 Cernavoda NPP (Romania)

In Romania, there is one nuclear power plant (Cernavoda NPP), which is located in Constanta county, about 2 km southeast of the Cernavoda town boundary, at 4 km southeast of Danube River and at about 1.5 km northeast from the first lock on the Danube-Black Sea Channel. Cernavoda NPP is owned and operated by the National Company Nuclearelectrica (Societatea Nationala Nuclearelectrica, SNN) [RNR 2011].

Cernavoda NPP has two pressurised heavy water reactors (PHWR) of CANDU 6 design. These are the only units in Europe based on the CANDU (CANadian Deuterium Uranium) technology. The plant project was initiated in the 1970s and was initially proposed to house five units. Construction began in 1980 on all the reactors, but this 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.[9] Unit 1 and 2 (650 MWe net capacity each) generated 10.8 TWh or 19 percent of Romania's electricity in 2011 [SCHNEIDER 2012].

The Romanian Government plans the completion of Cernavoda units 3 and 4. The project was started in 2007 and the works were estimated to start in 2010. But 2010/2011 four of six involved companies[10] withdrew from the project. The project was halted, as the government could not find other partners for the project [SCHNEIDER 2012]. In October 2012, Romania announced that the state is willing to bring the four companies back in the project under any form by the end of the year [RBN 2012].

The Romanian Regulator, the National Commission for Nuclear Activities Control (CNCAN), agreed that any potential design improvements resulting from the stress tests for the operating units will have to be implemented also in units 3 and 4. Their detailed design is not yet finalized [RNR 2011].

[9] Unit 2 was completed with foreign financial assistance (Canadian loan of US$146 million and a Euratom loan of US$324 million).

[10] CEZ (Czech Republic), RWE (Germany), Iberdrola (Spain) and GDF Suez (French-Belgium group) left, only Enel (Italy) and ArcelorMittal Romania did not withdraw. The Romanian ministry of economy, through Nuclearelectrica got to own 80% of the project company.

1.3.1 Weaknesses the Romanian Stress Tests Described

The following chapter is based on the information provided by the national stress tests report and the peer review country report of Romania [RNR 2011; RCR 2012].

Romania is one of the most active earthquake regions in Europe. Nevertheless, currently there are major shortcomings regarding earthquake:

- The calculation of the original Design Basis Earthquake (DBE) was based only on a deterministic assessment; in 2004 a Probabilistic Seismic Hazard Analysis (PSHA) was performed. However the value for the exceedance probability (return period) associated to the DBE is considerably lower than the current European practices. The value is 1/1,000 per year instead of 1/10,000 per year.
- The absence of a seismic level comparable to the SL-1 defined by IAEA[11] leading to plant shutdown and inspection is regarded as being a critical issue taking into account the fact that the probability of large earthquakes is extremely high (recurrence intervals for the Vrancea seismic zone: 50 years for MW > 7.4). The peer review team suggested to the regulator to adopt adequate regulations.
- The peer review team criticized that only little information about margins to cliff edge effects, weak points and plant behavior under beyond design earthquake was provided. The fact, that further improvements in the seismic upgrading have been not been considered was also a point of critic. The peer review team asked for further efforts in this area and recommended that the CNCAN obtains good quality programmes from the licensees and ensures proper follow-up.

The Cernavoda site grate is about two meters higher than the calculated Design Basis Flood DBF). According to the national report, the existing margins are considered as being adequate and no additional measures are required to protect the plant against ***external flooding***. However, the peer review team criticized that the margins for flooding have been assessed with limited identification of cliff edge effects and weak points. The peer review team pointed out that for a number of safety significant equipment located underground the protection against flooding needs to be improved. Furthermore, the peer review team criticized the lack of routine inspections of the flood protection design features.

The national report provides limited information about ***extreme weather conditions***. The peer review team pointed out, that there is no information about the plant capability beyond the design basis and also no identification of cliff edge effects and weak points. Thus, the plant resistance against extreme weather is still unknown.

Because ***Station Black-out*** (SBO) was not considered in the design basis of the units, there is no adequate protection against this kind of situations.

- In case of SBO, the dousing tank contains sufficient water for at least 23 hours to prevent core damage. During this time span, the operators have to

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[11] According to IAEA, for the design basis earthquake (DBE) two levels of ground motion hazard should be evaluated for each plant sited, 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].

restore the Emergency Power Supply (EPS) in order to start the Emergency Water Supply (EWS) pumps and ensure a long term heat sink. If the EPS cannot be recovered, the operator would use mobile DGs (autonomy for only 6 hours). If the EWS system is unavailable the fire water trucks would be used to provide water directly to the steam generators (SG) through the EWS pipes, but the location of the fire trucks is not qualified against extreme external events.

- However, in case SBO will be induced by an earthquake, fuel damage could occur after only 4 hours as a consequence of not being able to depressurize the SGs. To avoid this scenario operator action in less than 2 hours are necessary (manual opening of the Main Steam Safety Valves and in addition, in 2.5 to 3 hours, the mobile DGs have to be available to provide electrical power). The licensee is currently undertaking preparatory work to increase the seismic robustness of the batteries to prolong the coping time.
- In case SBO were to occur at certain points during the refuelling 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 be retained either within the pressure boundaries of the refuelling machine or in the worst case in the spent fuel discharge room which is part of the containment extension.)

Currently no regulatory requirements are in force on ***Severe Accident Management*** (SAM), the peer review team pointed out that CNCAN should finalize the incorporation such requirements in the regulation and also incorporate some qualitative or quantitative safety objectives related to the protection of the population.

The stress tests reveal the lack of a filtered venting system, the lack of passive autocatalytic recombiners (PAR) to prevent hydrogen explosions as well as the lack of instrumentation for severe accident (SA) condition (e.g. hydrogen concentration monitoring in different areas of the reactor building). Further necessary actions are planned, among others they include:

- A design modification for water make-up to the calandria vessel (completed for unit 2) and the calandria vault to ensure cooling of the fuel,
- Use of a new, seismically qualified, fire water pipe to allow water makeup without entering in the Spent Fuel Pool (SFP) area,
- A new seismically qualified building to host the on-site Emergency Control Centre fire fighter's facility and main intervention equipment,
- Assessment of the habitability of the main control room (MCR) in the case of a total core melt accident associated to a containment failure (or voluntary venting).

The peer review team noted the good progress in the implementation of SAMGs, associated with a significant number of hardware modifications during a short time period. However, the peer review team highlighted that the licensee has not examined, particularly for plant shutdown states, any possible weaknesses of the Cernavoda units in agreement with the stress test specifications. Furthermore, SAMGs for shutdown states have to be developed (they are under consideration) and the completeness of Emergency Operating Procedures (EOPs) for all accidental situations needs verification. This shows that not all weaknesses the stress tests should reveal are known yet.

1.3.2 Weaknesses the Romanian Stress Tests Ignored

- The design of the units 1 and 2 of Cernavoda NPP shows many shortcomings, among others [HIRSCH 2005; UBA 2007]:
- The core consists of many pressure tubes instead of being confined in a pressure vessel, this design precludes the possibility of massive pressure vessel failure, but the accompanying greater length, surface area and complexity of the primary system piping results in a greater risk of loss-of-coolant accidents. Additionally the possibility for on-load refueling introduces means by which loss-of-coolant can be initiated. The refueling machine is also the major pathway for releases of radioactive "hot particles" – particles that have broken off the fuel or other activated metal particles.
- 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. There have been problems 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. Hydride cracking and fretting were observed at the Cernavoda-1.
- The fuel used is natural uranium (i.e. not enriched), and heavy water serves as coolant and moderator. This combination has seriously negative safety implications. The void coefficient of reactivity is positive, so that any loss-of-coolant accident could lead to a power excursion (sudden rise of power). A loss-of-coolant with shut down failure (scram) will result in rapid melting of the fuel and possibly common mode breach of the containment.
- The large zirconium inventory of the CANDU could react exothermically with steam during a severe accident. This reaction produces hydrogen, which is a threat for the containment stability, because it reacts explosively with air in the containment.
- The reactor building has a pre-stressed concrete structure (diameter 41.46 m with a cylindrical perimeter wall of only 1.07 m thickness). It is seismically qualified, but external threats as natural disasters, airplane crash and other human impacts as terrorism and sabotage are not considered in the design.
- The CANDU 6 reactor has a containment consisting of a concrete dome, which is not designed to withstand worst case accidents, for example hydrogen detonations. Furthermore, the CANDU containment is not a passive system, as most PWRs are equipped with (e.g. ventilation dampers and dousing system need power).
- Spent Fuel Pool ("bay") is located outside the containment, which could result in a major release of radioactive substances in case of an accident.

Several design weaknesses of the reactor, which the stress tests did cover, cannot be remedied. Not surprisingly the owner of the Canadian CANDU 6 reactor Gentilly-2 (Hydro-Quebec's) recently decided to close its reactor after the planned operation time of 30 years and explained that the decision was made for financial reasons, because major problems were encountered in comparable refurbishment projects at CANDU 6 reactors[12] and also the Fukushima accident in March 2011 contributed to concerns about lifetime extension [NW 2012a].

[12] Point Lepreau PP (Canada) and Wolsong NPP (South Korea)

1.3.3 Conclusions

The main findings of the stress tests show that seismic risk, flooding and Severe Accident Management are not sufficiently addressed and the Romanian Regulator seems not to insist on adequate responses.

The protection of the Cernavoda NPP against seismic impacts is inadequate, although earthquakes have to be expected at the site. This is a serious deficit, particularly regarding the fact that for a seismically induced Station Black-out (SBO) a situation occurs, when four hours only need to suffice to prevent a core melt accident. Four hours is not enough time to guarantee that the necessary manual actions can be conducted under the conditions after a severe earthquake. This situation is even aggravated by the fact that appropriate measures to assure containment integrity during a severe accident are lacking; this amounts to a relatively high risk of a core melt accident with major radioactive releases.

On the issue of external flooding the operator missed the opportunity to investigate and if necessary improve the protection as did the regulator. The stress tests revealed that plant resistance against earthquakes is too weak and that flood protection is insufficient.

Regarding Severe Accident Management (SAM), the operator has not examined all possible weaknesses of the Cernavoda units in line with the stress tests specifications, i.e. not all weaknesses the stress tests should examine were assessed. This approach shows that both operator and regulator are not trying to understand the full range of risks and threats to the NPP. This is mirrored by the lack of qualitative or quantitative safety objectives related to the protection for the population in the regulatory requirements.

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 are outdated. Several design weaknesses of the reactor – original design not being covered by the stress tests in general, cannot be remedied (e.g. wall thickness of reactor building and location of Spent Fuel Pools).

Overall conclusion shows the risk of a severe accident with major release to the environment being unjustifiably high: Cernavoda units 1 and 2 need to stop operation immediately – at least until comprehensive backfitting measures will have been completed.

1.4 Kozloduy NPP (Bulgaria)

In Bulgaria, there is one nuclear power plant (KOZLODUY NPP), which is located in the north-west of Bulgaria on the right bank of the River Danube, 5 km to the east of the town of Kozloduy and 200 km to the north of Sofia [BNR 2011]. The NPP is operated by Kozloduy NPP-Plc. In 2011, this NPP provided 15.3 TWh or 32.6 percent of the Bulgarian's electricity [SCHNEIDER 2012].

Today, Kozloduy 5 and 6, two WWER-1000/V-320 reactors with a net capacity of 953 MW each are in operation. The first grid connection of these reactors was 1987 (unit 5) and 1991 (unit 6) respectively. Kozloduy NPP previously operated also four older reactors of the WWER-440/V230 design, but under an agreement between the European Commission and the Bulgarian government, units 1 and 2 were taken off-line at the beginning of 2004; units 3 and 4 at the end of 2006 [BNR 2011].

Currently, a feasibility study on a potential seventh unit at Kozloduy NPP is performed by Westinghouse in partnership with the Kozloduy NPP – New Build PLC. This study will encompass a review of two potential designs: a WWER design utilizing equipment already purchased by the customer (for the abandoned Belene project)[13] or a construction of a 1000 –1200 MW PWR design [NEI 2012a].

The Bulgarian Nuclear Regulatory Authority (BNRA) has published the National stress tests report.

1.4.1 Weaknesses the Bulgarian Stress Tests Described

The following chapter is based on the information provided on the national report stress tests report and the peer review country report of Bulgaria [BCR 2012; BNR 2011].

The evaluation of the seismic characteristics of the Design Basis Earthquake (DBE)[14], confirmed by IAEA during the period 1992 – 2008, is widely acceptable in comparison with international standards; however adequate paleo-seismological studies are missing. The peer review team recommended performing such studies to evaluate the need of re-assessment of the seismic hazard on site.

A considerable amount of work has been done to protect the units against DBE, but the qualification or replacement of equipment is not completely finished. Important modifications to the plant have been implemented, especially concerning the heat sink and the implementation of an alternative feedwater pump, powered by the mobile Emergency Diesel Generator (EDG). But the peer review revealed that the sheltering structure of the EDG will be probably destroyed in case of earthquake, which could also damage the EDG.

[13] Construction of a reactor at the Belene site began in 1985 but was suspended following the political changes in 1989 and formally stopped in 1992, partly due to concerns about the geological stability of the site. However, in 2004, a call for tender for completion was made and seven companies initially expressed an interest. After Fukushima, the Bulgarian Economy Minister stated that Bulgaria would request additional information and guarantees from the manufacturer. In March 2012, the Prime Minister officially cancelled the project [SCHNEIDER 2012].

[14] recurrence period of 10,000 years, peak ground acceleration (PGA) of 0.2g

The assessment of the impact of potential failures of not seismically qualified Structures, Systems and Components (SSC) showed deficiencies. A complementary action plan including studies and modifications was developed. The action plan suggests delivering two additional mobile generators. The peer review team pointed out that if these mobile generators are supposed to cope with beyond design basis events, they should be adequately protected for such events.

The site is located in the northern part of the first non-flooded terrace of the river Danube and has average height of the site elevation about 2 m above the calculated water level of the Design Basis Flood (DBF). There is no risk of flooding the rooms where the safety equipment is installed. Nonetheless the scenarios for beyond ***Design Basis Flood*** showed that some locations could be flooded. The peer review team recommended that regulator should monitor the back-fitting measures for beyond design basis conditions identified in the action plan (such as improvement of the leak tightness of certain rooms below ground level and modification of the drain and sewage system).

Extreme weather effects were not sufficiently evaluated, because the operator did not take all possible combinations of extreme weather conditions into consideration. Thus, the regulator BNRA required a review of extreme weather hazards in line with IAEA guidance. The peer review team criticized furthermore the lack of an extreme weather monitoring and alert system with adequate operating procedures.

According to the peer review team, the so-called coping times for most cases of ***SBO and UHS situations*** are sufficient to implement measures to prevent a severe accident, and if not successful or possible, to implement measures to mitigate the consequences of a severe accident with major radioactive release. However, the peer review team pointed out that several vulnerabilities were identified which require further attention. These are linked to SBO situations and concern the heat removal from the reactor, shortly after shut down (coping time only 7.5 hours) as well as from the Spent Fuel Pool (coping time 17 hours). Envisaged backfitting measures are, among others, the delivery of two new mobile DGs.

The implementation process of the WENRA Reference Levels regarding ***Severe Accident Management*** (SAM) is under way, but not yet fully completed. Furthermore, the stress tests revealed the need for a lot of additional improvements. The "Program for Implementation of Recommendations Following the Stress Tests Carried Out on Nuclear Facilities at Kozloduy NPP plc" covers these measures. Among them:

- Development of technical means for direct water supply to the steam generators (SG), Spent Fuel Pools (SFPs) and the containment using mobile fire equipment;
- Installation of additional hydrogen recombiners in the containment[15];
- Closing the ionizing chamber channels located in the walls of the reactor cavity (see below);
- Study of the options for localizing the molten core in case of a severe accident;

[15] The installed PARs were designed for DBA, but there is no prove they can mitigate hydrogen explosion risks in severe accidents.

- Updating on-site and off-site emergency plans, taking into account that the Emergency Control Rooms (ECR) might be inaccessible; and providing alternative routes for evacuation, transport of fuels and materials and access of staff;
- Implementation of Emergency Operation Procedures (EOPs) for the shutdown states;
- Implementation of Severe Accident Management guidelines (SAMGs);
- Development and implementation of the SAMGs for Spent Fuel Pools (SFPs);
- Installation of instrumentation for monitoring severe accident conditions.

The peer review team pointed out, that it is an open issue under which conditions implementation of the different SAM measures is feasible, e.g. due to possible lack of some hardware provisions. Additionally, the peer review team recommended that the above mentioned program should be monitored and regularly updated to guarantee co-ordination of all activities and their timely completion.

The peer review team assessed the envisaged program the Bulgarian regulator required the operator to implement as being insufficient. The peer review team pointed out that more measures are necessary within the framework of this program, for example:

- Considerations and analyses for mitigation of hydrogen risk; and prevention of basemat melt through (see below) should be pursued with high priority;
- Accidents in Spent Fuel Pools (SFP) should be analysed in detail;
- Simultaneous core melt accidents in both units should be further investigated;
- SAMGs fully covering shutdown states, including those with open reactor, should be developed;
- The issue of the management of large volume of liquid releases in the event of a severe accident should be investigated further.

1.4.2 Weaknesses the Bulgarian Stress Tests Ignored

Design weaknesses

Important design weaknesses of Kozloduy 5 and 6 are:

- The WWER-1000/V320 is fitted with a full-pressure single containment; however, it has a basic shortcoming not encountered in western PWRs. The lower containment boundary (containment basemat) is not in contact with the ground, but is located at a higher level inside the reactor building. In case of a severe accident, melt-through can occur within approx. 48 hours. The containment atmosphere will then blow down into parts of the reactor building that are not leak-tight resulting in high radioactive releases. The reactor building – including the Main and Emergency Control Rooms – will have to be abandoned [HIRSCH 2005].
- The plant layout has weaknesses that make the redundant safety systems vulnerable to hazardous systems interactions and common-cause failures due to fires or internal floods [HIRSCH 2005].

An analysis performed as part of a European Union pre-accession instrument (PHARE project) Kozloduy 5 and 6 discovered a vulnerability of the design consisting of very early (one-hour) containment melt-through via ionization chamber channels situated around the reactor pit. According to a recently published article [NEI 2012b] a technical solution was developed. However, implementation of the improvements usually takes several years.

INES 2 incident at unit 5 [NIRS 2006]

On March 1, 2006, the function a considerable amount of control rods failed at unit 5. The operator had tried to activate one cluster of regulation rods to reduce the reactor's capacity by 30% after one of its four main cooling pumps became disconnected. Of the six rods in the cluster, three remained in place. In order to shut down the reactor, workers pumped boric acid in. After the reactor was stabilized, the remaining nine clusters were tested by carrying out an emergency shutdown resulting in a total 22 of the 60 regulation rods remaining stuck in the highest position. This means, that in the case of an emergency shutdown with loss of cooling water, it would not have been possible to stop the reactor quickly, which could have led to core meltdown.

This situation occurred after the Russian maintenance company Gidropress made changes to the fuel lay-out during one of the safety upgrades at Kozloduy 5 in the summer of 2005; the upgrade programme was partially funded by Euratom.

Not only the incident itself and the cause of it, but also the handling of the incident raised relevant safety concerns. Following the incident Kozloduy 5 remained off-line for ten days, the incident was rated as INES[16] 0 ("no safety significance") by the operator. Almost two months later whistleblowers from the NPP leaked the details of the incident to their former chief. He informed the German press, and Bulgaria became aware of the real circumstances behind the incident. The director of the Kozloduy NPP accused the Bulgarian press of being un-patriotic for quoting

[16] International Nuclear Event Scale

information on the incident from the German press and showed no understanding of the safety culture, which should be applied an NPP.[17]

The Bulgarian Nuclear Regulation Agency (BNRA) immediately reacted to the revelations by upgrading the incident rating to INES 1 ("abnormally"). However, later the incident was upgraded to INES 2 ("incident").

Power uprate and lifetime extension

In January 2012, the operator of Kozloduy NPP has notified the Bulgarian Nuclear Regulatory Agency (NRA) about the intended ***power uprate*** of units 5 and 6 by a combined 120 MWe (gross). According to NRA, the new license could be given to the plant by the end of 2013, provided that all the necessary documents would be supplied in time [WNN 2012a].

Power uprating, which is often combined with life time extension, is an option to increase the profitability of a NPP. Increasing the thermal power of the reactor, usually by increasing coolant temperature, results in the production of more steam. Thus the reactor can produce more electricity via the turbines. An increase of thermal power implies more nuclear fissions and more fission products as a result. Also, higher loads to the reactor systems are unavoidable. Safety margins are reduced and at the same time ageing processes are accelerated.

An IAEA report highlighted the negative safety effects of power uprates: Because changing the thermal power affects very high number of systems and analyses, there are numerous "opportunities" to overlook potential problems. Experiences have shown that an increased flow will have an impact on flow-induced vibration in the steam/feedwater lines; non-linear effects might occur. Higher excitation/vibration of steam lines leads to accelerated wear of supporting structures and studs. Higher steam flows can also result in valves not performing as they did before the power uprate. Effects on electrical components may sometimes be neglected or overlooked because of lack of knowledge or incorrect assumptions. The US nuclear power industry, for example, has experienced over 60 events related to power uprates between 1997 and 2010 [IAEA 2011].

All in all, power uprates caused unexpected failures in safety systems that could aggravate accident situations. Power uprates would also accelerate an accident sequence, which could lead to a further decrease of the intervention time (coping times). Furthermore, in case of a severe accident, the potential radioactive release will be higher.

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, particularly if lifetime extension for additional 20 years will be approved.

The units are currently licensed to operate until 2017 and 2019, but there are plans to extend their operating ***lifetimes*** beyond the current 30 years to 50 years. This was initiated in April 2012 when the operator signed a contract with a consortium of Rosenergoatom and EDF to investigate this issue [WNA 2012].

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[17] e.g."Things like this happen every day in the power station"

1.4.3 Conclusions

At units Kozloduy 5 and 6 earthquake protection is insufficient, further assessment and back-fitting is needed. The stress tests also revealed dangerous sloppiness in this field: Emergency Diesel Generators (EDGs) necessary to prevent a core melt accident after a Design Basis Earthquake (DBE) are stored in a not earthquake resistance shelter. Appropriate seismic margins do not exist. The first step of the envisaged back-fitting measure is the delivery of two new mobile diesel generators (DG) which obviously will be stored inadequately as well.

Operator and regulator are not fully responding to the threat of an earthquake or to the (increasing) threat of flooding or the possible negative effects of extreme weather events. To summarize: currently natural hazards, particularly earthquakes can cause a severe accident at both units.

Appropriate Severe Accident Management (SAM) provisions do not exist. Even as a result of the stress tests, a lot of necessary measures are envisaged. According to the peer review team it remains open whether the different measures are feasible. The peer review team also criticizes that the envisaged programme is insufficient. Moreover, the containment of the reactor type (WWER-1000/V320) shows design weaknesses that can be remedied only with great difficulty or not at all.

The incident in 2006 caused by the control rods of unit 5 proves that backfitting measures can result in new safety problems. This is an important issue regarding the need of comprehensive backfitting measures. The incident also proved that in the past the safety culture at Kozloduy NPP was not strong enough; obviously this has not been changed sufficiently as the example of storing the EDGs proves.

Moreover, the operator is planning to uprate the power and to extend the life time of the units. These measures will lead to a further increase of the risk those units pose.

Operation of Kozloduy 5 and 6 should be halted – at least until the necessary protection against earthquakes and Severe Accident Management provisions were implemented. Neither power uprate nor lifetime extension can be performed without causing an unacceptably high nuclear risk. On the contrary: we recommend reducing power output and shutting down the reactors soon.

1.5 Paks NPP (Hungary)

In Hungary one NPP (Paks NPP) is in operation. It is located 5 km south of the city centre of Paks, 114 km south of Budapest and 1 km west of the River Danube. Paks NPP comprises four units of WWER-440/V-213 reactors. The four units are placed in two building structures in a twin arrangement. The first grid connection of unit 1 and 2 was in 1982, unit 3 and 4 followed in 1984 and 1986 (473 MWe). After modifications being implemented on the secondary circuit in the nineties, and on the primary circuit and on the fuel on the first decade of the century, the net capacity of the four units is 500 MWe each. In 2011, the Paks NPP provided 14.7 TWh or 43.2 percent of Hungary's electricity [HAEA 2011; SCHNEIDER 2012].

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 Villamos Művek, MVM). The Hungarian Atomic Energy Authority (HAEA) published the national stress tests report [HAEA 2011; SCHNEIDER 2012].

1.5.1 Weaknesses the Hungarian Stress Tests Described

The following chapter is based on the information the national stress tests report and the peer review country report of Hungary provided [HNR 2011; HCR 2012].

The plant has not been originally designed to withstand ***earthquake*** loads, but a large number of important reinforcement and qualification measures were implemented, thus the plant complies with the current seismic safety requirements. However during the stress tests, some weaknesses were identified. Additional protection against seismic induced fire and internal flooding as well as upgrading or fixing of Structures, Systems and Components (SSCs) are necessary.

The filter structures of the Essential Service Water System (ESWS) are not seismically resilient, so it is possible that heat removal fail in case of DBE. The regulator required investigations of this issue and a review of the database of the seismic safety classification of components after having come discovered mistakes. A quantitative assessment revealed only narrow seismic safety margins. Therefore measures are necessary to prevent failures of underground line structures and connections due to buildings settlement caused by liquefaction. The peer review team highlighted the importance of the planned measures and recommended the regulator to monitor the implementation.

The level of the Design Basis Flood (DBF) of the Danube River is above the level of the machine room, which houses the Essential Service Water Pumps[18]. Thus, it is necessary to seal the penetrations of the machine room wall. If the ESWS get lost, the function of the EDGs, the Emergency Core Cooling and the Spent Fuel Cooling is jeopardized.

The vulnerability of structures with respect to beyond design basis loads has been assessed and evaluated, however, the National stress tests report does not contain specific information about the numerical values of the safety margins of the

[18] In emergency situations, the Essential Service Water System (ESWS) supplies Emergency Diesel Generators (EDG), Emergency Core Cooling System (ECCS) and cooling of the Spent Fuel Pool (SFP) with cooling water; however the fire water system can also provide cooling water.

extreme weather conditions parameters. In this context, the peer review team stated special attention should be paid to the rain drainage system in case of extreme precipitation and snowmelt. Backfitting measures are already identified. The peer review team suggested to the regulator to monitor the implementation of specific measures for strengthening the protection (e.g. against lightning).

The total loss of Electric Power Supply, Station Black-out (SBO) is always connected with the loss of Ultimate Heat Sink (UHS). If the Ultimate Heat Sink (UHS) is unavailable, the secondary feed & bleed via steam generator (SG) may be initiated. In case of SBO occurring during operation at normal power, without any countermeasures the steam generators dry-up within 4.5 hours, the heat removal gets lost and core damage may occur in about 10 hours after the loss of power.

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

In the case of SBO, mobile severe accident diesel generators are available, but their capability is limited thus it is decided to supply additional, diverse diesel generators to manage accident situations. A lot of further measures have been envisaged, among others:

- The equipment necessary for the cooling water supply to at least one Emergency Diesel Generator (EDG) of each unit from the fire water system have to be available; so as the EDG can be started and operated in case of loss of the essential service water.
- The water make-up to the SFP from an external source has to be made possible by the construction of a supply pipeline having adequate design against external hazards.

According to the peer review team, the deficiencies identified are covered by proposed improvement measures. The peer review team also stated that the proposed possibility of using discharge water canal for water intake of fire water pumps, which could in turn supply Essential Service Water System, might lead to loss of separation. Before the implementation, separation issues should be investigated carefully.

At the time of construction of the Paks NPP no regulatory requirements existed for Beyond Design Basis Accidents (DBDA). The program on development and implementation of hardware measures for ***Severe Accident Management*** and of SAMGs started before the Fukushima accident. In 2011 it was completed on unit 1, units 2 – 4 will be completed by 2014. HAEA requires that the modifications necessary for the management of severe accidents shall be completed prior to the expiry of the original design lifetime (30 years) for each unit.

The peer review team stated that in general, the stress tests review did not identify major weak points for SAM. This statement is only true compared to the shortcomings discovered at reactors in other countries, particularly Ukraine. The Paks units are not equipped with a filtered containment venting system. HAEA required that suitable measures to prevent over-pressurization of the containment have to be developed and implemented to avoid the release of radioactive material to the environment; this should be realized with filtered venting or additional measures for internal containment cooling. HAEA stated that the envisaged specific long term internal containment cooling that is envisaged by the operator is only considered to be adequate in the case of a successful in vessel retention of the molten core.

Regarding SAM, HAEA requires the operator to conduct following studies and measures in reaction to the stress tests:

- Water supply with (boron concentration) to the SFP from an external source has to be made possible by pipeline having adequate design against external hazards, with additional connection from outside.
- The on-site organization and management of events, especially of multi-unit accidents, including severe damage to the infrastructure has to be improved.
- The SAMGs have to be developed to manage simultaneous accidents in the reactor and Spent Fuel Pool (SFP).
- Analyses have to be carried out in order to avoid hydrogen explosion in the reactor hall during severe accidents that simultaneously affect both units in the common reactor building.
- Liquid radioactive waste management procedures have to be developed for severe accident situations.

1.5.2 Weaknesses the Hungarian Stress Tests Ignored

Design weaknesses and vulnerability against external hazards

The WWER-440/V213 is a second-generation WWER of Russian design with six primary cooling loops. This reactor type is not equipped with a full-pressure containment. The so-called confinement consists of compartments, which enclose the essential primary circuit components: steam generator, pipelines, pumps, shut off valves and Reactor Pressure Vessel. But the confinement itself does not guarantee to hold back the radioactive steam from large leaks, but needs to condense the steam in the special pressure relief system (Bubbler Condenser). A failure of the relief system can cause the confinement to burst and result in a major emission of radioactive material. In recent years studies on the behaviour during severe accidents were commenced. Safety analyses showed that the confinement and in particular the Bubbler Condenser have very low or even no safety margins under certain conditions [WENISCH 2012a].

The vulnerability of the Paks NPP against external hazards is relative high: The reactor building does not provide sufficient protection against external impacts like airplane crashes or explosions, but houses two reactors. WWER-440 plants are twin units, located in a common reactor building. Furthermore, the Spent Fuel Pool (SFP) is located outside the containment in the reactor building. An airplane crash could cause a severe accident with a large radioactive emission: the worst case could even lead to releases from two cores and molten fuel from two Spent Fuel Pools.

Lifetime extension and power uprate

The original design lifetime of the reactor type (WWER-440/V213) is 30 years, thus the four units of Paks NPP reach the end of their operating lifetimes between 2012 and 2017. However, a feasibility study on extending the operational lifetimes of the units by 20 years was carried out in 2000 (and updated in 2005). The Hungarian Atomic Energy Authority (HAEA) has approved the lifetime extension program (submitted in November 2008). Additionally, between 2002 and 2009, the thermal capacity of the units were uprated to 108% (1485 MWth), compared to the original value (1375 MWth), resulting in upgrading the electric capacity to 500 MWe. A contract signed in May 2007 with Atomstroyexport relates to this work, in particular: new design fuel assemblies, modernization of the in-core monitoring system, the reconstruction of the primary pressure control system, and the modification of the turbine and the turbine control system [WNA 2012b]. Ageing is an issue at all units of Paks NPP, which are now near the end of their design operation time. In addition, the power uprates accelerate 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.

Serious incident at Paks 2 (2003)

In April 2003, at Paks 2 a severe damage to a batch of 30 fuel assemblies occurred inside a cleaning tank designed, manufactured and operated by Framatome. The event was rated on the International Nuclear Event Scale (INES) as a "serious incident" (INES Level 3). It resulted in evacuation of the main reactor hall and the venting of radioactivity to the outside environment. The accident was caused by inadequate cooling of the fuel rods during maintenance and cleaning, leading to their overheating and to their damage. The reactor was out of operation for 18 months. According to the Hungarian Atomic Energy Authority (HAEA) problems associated with organization and safety culture contributed to the fuel leakage event. An International Atomic Energy Agency (IAEA) mission requested by the Hungarian government to provide an independent assessment concluded that operator, vendor (Framatome ANP) and regulator shared responsibility for the fuel cleaning incident. On regulatory oversight, the IAEA team said the HAEA underestimated the safety significance of the proposed designs for the fuel cleaning system, which resulted in a less than rigorous assessment than was necessary. On the fuel cleaning operation in the course of the incident, the team found that the contractor worked without proper supervision of Paks personnel, who did not receive adequate safety training for this operation [NEI 2003a, b; SCHNEIDER 2012].

At the beginning of 2007 the Russian company TVEL removed the damaged fuel and the cleaning tank. Fuel debris was put into purpose-built containers. The containers are allowed to be stored in the cooling pond of the reactor; the long term handling of those containers is far from being solved.

1.5.3 Conclusions

The stress tests for the only NPP in Hungary, with four units at Paks, revealed on the key issues of seismic hazard, flooding and extreme weather conditions and the existing safety margins certain deficits.

While it remains a fact, that Paks NPP underwent comprehensive reinforcement and qualification programs, still upgrading or fixing of Structures, Systems and Components (SSCs) will be necessary in response to the insufficient protection against seismic hazards: the quantitative assessment proved that current safety margins are too small to guarantee sufficient resilience against earthquakes. Further investigations are necessary to assess the situation.

The stress tests found, that extreme precipitation and snowmelt could also jeopardize the units because they could flood parts of the units. The peer review team recommended to commission additional investigations to be able to assess additional back-fitting needs.

Loss of electrical power supply and heat removal triggered by an external hazard during operation of normal power – if countermeasures cannot be taken in time – result in core damage after approx. 10 hours; damage of the fuel in the Spent Fuel Pools starts after about 19 hours.

The EU stress tests devoted gave attention to the question of accidents and how the individual plants are prepared to deal with severe accidents in particular. At Paks the implementation of hardware measures for Severe Accident Management (SAM) and Severe Accident Management Guidelines SAMG had started before the Fukushima accident happened. This program was completed for unit 1 in 2011, and will be completed for units 2 – 4 by 2014. HAEA requires that these modifications will be implemented prior to the expiry of the original design lifetime of 30 years. However as a reaction of the stress tests, regarding SAM, the regulator HAEA requires further studies and measures, especially regarding multi-unit events and Spent Fuel Pools, to remedy deficiencies that the stress tests revealed. The topics to be resolved concern e.g. water supply with boron concentration to the SFP, multi-unit accidents, prevention of hydrogen explosion etc.

A serious deficit of Paks NPP is the fact that the Paks units are not equipped with a filtered containment venting system to mitigate the amount of radioactive emissions caused by long term containment over-pressurization; implementation of these systems is not planned. Instead Paks management intends to introduce internal containment cooling. This measure is only adequate if reliable in-vessel retention can be guaranteed, but this is not completely proven yet.

To remedy all design weaknesses of the outdated second generation reactors (WWER 440/V213) is not possible, in particular wall thickness of the reactor building and location of the Spent Fuel Pool. 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.

At this point it is important to understand that the stress tests did not assess design, siting and the highly safety relevant issue of ageing of all plant components. This will become an increasingly serious issue for all units. All four units are supposed to be in operation for additional 20 years. The combination of design weaknesses, ageing impacts and the recently recognized additional safety 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 not be licensed for prolonged operation and be shut-down soon instead.

1.6 Khmelnitsky, Rovno, South Ukrainian and Zaporizka NPP (Ukraine)

In the Ukraine all 15 operating reactors are WWERs (Water-Water Energetic/Pressurized Water Reactors). These reactors provided 84.9 TWh or 47.2 percent of the electricity consumed in the Ukraine in 2011. All units are operated by NNEGC (National Nuclear Energy Generating Company) known as "Energoatom" at four sites (see table 1) [SCHNEIDER 2012; UNR 2011].

The ***Khmelnitsky NPP*** (KhNPP) with two operating reactors (WWER-1000) is located in Slavuta area of Khmelnitsky region, near a tributary to the Pripyat River. The first unit started operation in late 1987. Construction of units 2 – 4 was halted as part of a moratorium on new plant construction in 1990. However, in August 2004 the construction of unit 2 was completed after the moratorium had been lifted. On 10 February 2011, Energoatom and Atomstroyexport signed a contract for the completion of units 3 and 4, which were 75% and 28% complete, respectively [SCHNEIDER 2012; UNR 2011]. On 26 July, 2012 Ukraine's cabinet of ministers published its approval of a feasibility study for the completion of construction of the units. The units are expected to be commissioned in 2017 and 2019, respectively [NW 2012b].

The ***Rovno NPP*** (RNPP) is located in Rovno region on the bank of the river Styr. Four units (two WWERs-440/V213 and two WWERs-1000) are operating at the site. In December 2010, the operating license of Rovno-1 and -2, Ukraine's oldest operating reactors (30 years), were extended for another 20 years.

The ***South Ukrainian NPP*** (SUNPP) is located in the south of Ukraine on the river Yuzhny Bug in Nikolayev region, about 350 kilometers south of Kiev. The NPP comprises three WWER-1000 units.

The ***Zaporizka NPP*** (ZNPP) is situated in the south-eastern part of Ukraine on the bank of Kakhovka reservoir on the Dnieper River. With six operating WWER-1000 units it is the largest NPP in Europe. The first five units were successively brought online between 1985 and 1989, and the sixth was added in 1995 [SCHNEIDER 2012; UNR 2011].

Table 1: Operating reactors in Ukraine (October 2012)

Reactor unit	Reactor Type	Net capacity	First grid connection	Design lifetime (expiry date)
Khmelnitsky 1	WWER-1000/V-320	950	1987	2017
Khmelnitsky 2	WWER-1000/V-320	950	2004	2034
Rivne 1	WWER-440/V-213	381	1980	2010* ext. 2030
Rivne 2	WWER-440/V-213	376	1981	2011* ext 2030
Rivne 3	WWER-1000/V-320	950	1986	2016
Rivne 4	WWER-1000/V-320	950	2004	2034
South	WWER-1000/V-302	950	1982	2012
South	WWER-1000/V-338	950	1985	2015
South	WWER-1000/V-320	950	1989	2019
Zaporizka 1	WWER-1000/V-320	950	1984	2014
Zaporizka 2	WWER-1000/V-320	950	1985	2015
Zaporizka 3	WWER-1000/V-320	950	1986	2016
Zaporizka 4	WWER-1000/V-320	950	1987	2017
Zaporizka 5	WWER-1000/V-320	950	1989	2019
Zaporizka 6	WWER-1000/V-320	950	1995	2025

The stress tests report also included the fifth NPP in Ukraine, the Chernobyl NPP. The site is situated in the north of the Kyiv region in the 30 km exclusion zone that was established after the accident at unit 4 in 1986. Units 1 – 3 are under decommissioning, the stress tests did not cover the destroyed unit 4.

It is out of the scope of this study to assess all 15 operating units individually.

The State Nuclear Regulatory Inspectorate of Ukraine (SNRIU) prepared the national stress tests report.

1.6.1 Weaknesses the Ukrainian Stress Tests Described

The following chapter is summarizing the key information the peer review country report and the national report of Ukraine provided on the nuclear safety in the Ukraine [UNR 2011; UCR 2012].

The peer review team stated that the 'design safety assessment' of Ukrainian NPPs shows that these NPPs are to be compliant with only 172 of 194 requirements of IAEA NS-R-1 'Safety of Nuclear Power Plants: Design'. Issues that were found to be not fully compliant included: equipment qualification, consideration of severe accidents, NPP seismic resistance, completeness of probabilistic and deterministic safety analysis, and post-accident monitoring.

Implementation of necessary improvements is on-going under the recently adopted Upgrade Package (e.g. Comprehensive (Integrated) Safety Improvement Program for Ukrainian NPPs (C(I)SIP)). Scheduled completion of the main improvements is 2012 – 2017. According to the peer review team these non-full compliances represent a significant weakness of Ukrainian NPPs in the context of the stress tests. The peer review team recommended that the national regulator gives priority to achieving or enhancing this schedule. The peer review pointed out that this should include due consideration of the parallel needs arising from envisaged long term operation. Addressing most of these issues forms a part of the licensing basis for lifetime extension.[19]

Measures identified from the lessons of the Fukushima accident and the ENSREG stress tests review have been incorporated into the "Comprehensive (Integrated) Safety Improvement Program for Ukrainian NPPs" (C(I)SIP)[20] updated in 2011/2012 by the operator and approved by the regulator.

Re-assessment of the ***seismic hazard*** has been carried out between 1999 and 2010. The recently accepted design basis of 0.1g (0.12g SUNPP) is in compliance with the IAEA recommendation for the minimum PGA. However, the seismic evaluations for some parts of the equipment, piping, buildings and structures important to safety are not yet completed. Some additional seismic safety upgrading measures are envisaged, but not implemented yet. Furthermore, additional seismic investigations of NPP sites are necessary. A seismic PSA for all NPPs still needs to be developed. Currently, no NPP has a seismic monitoring systems installed.

The peer review team criticized that the regulator confirmed that the robustness of the main equipment and piping essential for safety functions has been proven against design basis seismic impacts while many assessments and investigations still need to be performed. Furthermore, the peer review team pointed out that the National Report the National Report did not provide a satisfactory justification on the sufficiency of overall safety margins.

The peer review team recommended that the regulator should monitor in a systematic way the implementation of the upgrading measures in order to assure timely completion as a part of the (C(I)SIP).

Regarding ***external flooding hazards***, the stress tests evaluations did not identify any cliff edge effects yet. But the safety margins evaluation reveals weaknesses for the Zaporizka NPP, which is most likely to be affected by impacts of the combination of upstream dam (Kakhovka Hydroelectric Plant) breaking caused by an earthquake and followed by a flood. Measures against possible flooding of the reactor building have been implemented; however, additional detailed analyses of possible loss of Ultimate Heat Sink (UHS) still need to be performed.

Regarding **extreme weather events**, special attention should be paid for defining vulnerability in case of beyond design basis tornado. Tornado strikes can potentially result in a failure of spray ponds of the Essential Service Water System (ESWS) due to its impact on the open water surface. Loss of ESWS can cause failure of Emergency Power Supply (EPS) from Emergency Diesel Generators (EDGs). The peer review team agreed on the recommendation that the regulator should monitor additional analysis of this threat. The peer review team also pointed out that the issue of power plant staff being able to reach all NPP sites under severe weather conditions needs to be answered. Furthermore safety margins with respect to

[19] Robustness of safety equipment at 0.1g/0.12g, performance of main safety functions in 'harsh' environments, containment venting for WWER-1000, measures to ensure Steam Generator (SG) and Spent Fuel Pool (SFP) make-up under Station Blackout (SBO) and loss of UHS.

[20] Upon results of deterministic and probabilistic safety assessments (within the Safety Analysis Report, SAR) the (C(I)SIP) was developed. On 30 November 2010, the SNRIU and the Ministry of Energy and Coal Industry of Ukraine approved this Program.

extreme wind and extreme snow are not evaluated yet, thus the possible threat of these extreme events is not known.

In case of loss of off-site power, power is supplied from Emergency Diesel Generators (EDG) and batteries. In case of also all EDGs fail, decay heat removal function is not performed. Currently, reliable measures to prevent core damage do not exist.[21] Without operator actions, loss of the primary coolant and uncovering and damage of fuel would result. The minimum time available to prevent core damage after Station Black-out (SBO) and loss of heat removal to the ***UHS*** occurred without operator actions are (assuming power operation before the initiating event started): only 3.5 – 4 hours for type WWER-1000 and 10 hours for type WWER-440/V-213. The time available until the fuel stored at the Spent Fuel Pool (SFP) heats up and reaches temperatures above the design limits are 6.5 hours for type WWER-1000/V302, V338, 7.5 hours for type WWER-1000/V320 and 16 hours[22] for type WWER-440/V-213.

The operator plans the modernisation of I&C and DC[23] power supply within the C(I)SP, which increases the discharge time of batteries (1 hour to 8 hours) and thus prolong the coping times. The peer review team pointed out that the national regulator should ensure that these measures are implemented on schedule. The operator is investigating to improve makeup possibilities to primary circuit, to the steam generators (SGs) and to the spent fuel ponds (SFP) via so-called Mobile Diesel Generator and Pumping Units (MDGPUs). However, the deployment of the (MDGPUs) requires more detailed analyses. The peer review team highlighted that the regulator should monitor the resolution of this proposal.

Currently, neither Severe Accident Management Guidelines (SAMGs)[24] nor hardware provisions for SAM have been implemented (e.g. for prevention of hydrogen explosions). Work on SAM has been started in 2005 – 2008 and it is now part of the C(I)SIP. These safety upgrades should be implemented to avoid large releases to the environment after core melt and consequent reactor vessel rupture, since existing safety system will not be helpful on the latest phase of the severe accident propagation without support of the dedicated SAM system.

It is the intention of the regulator to accelerate the development and implementation of the Severe Accident Management Guidelines (SAMGs)[25], the implementation of measures to prevent hydrogen (H2) explosions in the containment and the implementation of a filtered containment venting system (only WWER-1000).

The impact of a severe accident on accessibility of Main and Emergency Control Rooms (MCR and ECR) has not yet been analyzed and may be a relevant cause of a cliff edge effect in the case of evacuation. Also measures for diagnostics in the case of a severe accident have to be developed and implemented.

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[21] It is planned that fire trucks provide make-up water to the steam generators (SG). According to the Peer Review team the time needed to install this mobile equipment could be several hours, especially taking into account degraded conditions.

[22] An independent steam generator additional emergency feedwater system (AEFS) has been introduced at Rivne NPP units 1 and 2 (WWER-440).

[23] I&C = Instrumentation and Control, DC= Direct Current

[24] Furthermore, emergency operation procedures (EOPs) for shutdown states have to be completed.

[25] SAMG are to be put into implementation at Rivne-1 and South Ukrainian-1 by the end of 2012.

The peer review team highlighted the dangerous lack of any SAM provision (i.e. SAMGs equipment qualification in severe accident conditions and hardware provisions). Because of the possibility of cliff-edge effects in the case of a severe accident, the team insisted that the implementation of the envisaged SAM provisions is given high priority. But the SAM provisions planned by Ukraine are far from being sufficient. Thus, the peer review team sees the need for much higher efforts to be undertaken; the schedule for hardware and procedures implementations should stay under strict control of the regulator:

- A strategy and program for the qualification of equipment needed in severe accident conditions should be implemented.
- Further analysis of accidents regarding Spent Fuel Pools (SFPs) is necessary.
- The robustness of the means to cool the SFP after core melt should be improved.
- The risk induced simultaneously by reactor and SFP in case of a severe accident should be assessed.
- The habitability of the Main and Emergency Control Rooms (MCRs and ECRs) in case of a severe accident should be further investigated.
- Protection of population with regard to the SAM provisions should be considered.
- The feasibility of immediate actions required to avoid core melt, to prevent large release, and to avoid site evacuation for a disaster affecting more than one unit at site should be verified in detail.
- Enhanced seismic capabilities for the building hosting the crisis center should be assessed.

This long list of additional measures and investigations proves that the operator and not even the regulator take the danger of a severe accident seriously into account.

1.6.2 Weaknesses the Ukrainian Stress Tests Ignored

Design weaknesses and safety upgrade programmes

According to the date of design, the operating units in Ukraine belong to second (1970ties) and third (1980ties) generation of Russian reactors[26]: Second generation units are SUNPP 1,2 (WWER-1000/V-302, V-338) and RNPP 1,2 (WWER-440/V-213); third generation units are ZNPP 1-6; SUNPP 3; RNPP-3,4; KhNPP-1,2 (WWER-1000/V-320). The safety design of nuclear power plants is crucial for preventing as well as dealing with incidents or accidents, but is not part of the stress tests. The safety design of all Ukrainian reactors is outdated and show deficiencies (see chapter 4.2 and 5.2)

Under the framework of joint ***EC-IAEA-Ukraine projects*** a design evaluation was carried out to conduct an overall evaluation of the compliance of the design of each of the Ukrainian NPPs with the IAEA Safety Standards. The Design Safety evaluation was based on the IAEA document "Safety of Nuclear Power Plants: Design" (NS-R-1) published in 2000 [IAEA 2000]. Ukrainian NPPs non-compliant

[26] The first generation (WWER-440/230) reactors have been declared as "non upgradeable" or high risk reactors by the European Union and the G7. They must be closed in all new EU member states.

with 22 of these requirements (194). Meanwhile, this IAEA document is outdated; IAEA published new safety requirements in January 2012 [IAEA 2012].

During the last decade, the European Commission, the EBRD, Euratom and the IAEA supported the safety analysis of WWER reactors and provided significant funds to enhance the safety of these plants.

In 2002, the first safety upgrade program started. It was based on IAEA Issues Books[27] containing safety issues ranked into categories. While implementation of 389 measures was planned for completions between 2002 and 2005, only 35% of these measures were implemented during this period. The content of the second program (2006 – 2010) was supposed to complete the safety measures from the former program and to adopt the new requirements formulated by international organizations (IAEA and WENRA) - the Ukrainian nuclear authority SNRIU. The implementation required a substantial time and money; however backfitting measures were not completed when the second project finished in 2010. Only 80% of 253 the pilot[28] measures and 37 % of 472 adopted measures were implemented [BOZHKOA2009; WENISCH 2009b].

Taking into account the results of implementation of safety upgrade and modernization programs, outcomes from joint IAEA-EU-Ukraine project and strengthening national regulatory requirements, United Safety Upgrade Program (2010 – 2017) has been developed [BOZKOA 2009].

Currently the EBRD is preparing a loan for safety upgrades only, at all 15 operating reactors "to bring them in line with internationally accepted safety standards and the Ukrainian requirements." The project includes measures to replace equipment in safety relevant systems, such as the modernisation of monitoring and control equipment. The EC has provided assistance to the Ukrainian nuclear regulatory authority in the review of the proposed upgrade programme. According to EBRD, the project will also allow, as part of the loan requirements, to engage with the authorities to ensure that the results of the stress tests are implemented at all units. EBRD pointed out that the project is a key milestone to the further integration of Ukraine into the EU and is a requirement for the energy cooperation between EU and Ukraine. The long-term sovereign loan up to EUR 300 million to Energoatom is expected to be granted in parallel with a similar loan, also to part-finance the Project via the Euratom loan facility. Total project costs are 1.45 billion EUR. The project passed the final review; the EBRD board approval is pending. The decision is expected to be taken on 18th December 2012 [EBRD 2012].

A recently published report discussed this "Ukraine NPP Safety Upgrade Program" (SUP), within the framework of the loan applications to the EBRD and EURATOM [WENISCH 2012b]. Proponent of the SUP, the Ukrainian state nuclear operator, Energoatom, claims that SUP measures will address only safety measures and are not a precondition for the lifetime extension of reactors. According to the above mentioned report this claim is misleading: SUP measures will be used to provide a sufficient safety level to extend operations. The other major point of critique is that European institutions intend to finance this major, high-risk project without the public in EU member states being informed. One year after the Fukushima accident,

[27] IAEA-EBP-WWER_03, IAEA-EBP-WWER_05 and IAEA-EBP-WWER_14

[28] Khmelnitsky 2, (WWER-1000/320), Rivne 1 (WWER-440/213), South Ukrainian 1 (WWER-1000 small series) were selected for the first reviews on the basis of being representative of the three types of reactors operating in Ukraine.

the European public would welcome information about the lifetime extension of NPPs that are already in operation for three decades [WENISCH 2012b].

An important issue for SUP for RNPP 1/2 (WWER 440/V 213), is e.g. the modernization of the fire alarm system and the improvement of the fire extinguishing system, which are ongoing. Fire was the most important internal hazard for RNPP 1/2 according to [IAEA 1999]. However, not all deficiencies in this field were eliminated by 2011 [WENISCH 2012b].

For WWER 1000 reactors, measures to prevent cold overpressure in primary circuit and the "Leak before Break" concept are currently being implemented. Also ongoing is the assessment of the Reactor Pressure Vessel (RPV) as well as the improvement of RPV joints and connections. The RPV is exposed to heavy loads (tension, neutron flux, temperature, pressure); in particular changes of these loads contribute to material fatigue. After 30 years these effects are likely to be substantial. Also the modernization of several monitoring systems is ongoing. They concern neutron flux, emergency protection, core control and protection system including control rod drives and position indicators. Strengthening the electrical power supply is an important issue for all WWER 1000 reactors. For example, the replacement or modernization of accumulators, switches and relays are required. This area is in need of enormous efforts to achieve an acceptable standard concerning separation, redundancy and diversity [WENISCH 2012b].

Lifetime extension

Original design lifetime of the Russian reactor types that were operator in Ukraine is 30 years. The first units in Ukraine that have reached their original 30 year lifetime of operation were Rivne NPP-1 and -2 both WWER 440/V213 units. Relevant safety relevant issues from 1999 are not completely solved for RNPP-1, 2. In spite of this, a 20-year extension of the operating licenses for RNPP-1, 2 the State Nuclear Regulatory Committee (SNRC) of Ukraine granted a life time extension in December 2010.

Energoatom stated that these units are pilot facilities and that lifetime of all reactors is planned to be extended in a similar way. In mid 2011 (after the Fukushima accident), the Ukraine Energy Strategy to 2030 was updated. The strategy emphasizes the role of nuclear power in the electricity sector while improving safety. In mid 2012, Energoatom announced that the eleven oldest WWER-1000 reactors are to receive 20-year life extensions by 2030. Additional 5 to 7 GWe of new nuclear capacity is to be realized by 2030 [WNA 2012a].

Unit 1 of the South Ukrainian NPP is the next candidate for lifetime extension. The original operational lifetime of SUNPP 1 ends on the 31 December 2012. For this reactor type, the V302 and V338 models (SUNPP 1/2), which are earlier models of the WWER-1000/320 [WENISCH 2012b], the relevant safety document [IAEA 1999] emphasizes the relevance of physical separation for safety systems.

1.6.3 Conclusions

In general the stress tests for Ukraine showed that after decades of safety programs, Ukrainian reactors remain to be exceptionally high risk nuclear power plants. The strategy of continuous upgrading programs did not prove successful and did not deliver the promised results.

The implementation of the stress tests results should not follow this example from the past: For assessing the safety risk of the current safety level is decisive, not the safety level the plants could have reached in 2017. This is true for all NPPs in the world, but particularly for the Ukrainian NPPs, because the experience shows that back fitting measures are severely delayed. During the last improvement programmes only about 40% of the planned measures were implemented. It seems that despite of permanent safety upgrade programs the gap between the required safety level and the envisaged safety level keep growing. It cannot be expected that the Ukrainian NPP reach the safety level of comparable NPP in the EU in the foreseeable future.

The stress tests showed that today at Ukrainian NPP neither Severe Accident Management Guidelines (SAMGs)[29] nor hardware provisions for SAM have been implemented. SAM are designed to avoid large releases to the environment after core melt. Furthermore, the impact of a severe accident could result in the inaccessibility of the control rooms and measures for diagnostics under severe accident condition are lacking. This is a serious issue and cannot be solved quickly.

The peer review team highlighted that the implementation of the envisaged SAM provisions must have a high level of priority; before that however a wide range of further measures and investigations needs to be started and completed; a long list of additional measures and investigations was identified by the peer review team. This very serious situation highlights one more time that both operator and regulator do not adequately respond to the danger of a severe accident.

Seismicity at the NPP sites is another issue the Ukrainian side does not devote the necessary attention to. The stress tests peer review found that the protection against seismic hazards has of several weaknesses. Again, additional seismic measures are envisaged, but not implemented yet. Seismic monitoring systems are not installed. But also after implementing the envisaged back-fitting measures the protection against earthquake probably is not sufficient, because additional seismic investigations are necessary. A seismic PSA for all NPPs still needs to be developed. At other NPP the re-assessment of the seismic hazards in almost all cases showed the protection level needed to be improved.

Regarding external flooding, the safety margins evaluation reveals weaknesses for the Zaporizka NPP. Measures against possible flooding of the reactor building have been implemented; however, additional detailed analyses of possible loss of Ultimate Heat Sink (UHS) still need to be performed.

Beyond design basis tornadoes can potentially cause failure of Emergency Power Supply additional analysis are necessary. Furthermore safety margins with respect to extreme wind and extreme snow are not evaluated yet, thus the possible threat of these extreme events is not known. According to the peer review team currently

[29] Furthermore, emergency operation procedures (EOPs) for shutdown states have to be completed.

it is not possible to prove that staff can reach all NPP sites under severe weather conditions.

The bigger picture shows that this might lead to very dangerous situations: In case of loss of all power supply (SBO) reliable measures to prevent core damage do not exist.[30] The time span to prevent core damage after Station Black-out (SBO) and loss of heat removal to the UHS without operator actions are only 3.5 – 4 hours for type WWER-1000 units and 10 hours for type WWER-440/V-213 units. The time span until the fuel stored at the Spent Fuel Pool (SFP) heats up and reaches temperatures above the design limits are 6.5 - 7.5 hours (WWER-1000) and 16 hours (WWER-440) respectively.

Ageing is an increasingly serious issue at the Ukrainian NPPs (with the exception of KNPP-2 and RNPP-4), table 1 offers an overview over the operational lifetimes of the reactor fleet. This is only one issue contributing to the irresponsibly high operational risk. A look at the operator´s safety culture and the situation of the regulator does not give much hope that safety could improve in the foreseeable future.

The peer review team also pointed to one of the problems, which are characteristic of nuclear safety in the Ukraine when it recommended that the regulator should monitor in a systematic way the implementation of the upgrading measures in order to assure timely completion as a part of the (C(I)SIP). One key result of this study is that the Ukrainian side constantly has been engaging in safety upgrade programs without completing them. ENSREG (European Nuclear Safety Regulators Group) draw the very same conclusion and formulated a warning by stating that "So far no comprehensive modernization program in Ukraine (except for Khmelnitsky2/Rovno4 was completely solved, but in most cases replaced by new ones before all measures were implemented;"[31]

Currently this is happening again. The Nuclear Regulatory office requested safety upgrades for the South Ukrainian unit 1 to be implemented until the end of 2012 as a precondition of granting an operational license: the required measures were again not fully implemented cannot be completed during December any more.

However, in spite of lack of safety culture and reliable management of safety programs, the operator Energoatom with the support of the government of Ukraine is preparing life time extensions for all its reactors. The stress tests result confirms one more time, that the status of nuclear safety of the Ukrainian nuclear power plants is significantly lower than in EU countries. The very unreliable implementation of safety measures even when they were agreed upon by all sides and are part of an international program is not a viable basis for life time extensions.

Instead of an unlimited and undirected continuation of the NPP the Ukraine needs to receive support for implementing nuclear safety programs with strict deadlines on selected NPP which will continue operating for a clearly limited time after a sensible shut-down program was established and the most dangerous NPP are shut-down one by one.

[30] Furthermore, Emergency Operation Procedures (EOPs) for shutdown states have to be completed.
[31] Technical Opinion of ENSREG, Final report of the EC-IAEA-Ukraine Joint Project: "Safety Evaluation of Ukrainian Nuclear Power Plants", Feb. 20, 2012

1.7 Potential Impacts of Severe Nuclear Accidents

The first chapters explained the EU stress tests results for the nuclear power plants in Bulgaria, Hungary, Romania and the Ukraine. Chapter 7 assesses the potential impacts of severe accidents of these NPPs. The accident results were taken from flexRISK project (Flexible tools for assessment of nuclear risk in Europe).

The flexRISK project modelled the geographical distribution of severe accident risk arising from nuclear facilities, in particular nuclear power plants in Europe. Using source terms and accident frequencies as input, for about 1,000 meteorological situations the large-scale dispersion of radionuclides in the atmosphere was simulated.

For each reactor an accident scenario with a large release of nuclear material – usually rather unlikely – was selected. To determine the possible radioactive release for the chosen accident scenarios the specific known characteristics of each nuclear installation were taken in consideration.

The figures provided by the operators come from Probabilistic Safety Analyses (PSA), which however are not always based on comparable assumptions: some consider only accidents caused by failure of nuclear power plant components, the ageing of materials is difficult to include, others take accidents caused by external triggers into consideration (flooding, earthquakes, plane crash,...). Human failure is especially hard to quantify. The estimated frequencies of severe accidents are therefore afflicted with high uncertainties (factor of 10 and more).

The accident scenarios for the dispersion calculation are core melt accidents and containment bypass or containment failure; the release rates are in the range of 20 to 65% of the core inventory of caesium.

The dispersion of radioactive clouds as a consequence of serious accidents in nuclear facilities in Europe and neighbouring countries is calculated for selected accidents with varying weather conditions.

Using the Lagrangian particle model FLEXPART both radionuclide concentrations in the air and their deposition on the ground were calculated and visualised in graphs. The total cesium-137 deposition per square-meter is used as the contamination indicator.

The following pages show the results which were calculated for one unit of each of NPP site. More results also for other NPP can be found on the FlexRISK website [FLEX 2012].

Explanation of the legend used here: After the Chernobyl accident in the Soviet Union the following contamination limits were used:

- 37 – 185 kBq/m² (3.7E+04 – 1.85E+05 Bq/m²) was defined as a contaminated area; radiation monitoring was carried out in this area (estimated dose < 1 Sv/a)
- 185 – 555 kBq/m² (1.85E+05 – 5.55E+05 Bq/m²) people were allowed to leave the region (estimated dose 1 – 5 mSv/a)
- 555 – 1480 kBq/m² (5.55E+05 – 1.48E+06 Bq/m²) relocation at a later time
  (estimated dose > 5 mSv/a)
- > 1480 kBq/m² (1.48E+06 Bq/m²) immediate evacuation (estimated dose > 5 mSv/a)

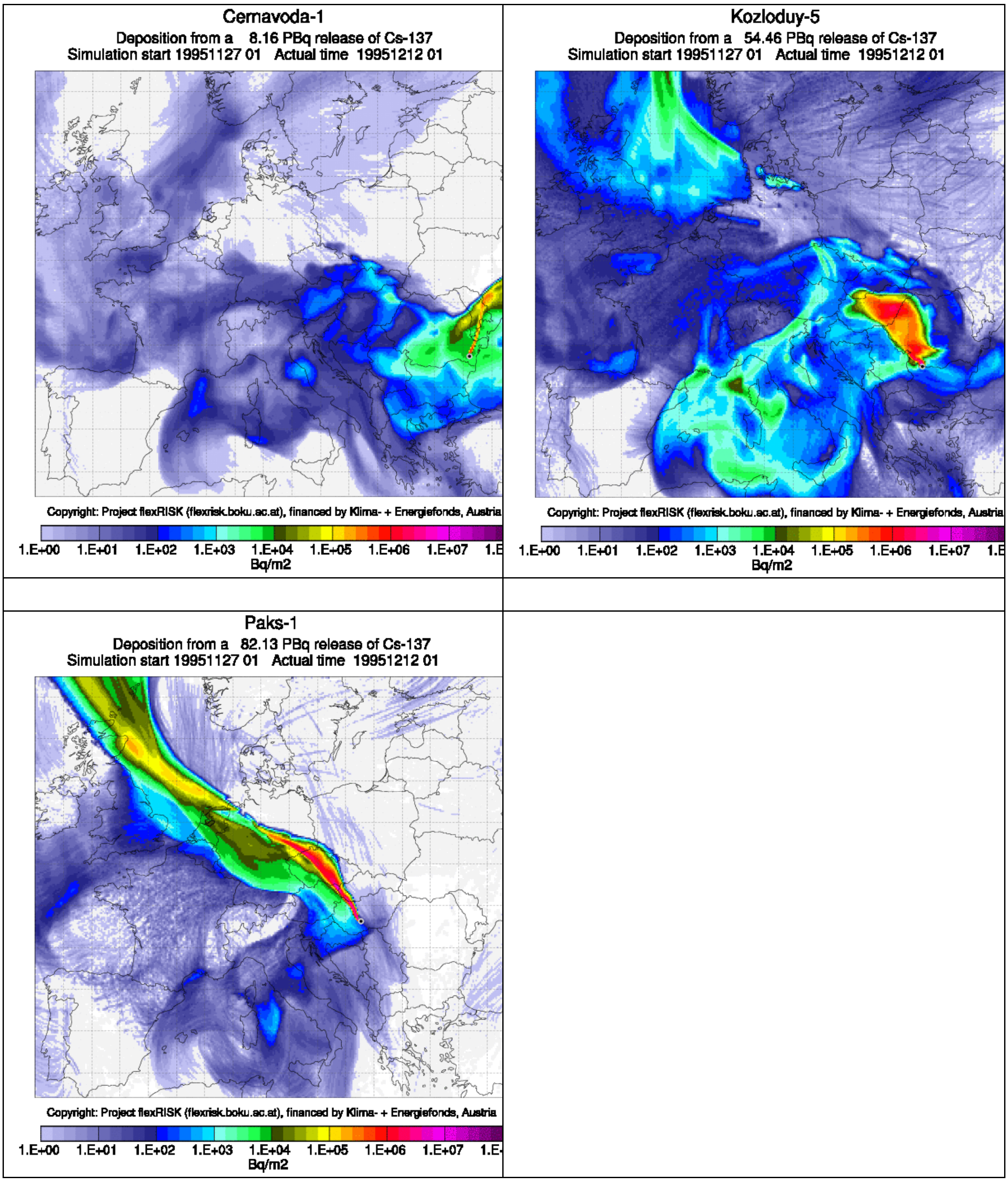

Figure 1: Caesium-137 deposition after a severe accident at Cernavoda NPP unit 1; Kozloduy NPP unit 5; or Paks NPP unit 1 [FLEX 2012]

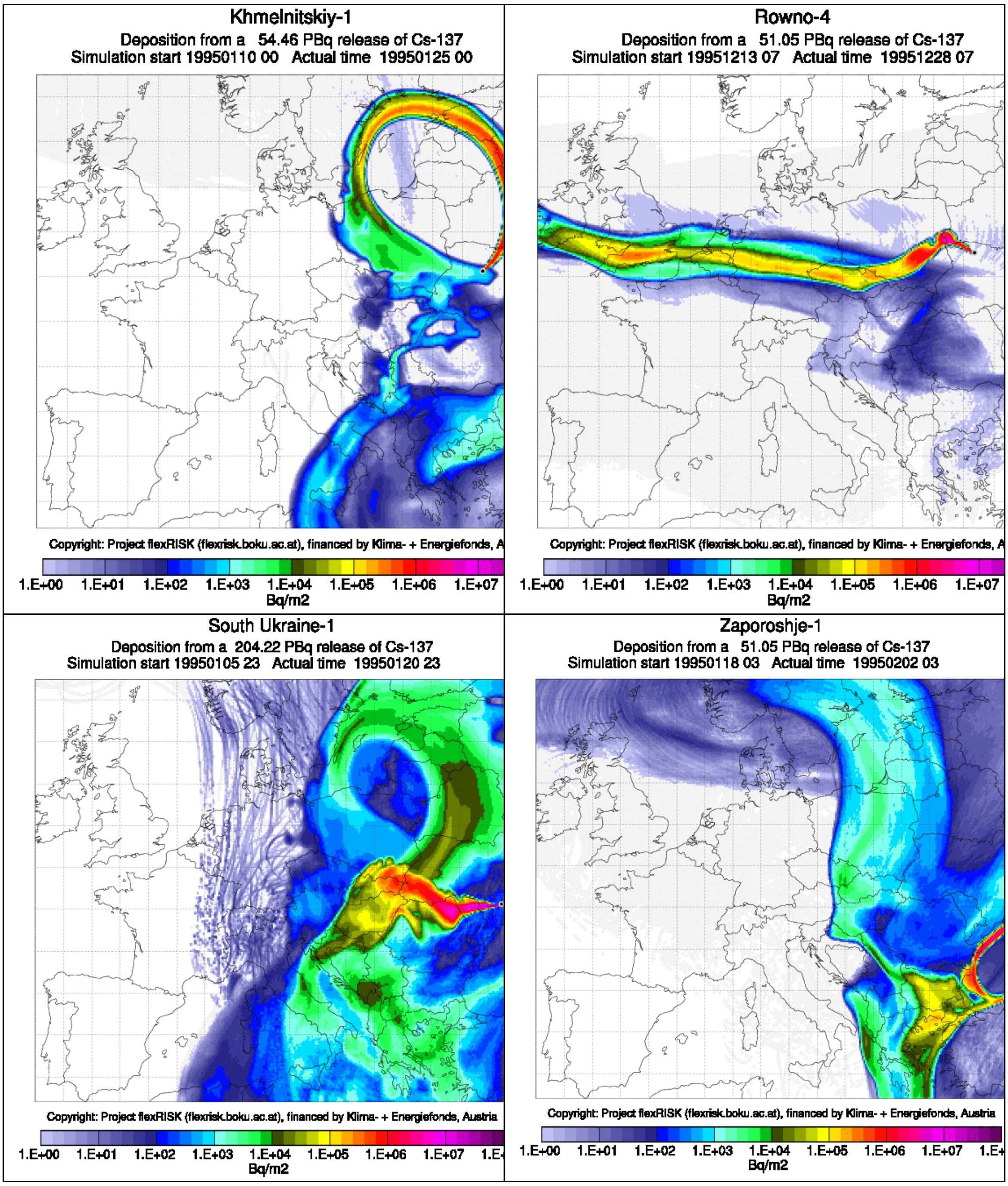

Figure 2: Caesium-137 deposition after a severe accident at Ukrainian NPPs [FLEX 2012]

1.8 Conclusions and Recommendations

1.8.1 General Conclusions and Recommendations

The stress tests cannot be understood as a „safety label" awarded to NPP in Europe. Too many factors were not taken into account - most importantly design, siting and ageing. The study at hand points out those design weaknesses, e.g. wall thicknesses, location of Spent Fuel Pool outside the containment, which cannot be remedied.

The next step in the EU stress tests is the presentation of the National Action Plans. They also will be subjected to the EU peer review. Clearly, those plans need to contain measures which are defined on a technical level; information should be provided also on the intended safety level and the costs of the measures. The ENSREG peer review hopefully will insist on including more measures than the National Regulators suggested; e.g. the Ukrainian regulator suggested significantly less safety measures than the peer review did.

A very strict timetable needs to be agreed upon and monitored by the National Regulator. We strongly recommend conducting the whole process starting with setting up the plan, actual implementation of the measures as well as follow-up in a fully transparent manner and open to public control, including independent experts who have no links to nuclear industry as well as members of civil society and NGOs. Transparency is one important tool to control nuclear risk; while ENSREG certainly recognizes this fact, not all national nuclear regulators and operators act accordingly to fulfil this need of higher transparency.

This study but also the EU Communication (EC COM 2012) on the stress tests concluded that a general lack of safety culture exists in most countries. In combination with ageing as a high risk factor and the higher awareness of risk, this study arrives at the conclusion that power uprate and particularly lifetime extension cannot be conducted without increasing nuclear risk to an irresponsible level.The IAEA safety system as such cannot guarantee safety, which has been clear. What came as a surprise, that in-spite of high numbers of IAEA missions, many National Regulators were confronted with stress test results showing that IAEA recommendations were not fully implemented, while the operators and regulators constantly informed the public about successful missions proving the best safety practices. The EU Communication on the stress tests made a remark showing severe deficiencies: "Following the accidents at Three Mile Island and Chernobyl, urgent measures to protect nuclear plants were agreed. The stress tests demonstrated that even today, decades later, their implementation is still pending in some Member States." [EC COM 2012]

1.8.2 Conclusions and Recommendations by Country

Bulgaria

At units Kozloduy 5 and 6 earthquake protection is insufficient, further assessment and back-fitting is needed. The stress tests also revealed dangerous sloppiness in this field: Emergency Diesel Generators (EDGs) necessary to prevent a core melt accident after a Design Basis Earthquake (DBE) are stored in a not earthquake resistance shelter. Appropriate seismic margins do not exist. The first step of the envisaged back-fitting measure is the delivery of two new mobile diesel generators (DG) which obviously will be stored inadequately as well.

Operator and regulator are not fully responding to the threat of an earthquake or to the (increasing) threat of flooding or the possible negative effects of extreme weather events. To summarize: currently natural hazards, particularly earthquakes can cause a severe accident at both units.

Appropriate Severe Accident Management (SAM) provisions do not exist. Even as a result of the stress tests, a lot of necessary measures are envisaged. According to the peer review team it remains open whether the different measures are feasible. The peer review team also criticizes that the envisaged programme is insufficient. Moreover, the containment of the reactor type (WWER-1000/V320) shows design weaknesses that can be remedied only with great difficulty or not at all.

Operation of Kozloduy 5 and 6 should be halted – at least until the necessary protection against earthquakes and Severe Accident Management provisions were implemented. Neither power uprate nor lifetime extension can be performed without causing an unacceptably high nuclear risk. On the contrary: we recommend reducing power output and shutting down the reactors soon.

Hungary

The WWER-440/V213 like Paks, a second-generation WWER of Russian design, is not equipped with a full-pressure containment; they have a so-called confinement and Bubbler Condenser. Safety analyses showed that the confinement and in particular the Bubbler Condenser have very low or no safety margins under certain conditions.

The vulnerability of the Paks NPP against external hazards is relative high: The reactor building does not provide sufficient protection against external impacts like airplane crashes or explosions, but houses two reactors. (WWER-440 plants are twin units, located in a common reactor building.) Furthermore, the Spent Fuel Pool (SFP) is located outside the containment in the reactor building. An airplane crash could cause a severe accident with large radioactive emissions. An airplane crash can cause a severe accident with a large radioactive emission: the worst case could even lead to releases from two cores and two Spent Fuel Pools.

The plant should not undergo life-time extension and be shut-down soon: 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. In addition ageing will become an increasingly serious issue for all units especially in case of lifetime extension.

Romania

The main findings of the stress tests show that the safety level concerning seismic risk, flooding and Severe Accident Management are in-sufficient and the Romanian Regulator seems not to insist on adequate responses.

The protection of the Cernavoda NPP against seismic impacts is inadequate, although earthquakes have to be expected at the site. This is a serious deficit, particularly regarding the fact that for a seismically induced Station Black-out (SBO) a situation occurs, when four hours only need to suffice to prevent a core melt accident. Four hours is not enough time to guarantee that the necessary manual actions can be conducted under the conditions after a severe earthquake. This situation is even aggravated by the fact that appropriate measures to assure containment integrity during a severe accident are lacking; this amounts to a relatively high risk of a core melt accident with major radioactive releases.

Overall conclusion shows the risk of a severe accident with major release to the environment being unjustifiably high: Cernavoda units 1 and 2 need to stop operation immediately – at least until comprehensive back-fitting measures will have been completed.

While in Bulgaria, Hungary and Ukraine the dependence on nuclear energy is high, Romania should profit from its advantage of a much lower nuclear power share and take the direction of phasing-out. Because in an economic perspective and the long-term energy supply investing in other capacities of energy generation like wind, solar and small water power as energy of the future will have higher benefits than back-fitting the units 1 and 2 and the considered completion of unit 3 and 4.

Ukraine

In general the stress tests for Ukraine showed that after decades of safety programs, Ukrainian reactors remain to be exceptionally high risk nuclear power plants. The strategy of continuous upgrading programs did not prove successful and did not deliver the promised results.

The implementation of the stress tests results should not follow this example from the past: For assessing the safety risk of the current safety level is decisive, not the safety level the plants could have reached in 2017. This is true for all NPPs in the world, but particularly for the Ukrainian NPPs, because the experience shows that back fitting measures are severely delayed. During the last improvement programs only about 40% of the planned measures were implemented. It seems that despite of permanent safety upgrade programs the gap between the required safety level and the envisaged safety level keep growing. It cannot be expected that the Ukrainian NPP reach the safety level of comparable NPP in the EU in the foreseeable future. The stress tests showed that today at Ukrainian NPP neither Severe Accident Management Guidelines (SAMGs) nor hardware provisions for SAM have been implemented.

The bigger picture shows that this might lead to very dangerous situations: In case of loss of all power supply (SBO) reliable measures to prevent core damage do not exist. The time span to prevent core damage after Station Black-out (SBO) and loss of heat removal to the UHS without operator actions are only 3.5 – 4 hours for type WWER-1000 units and 10 hours for type WWER-440/V-213 units. The time span until the fuel stored at the Spent Fuel Pool (SFP) heats up and reaches temperatures above the design limits are 6.5 - 7.5 hours (WWER-1000) and 16 hours (WWER-440) respectively.

Ageing is an increasingly serious issue at the Ukrainian NPPs (with the exception of KNPP-2 and RNPP-4). Table 1 offers an overview over the operational lifetimes of the reactor fleet. This is only one issue contributing to the irresponsibly high operational risk. A look at the operator´s safety culture and the situation of the regulator does not give much hope that safety could improve in the foreseeable future.

The peer review team also pointed to one of the problems, which are characteristic of nuclear safety in the Ukraine when it recommended that the regulator should monitor in a systematic way the implementation of the upgrading measures in order to assure timely completion as a part of the (C(I)SIP). One key result of this study is that the Ukrainian side constantly has been engaging in safety upgrade programs without completing them. ENSREG (European Nuclear Safety Regulators Group) draw the very same conclusion and formulated a warning by stating that "So far no comprehensive modernization program in Ukraine (except for Khmelnitsky2/Rovno4 was completely solved, but in most cases replaced by new ones before all measures were implemented;"[32]

Instead of an unlimited and undirected continuation of operation of the NPP the Ukraine needs to receive support for implementing nuclear safety programs with strict deadlines on selected NPP which will continue operating for a clearly limited time after a sensible shut-down program was established and the most dangerous NPP are shut-down one by one.

[32] Technical Opinion of ENSREG, Final report of the EC-IAEA-Ukraine Joint Project: "Safety Evaluation of Ukrainian Nuclear Power Plants", 20 Feb 2012

2 Stress Test in Central and Eastern Europe: Experience of the Joint Project NGOs

The European Council of 24/25 March 2011 agreed that the safety of all EU nuclear plants should be reviewed, on the basis of a "comprehensive and ***transparent*** risk and safety assessment" ("stress tests")

In an effort to ensure transparency, one of the three ENSREG working groups working on the stress tests was dedicated to work on transparency issues (working group on transparency = WGTA)

Recommendations concerning safety were given by the ENSREG (e.g. within the working Paper "Transparency of "Stress Tests" - HLG_p(2011-16)_80") with the focus to get the right balance between transparency and security

In this context it has to be mentioned, that the participation in the stress tests was on a voluntary basis. The regulators had, however, to grant the public the rights bestowed by the Aarhus Convention concerning information and participation. In this context, any environmental information held by a public authority must be provided when requested by a member of the public.

The following chapters sketch out the experience of the Joint Project NGOs made with transparency during the stress tests. The information is no comprehensive evaluation of the transparency of the stress tests in general – such an evaluation is not possible within the scope of this brochure. The evaluation aims to show some activities concerning stress tests and how they were conceived by the JP NGOs. Some recommendations for improvement are given.

The following efforts concerning stress tests were made (this list doesn't claim to be exhaustive):

A) Public information

Information about the Stress Tests was made available on a microsite of the ENSREG **website**. The site included information about the stress test process including e.g. a document on frequently asked questions as well as the timetable for the availability of reports. Also the national reports, ENSREG reports, peer review reports and the reports to the EU Council were published on the website: http://www.ensreg.eu/eu-stress-tests

- ***Opinion of the JP NGOs:***
  The reports on the website were given in time. Further more, the document section contains an extensive list of documents concerning the stress tests made publically available – this availability of information helped to improve the transparency of the stress tests.

B) Opportunities provided for stakeholders to engage in the stress tests on a European level:

- **January 17, 2012: Public meeting on stress tests peer review** The first public meeting was held in Brussels to discuss the stress test process. The nuclear-critic experts Jan Haverkamp was on the speaker list, Toni Wenisch and Patricia Lorenz, experts also working for the Joint Project, were also present and gave their input. A document with conclusions was made available online –some of its points:

  - *"Mixed feelings were received on the modalities of the peer review. It has been recognized the given timeframe foreseen by the European Council and ENSREG is very tight for a thorough analyzes, considering in particular the large quantities of material to be reviewed. The logistical effort needed to coordinate all participants and to assure the quality of the review and reviewers is another burden lying basically on the peer review board."*

  - *"The independence of the review process was questioned, since regulators need to partially review own decisions and do not systematically involve other organizations during the review and peer review. Some organization also expressed the wish to have more frequently the occasion to express concern and to have an impact on the process via public meetings, public consultations and other means of public involvement."*

  - *"The stress-test execution has been globally welcomed. It was recognized that operators and regulators have provided extensive analyses. They have respected the given deadlines and published their respective reports, providing comprehensive information to all interested parties, including means for public participation."*

  In addition, the Peer Review Board decided to post an update once a month on the ENSREG website in an effort to improve transparency and to better inform the public between public meeting in January 2012 hosted by the Peer Review Board and the final reports in April 2012

  - ***Opinion of the JP-NGOs:***
    The information given in the presentations was very informative. It was, however, unclear for the present Joint Project experts how their input was taken into account.

  - ***Recommendation:***
    A document with answers how the comments were taken into account would improve transparency.

- **January 1-20, 2012: Online consultation for peer review process**
  The opportunity to submit suggestions via the internet to be considered in the peer review process was provided from 1 to 20 January 2012 at the Commission's Joint Research Centre website. A compilation of the comments and questions was made available online after the consultation period

  - ***Opinion of the JP-NGOs:***
    The JP-NGOs participated in the consultation process and appreciated the possibility of giving their input. However, it was unclear to them, how their input was taken into account within the peer reviews.

  - ***Recommendation:***
    A more interactive way of consultation would have been better for transparency. E.g. possibilities which allow to see the inputs of the participants right after the submission like blog style, sections with answers to the questions etc.

- **May 8, 2012: Second Public meeting on progress of the Stress Test process**
  An additional public meeting was held on 8 May 2012 in Brussels. Topic: progress of the stress tests in particularly of the peer review. The speaker presentations were made available online. Toni Wenisch and Patricia Lorenz of the Joint Project group were also present at this meeting and gave input. A document containing conclusions was published online, some of the conclusions were:

  - *"Critics focus on the facts that statements are very general, not indicating which specific plants are directly concerned and that sources of information, respectively cross references, are missing. Despite the efforts to have reports for the public, the terminology used is still rather exclusive. Finally, the input from public meeting in January to the peer review process is not visible"*

  - *"Some mixed feelings were expressed with regards to the results of the peer review. It is basically confirmed that all plants comply with the current licensing basis. In that context some minor doubts were expressed as to which extend latest and up to date assessments were used to support these conclusions. Some speakers also questioned why no plant would need to be shut down as a result of the stress test. It was nevertheless recognized that the stress test led to identifying of tangible improvements."*

  - ***Opinion/recommendations of the JP-NGOs:***
    The same as for the January meeting applies.

- **April 26 – May 6, 2012: Online consultation**
  An opportunity to submit comments via the internet was provided at the European Commission's Joint Research Centre website once again.

  - ***Opinion/recommendations of the JP-NGOs:***
    The same as for the January consultation applies.

C) National activities

Bulgaria

- June 17, 2012:
  On June 17th 2012 a press conference on the topic of stress tests took place. Representatives of Agroecofund, Za Zemiata as well as the experts on nuclear issues P. Kotev (Bulgaria) and Patricia Lorenz (Austria) took part.

- July 5, 2012: Stress test round table
  present: new director of NPP Kozloduy, 10 members of the Balkan anti-nuclear coalition (one of them was member of the front table)

Czech Republic

- ***February 28, 2012: Round Table on stress tests in Prague***
  The conference was organized by the State Office of Nuclear Safety and by the Nuclear research Institute in Řež near Prag. Among the speakers was Dana Drábová (head of the SONS). In the auditorium were journalists, students, mayors from towns near Dukovany NPP and representatives from nongovernmental organizations (including Monika Wittingerova from South Bohemian Mothers and Edvard Sequens from Calla). Discussion was about the procedure of stress tests, how they are carried out in Temelin and Dukovany (presented by above mentioned lecturers). The general attitude was that the two NPPs are fully prepared to every "disaster" and that detailed data how each NPP will solve problems with safety will be in so called actions plans. The event is a good example of the stress tests in the Czech Republic: already at this event the regulator arrived at the conclusion that the Czech plants passed the stress tests.

- ***March 1, 2012:***
  On Thursday, 1 March 2012 in České Budějovice, the Czech NGOs Calla and South Bohemian Mothers organized a conference with the title "Nuclear Power Plant Load Testing: Safety Inspection or Propaganda?" ?" Again both the regulator and Ms Drábová followed the invitation and took part.

- ***Activities concerning action plans***
  Czech NGOs Calla and South Bohemian Mothers made the following efforts to get information on the action plans of the stress tests:
  "We had two meetings with the director of Temelin NPP Mr.Štěpanovský 12.7.2012, 26.11.2012 We have discussed issues concerning the stress tests procedure and safety measurements at Temelin and Dukovany NPP. We have also asked Mr. Štěpanovský to give us the so called Action Plans of Temelin and Dukovany NPP (these plans are the next step after the stress tests procedure, it is a list of measurements which must be done in nuclear power plants to fulfilled the requirements of stress tests procedure). Unfortunately Mr. Štěpanovský said no to our request. Our next step (letter written by Calla) was to ask nuclear regulator (State Office for Nuclear Safety) to give us these Action Plans, but we did not success either."

Monika Wittingerova from the NGO "South Bohemian Mothers" summarizes the efforts and impressions on the transparency of the stress tests of the Czech NGOs Calla and South Bohemian Mothers as follows:

"We wrote letter to SONS in June 2011 with questions. Their answers, however, were very general, no details were given - but this was at the beginning of stress test procedure. We also sent an appeal to Heads of States and nuclear regulators on the stress tests, on the occasion of the EU Council meeting on December 9th 2011 together with other organizations, we did not receive any response.

As we expected, the stress test procedure was and still is only a formal process. Transparency is only written on paper, in reality the situation is completely different (an example are our efforts to get information about action plans). Without knowing the exact content of the action plans nobody can check if measures for increasing the safety level of Temelin and Dukovany are really carried out. Especially NPP Dukovany which doesn´t have containment needs to be monitored closely from really independent experts."

Hungary

András Perger of Hungarian NGO Energia Klub summarizes their efforts and impressions on the transparency of the stress tests as follows:

"According to my impressions, the transparency of the stress test process in Hungary is not so bad, however, the regulatory authority (HAEA) and Paks do not endeavour to get the most out of it, in terms of achieving the highest publicity of it, not to mention the early involvement of NGOs and the public

To our last year's question on the possibility of public workshops on stress tests, the HAEA answered that they have no capacity for organising such workshops.

After the closure of the international stress test process, a public forum was organised in Budapest (May 2012), for introducing the entire stress test process and evaluating it.

Since then, I asked the HAEA to send me the planned schedule of Paks, that was ordered by the HAEA. The HAEA sent me the document. I also asked the opinion of the HAEA on it, they just answered that it was not ready, but as soon as will be ready they will send it.

Romania

In the following we want to share the impressions of Romanian NGO Terra Mileniul II on the transparency of the stress tests in Romania:

"The stress tests process in the last year was completely misinterpreted by the nuclear regulator and operator in Romania. It failed to conduct realistic public information and consultation sessions, it failed to answer questions regarding emergency measures, and it failed to address the hazards that may have resulted from past labor practices and faulty equipment at the nuclear reactors, which we had specifically asked for. For these reasons, it is important to continue monitoring the implementation of the measures recommended by the Commission.

Also, even to the peer review's recommendations, CNCAN gave selective answers, avoiding important issues such as tackling the lack of studies for management of severe accidents.

Also, they avoid answering simple questions such as "How many days can Cernavoda survive without external energy sources", by providing this sort of arguments "The plant units have a high level of defense against the loss of power and its consequences. The robustness of the electrical power supply is provided by four levels of defense in depth." It doesn't really matter how many classes of super redundant supply you have, if any, if they are all connected to the local grid.

In October 2012, when the final reports were out by the Commission, we issued a press release as well,

We pointed out some of the problems not tackled by the reports and pointed out that CNCAN is avoiding important answers. On the same day, the regulator CNCAN representatives gave an exclusive and interview to the online magazine "Hotnews" reassuring about the safety of the CANDU reactors in Romania.

Soon after this, still in October 2012, we sent an email to CNCAN with four very specific questions related to the recommendations in the peer review and how they plan to proceed handling them. These questions were:

"what are the measures that you will take regarding severe accidents, margins for cliff-edge effects, a comparable seismic system to report to and the radiological situation in primary ands secondary control rooms". All these have been questioned in the conclusions of the peer review report, and CNCAN has long passed the 30-day legal time to answer these questions. We have re-sent them again last week, pointing out that they have breached the law on access to public information. We have also made it very clear again that we are always open for discussion, and that we request solid and realistic information sessions, not only media briefings to 4-5 accredited journalists."

Slovakia

- ***January 25, 2012:***
  On January 25th 2012, a meeting with UJD on stress tests took place in Bratislava. There, it was agreed with UJD that the questions which were not answered or not sufficiently, would be published together with all other questions on their homepage; however, only a short note was published. Main unanswered questions by the audience concerned doubts about emergency measures in cases of severe accidents and evacuation.

D) Aarhus and Nuclear

Within the Joint Project 201/2012 the progress on the stress tests was followed closely. The JP NGOs engaged in the several activities concerning transparency of the stress tests – like e.g. writing letters to regulators with questions concerning safety. These activities are summarised in the presentation quoted further down.

December 4-5, 2012: Aarhus Convention and Nuclear European Roundtable "Aarhus Convention implementation in the context of Nuclear Safety"

The 4th Aarhus Convention & Nuclear European Roundtable on "The Aarhus Convention implementation in the context of nuclear safety" was held on 4-5 December 2012 in Brussels. The event was organised by the ANCCLI, the European Commission (DG ENER), with support of the European Economic and Social Committee (EESC) and the French Institute for Radiation Protection and Nuclear Safety (IRSN).

According to the organisers, the European Round Table was aiming at the identification of key issues for the implementation of the Aarhus Convention in the context of nuclear safety in Europe. The implementation of the Aarhus Convention in decisions regarding nuclear safety was to be reviewed with the stakeholders in relevant contexts in Europe.

The current brochure does not aim to evaluate this roundtable. To give you an impression of an NGO input the presentation of Patricia Lorenz, an expert on nuclear energy also working within the Joint Project group, is given below:

Presentation by Patricia Lorenz, Friends of the Earth Europe at the fourth ACN European Roundtable on the "Aarhus Convention implementation in the context of Nuclear Safety" on December 5, 2012, Brussels.

"*The speaker before, Mrs. Zemanova from the Slovak regulator UJD, pointed to one of the current trends in the nuclear field. There are two types of stakeholders, locals living directly in the surrounding of nuclear installations, and national ones, like NGOs and strictly speaking everybody else. In the case of stress tests, there were held seminars locally for mayors during the stress tests and now again, but not for NGOs like FoEE, ZaZaMatkuZem and Greenpeace.*

Stress tests: NGO and independent experts contributed from the very first moment and continuously throughout the process.

Several facts made this challenging: the enormous technical and other know-how necessary to follow the process, the time pressure and yes, again, lack of transparency. I think at this point I like to introduce a term which describes the situation better: it is a lack of will, and the lack of real understanding why transparency ultimately is the only chance for keeping up nuclear safety.

In the past 1.5 years of course the regulators in each country took different approaches, I will give some examples later. Mr. Andreas Molin already explained how ENSREG set out transparency and how it was applied. At this point the difference between information and involvement certainly became obvious: Enabling access to completed reports on a web site is a far cry from public publication or involvement.

Internet consultation, public seminars were conducted on EU level organised by ENSREG. The big question is what was taken into account from the input given during the meetings? I think very little. Even smaller efforts, like our suggestion to publish the comments to the public filed was not taken up. I understand this is technically difficult, however, I am sure there were not too many comments and it would have been interesting and enabled and inspired a real debate. Under the current system, we sent comments which disappear in a black box.

What I consider a big mistake at the very beginning was allowing WENRA to hijack the stress test process. They set up the conditions for this process enabling those to be stress tested to check themselves again. Our input – e.g. leaving the obviously wrong nuclear safety concepts behind was not picked up, no independent experts were allowed in the process. The NGO inputs (Global 2000, Greenpeace and the independent Ökologie-Institut Wien) for the very set-up of the stress tests of May 2011 was completely ignored.

In the end the stress test report turned out fairly fuzzy. This was criticized widely at the May 8 meeting (by NGO, Mr. Renneberg and others). Criticism included the ENSREG report making statement without clear references and using unclear terminology like the newly coined "robustness".

So one of NGO functions I see is giving the stress tests exercise a frame and the spot on the wall where they belong. We explain to media and will continue doing so that stress tests did not prove NPP in Europe to be SAFE. We as NGOs in the field of nuclear power are in many countries usually the only ones to have the knowledge to comment or counter what was reported officially, why, what it means. Including facts, that siting, design and ageing of NPP were not part of the stress test; whether airplane crashes were looked into or not.

The national nuclear regulators had different attitudes. Some ignored their public, like the Romanian regulator. Their transparency effort was limited to answering one letter by a Romanian NGO only after they were threatened to be taken to court. No meetings took place. The Czech and the Slovak regulator did answer to letters, did organise hearings, but absolute minimum and still sticking to strategy of keeping meetings under strict control by offering presentations hardly anyone understands and giving very little space and room for questions. Mainly the Slovak hearing showed at the end that people wanted to know what happens after an accident at a NPP, but those questions were not answered. The regulator did come up with a good suggestion – to publish the questions/answers on the regulators homepage later; but this did not happen.

In Bulgaria the public was not informed until quite some media attention, when the first meeting with the public took place on July 5 2012.

I think the stress tests results in the Czech situation were interesting, surprising. After 25 IAEA mission and many other bilateral safety inspection the stress tests showed that not even the basics, the IAEA recommendations were completely fulfilled in spite of constant propaganda the Czech plant being the best with the highest maintenance.

Back to the future: What is of interest now is of course what will happen with the stress test results, the action plans and peer reviews of those. Czech NGOs already tried to get information about the Action Plan for the Czech plants for Temelin and Dukovany, but were turned down. We believe we will be more successful in other countries. In the next days we will present our study on Stress Tests in Bulgaria, *Hungary, Romania and Ukraine and hope to be able to discuss the results with the regulators and operators.*

*The next part of my presentation would like to focus more generally on **what should be done to get from talking about transparency** to at least seriously trying to achieve it.*

Therefore we suggest that clear guidelines will be formulated to define how each member states needs to involve the public. Some countries simply ignore „calls" for transparency and participation in the articles of directives.

Early implementation when all options are still open – the complaint most often brought to the Aarhus Convention Compliance Committee. But it is not only about the Aarhus Convention being breached. There should be a general understanding that Energy Strategies and feasibility studies for NPP etc. and all other nuclear installations and major changes need to be subject to SEA and EIA.

EURATOM needs to ratify the Aarhus Convention.

EURATOM loans and directive are still free from any transparency. Here again the waste directive is ignoring the public and the closed circle is getting to control itself again.

Currently a debate is taking place on transparency and involvement of the public for the nuclear waste directive. While we as NGOs made clear several times we would like to participate in setting up guidelines on who is a stakeholder, again only ENEF and NEA are heard by the Commission and their suggestions taken up. I am also not sure how the EURATOM directives will be implemented in member states who signed Aarhus without applying the Aarhus Convention. Therefore some other rules and guidelines will be set up. I think there should be a clear guideline, a minimum: the process on how to set up the plan to find a final spent fuel repository needs to be subject to a SEA process, and this needs to be said clearly, otherwise many countries will not subject their plans under this directive to a SEA or anything comparable.

I also would ask the EU Commission and other EU institutions and EU member states to support the suggestions by the ESPOO secretariat to include PLEX – operation over 30 years of NPP – in the ESPOO convention, PLEX needs to undergo SEA and EIA, national and trans-boundary.

There are many possibilities to engage the interested public, but the stress test did not deliver what would have been possible, however, they might have triggered a start in some places, like we heard from Bulgaria.

I think the tools to increase transparency do exist. The European institutions need to enforce that they are implemented – in all EU member states on the same level."

3 Safety relevant special topics

Within the main topic "nuclear safety" of the Joint Project 2011/2012 the NGOs of each JP country selected a special safety relevant topic, which is/was of particular interest in their country:

- Bulgaria: The short story of Belene NPP – The victory. Key points of the campaign against the nuclear power plant
- Romania: Risks of the CANDU reactor design
- Czech Republic: Conference "Power Plant Load Testing: Safety Inspection or Propaganda?"
- Slovakia: Safety deficits of the NPP Mochovce

These safety relevant issues are discussed in the following chapters to give the reader an impression of the work done.

3.1 Bulgaria: The short story of Belene NPP – the victory. Key points of the campaign against the nuclear power plant

By Todor Draganov Todorov, Energy and Climate Coordinator, EA Za Zemiata and Borislav Sandov, Campaign Coordinator, Foundation for Environment and Agriculture - June 2012

The project Belene NPP was started in 1981 when the government decided to build six nuclear units by the Danube river. When the communist rule was over it became clear that the project was not economically viable, therefore it was dropped in 1992. 11 years later, in 2003, the project was revived – the idea this time was to build two new reactor blocks (1000 MW each).

The local opposition against the project was strong at the time of the first halt of the project in the beginning of the 90's. During the project revival, once again local activists gathered forces with environmental NGOs and international anti-nuclear groups. The battle continued.

Problems with Belene NPP

The problems with the Belene NPP project were numerous but nevertheless it received governmental support:

- The site of Belene lies in a seismically active zone – in 1977 120 people died in an earthquake only 12 km from the Belene site in the town of Svishtov.
- The project was not economically viable – the projected costs were stated and contracted at 4 billion euros at the beginning - the actual estimation at the end of the project exceeded 10 billion euros.

- The technical design chosen for the reactor was a Russian design that had never been tested before – so even though the propaganda said that the proposed rectors were safe – no proof was ever given for that (not that such thing as "safe nuclear reactor" exists, given the fact that nuclear accidents keep happening in the world). This new reactor type so far has not been licensed in Europe.

- Belene NPP did not propose a solution for its end product – the radioactive waste.

- There were also severe problems with the procedures – e.g. the tender for choosing a company for the construction of the NPP was manipulated, allowing only Russian companies to be eligible.

- Bulgaria had no need for a new nuclear reactor for its energy balance – the project was developed with the intention of selling electricity to external markets

The campaign

The campaign against Belene NPP was carried out on a local, national and international level. Local citizens kept opposing the project and spreading information in the towns and villages surrounding the NPP. The NGOs formed a coalition called "No to BeleNE" with 17 Bulgarian organization involved. International organizations like Greenpeace, Bankwatch, Urgewald, Campagna per la Riforma della Banca Mondiale and others did an amazing job spreading information to foreign banks and potential investors.

Several court cases were undertaken - they delayed the project by 3-4 years. First the decision of the government for construction was appealed in court. Then the decision for approval of the EIA was appealed. The Macedonian NGO EcoSvest filed a complaint at the Sofia High Administrative Court because Macedonia was not informed of the project under the Espoo Convention. Bulgaria informed only Romania of its intentions. The court cases were lost but they delayed the developments of the project to a great extent.

One of the key issues was finding the finances for the construction. After an international campaign 12 Western banks withdrew their initial interest for participation - like Deutsche Bank and UniCredit Group. Campaigns in front of the branches of the banks in 22 European cities and a mass sending of letters to the banks were carried out. Useful was also the participation at the AGMs of the stakeholders of the banks or the potential investors.

Constant anti-nuclear work was done by the Bulgarian NGOs. Throughout the years there were protests, media events, press-conferences, exhibitions, info-tours, meetings with politicians, MPs and mayors, constant official requests for information and court cases, etc. The nuclear lobby in Bulgaria is strong and everything around it is nontransparent. There were threats and pressure on the anti-nuclear activists but they kept going.

In 2008 the strategic investor for the project was chosen of ten companies that had stated their interest. The German company RWE was chosen. A campaign in Germany followed this decision. Activists participated in the AGM and the German anti-nuclear movement strongly criticised the involvement of RWE in the risky project. One year later the company decided to withdraw from the project.

The Bulgarian state gave money from the state budget for the project. Immediately an appeal for illegal state aid was filed at the European commission.

Stress Tests

After the Fukushima nuclear meltdown accident the project company of Belene NPP decided to start a 'stress-test' in order to promote its stability and safety measures, concerning EU stress tests under ENSREG umbrella. It was the only 'stress-test' in the world which was made on a nonexistent nuclear power plant - the regulatory bodies didn't recognize it as eligible. The process of the 'stress tests' was intransparent, no answers were given to letters sent by NGOs, no public consultations were held. The product of the 'stress tests' was nothing more but just a short report on risk assessment criteria.

In March 2012 the Belene NPP project was officially cancelled by the government.

Still additional payments of 140 million euros need to be made for "completion" of the first ordered reactor, a loan of 250 million euros has to be paid to BNP Paribas. Payments may also be needed for the potential court case between the Russian and the Bulgarian side.

In 2009 the Belene project was frozen for revision by the new government. In March 2012 it was officially cancelled.

3.2 Czech Republic: Conference “Nuclear Power Plant Load Testing: Safety Inspection or Propaganda?”

The Czech NGOs Calla and South Bohemian Mothers organised a conference titled “Nuclear Power Plant Load Testing: Safety Inspection or Propaganda?” which took place on Thursday, March 1, 2012, 10 am to 3 pm in České Budějovice.

The invitation of the conference described the conference as follows:

In response to the accident in Fukushima nuclear power plant, the European Commission has invited EU Member States to run load tests on nuclear reactors in operation. They are aimed at proving the power plant safety and capacity to withstand beyond-design basis seismic, flood, meteorological and other phenomena. Along with other countries, the Czech Republic has submitted its test results to Brussels for further evaluation. What results have Dukovany and Temelín power plants achieved? Politicians will have the last word in the process; but will they have enough relevant information to make logical conclusions? Nuclear safety is not the only aspect of energy security, so let us take a look at the others.

The following presentations were given:

10.10 - 10.50 Fukushima, one year after: What have we learnt – Dana Drábová, Chairwoman of the State Office for Nuclear Safety

10.50 - 11.30 European load testing: media fiction versus reality – Jan Haverkamp, Greenpeace

11.30 - 12.10 Czech load test reports from a critical perspective – Dalibor Stráský, Upper Austrian Government Appointee for Nuclear Facility Issues, Linz

12.45 - 13.30 Seismic risks in location and operation of nuclear power plants – Roman Lahodynsky, Institute of Risk Research, Universität für Bodenkultur, Vienna

13.30 - 14.10 Current risks in power industry development - Ivan Beneš, General Manager, CityPlan spol. s r.o., Prague

Annotations of the presentations

To give you an impression of the conference, we´d like to show you the annotations of some of the presentations.

Czech reports on stress testing from a critical perspective

Emissary of Upper Austrian Government for Nuclear Installations, Dalibor Stráský

In spite of all the limitations that the final reports on the stress tests show, they also bring more or less new findings about the problems of nuclear safety in situations that were not considered during the design stage. According to the information in the reports elaborated by the operators themselves, it is obvious that the facilities are not ready for beyond-design basis malfunctions. That may be logical, but it is evident after the Fukushima accident at the latest that the safety philosophy has to change radically: accidents which nuclear facilities were designed to cope with have never occurred, whereas accidents not expected by the project design have been occurring. We are therefore facing a question of how to proceed in installations that were designed based on an outdated, now hardly sufficient safety philosophy. The stress tests were meant to answer that. Yet this has not succeeded, because many of the requested analyses have not been completed yet, and not all of the counter-measures proposed are quite realistic. In the most severe accidents with fuel meltdown, it becomes evident that we will have to expect releases of radioactive substances into the environment.

European Stress Tests - the sobering truth behind the media picture of "all power stations have passed the tests",

Jan Haverkamp, Greenpeace

In reaction to the Fukushima catastrophe on 25 March 2011, the European Council stressed "the need to fully draw the lessons from these events, and to provide all necessary information to the public." It wanted that "the safety of all EU nuclear plants should be reviewed, on the basis of a comprehensive and transparent risk and safety assessment ("stress tests");"

- What are those stress tests, and what are they not?
- How are they different from normal safety checks?
- What role is foreseen for the public and NGOs?
- What were the results in Europe?
- What have they revealed about Czech nuclear safety?

The stress tests are now on 2/3rd of their way and the results are sobering. Not only have they revealed that Fukushima could literally happen at every nuclear power station in the EU, Switzerland and Ukraine, they also showed that many problems that complicated the Fukushima catastrophe also exist here - and sometimes to a larger extent.

They also show that many questions remain open and unaddressed. The final word in the stress test will be for politicians - but will they be sufficiently equipped to draw the logical conclusions?

Results

95 participants from the Czech Republic and Austria took part in the conference. Among them were the governor of South Bohemia Jiří Zimola, the chairman of the CR Green Party Ondřej Liška, senator Tomáš Jirsa, pupils, students, NGOs and representatives of ČEZ und JETE.

Many critical questions of the participants were demanded to Mrs. Drábová concerning advantages of the NPP for the region, the independence of SUJB and questions on nuclear safety.

The following media reported on the conference: TV: Česká televize (TV); radios: Českém rozhlase, Rádiu Česko; print media: Českobudějovické listy, Haló noviny, Právo und E15, Econnet.

Audio recordings of the entire conference can be found under www.temelin.cz.

The event helped not only to understand the set-up of the stress tests, but also the broader situation (nuclear regulation etc.).

3.3 Hungary – Problems of lifetime extension of nuclear power plants

By András Perger, Energiaklub

The global nuclear reactor fleet is ageing; the average age of the officially 436 operated reactors is over 27 years. Where the reactors are older, especially in the USA, Canada and the European Union, practically so few reactors are under construction, that it would be impossible to replace the old units, when those reach their designed lifetime, with new ones (see next figure).

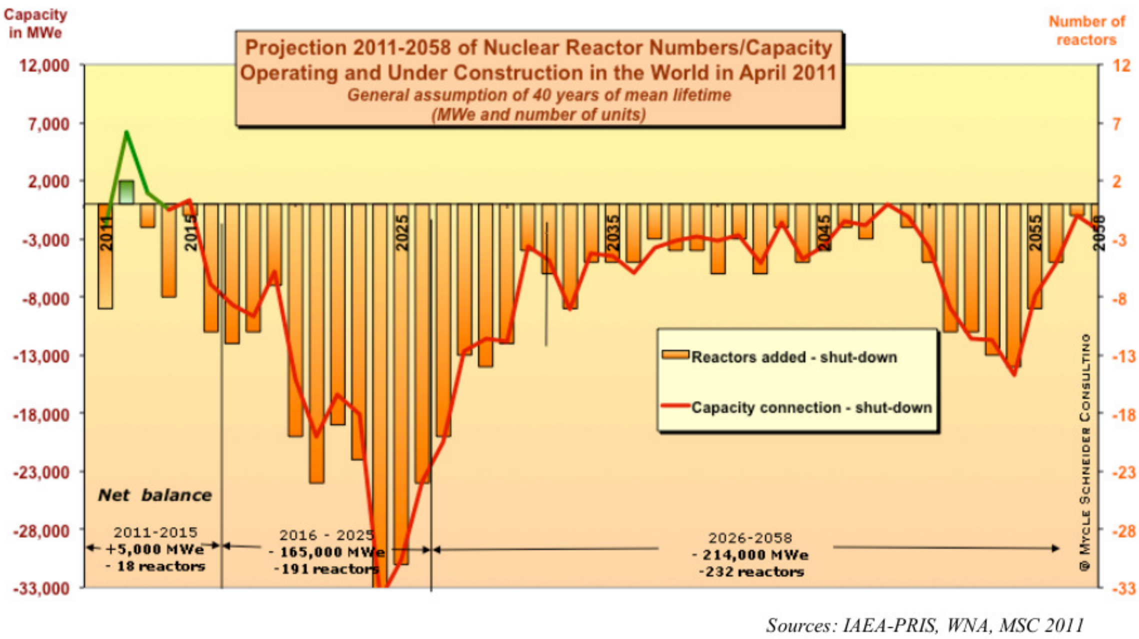

Figure 1. (Schneider et al.: World Nuclear industry status report 2010-11)

There are several reasons behind this phenomenon, but the most important factor is the economics of the new units. The construction costs of the designs that are available on the market are enormous, and investments on liberalized markets are too risky in comparison with other energy production solutions. As a result, private investors tend to choose alternatives.

The other option for maintaining the nuclear energy production is to extend the operation of the ageing reactors, beyond the originally designed lifetime. Having the construction costs paid back, the lifetime extension process is highly economic, as the already paid off facilities become money makers.

The second generation reactors that represent most of the worldwide fleet of reactors were generally designed for 30-40 years of lifetime. Those were built in the seventies and in the eighties, so most of them are about to reach the end of the designed lifetime, mainly in the next decade; the first couple of reactors has already started their prolonged lifetime, in the USA and in Russia. However, lifetime extension does not solve the main problem of the nuclear industry on the long run (see Figure 2).

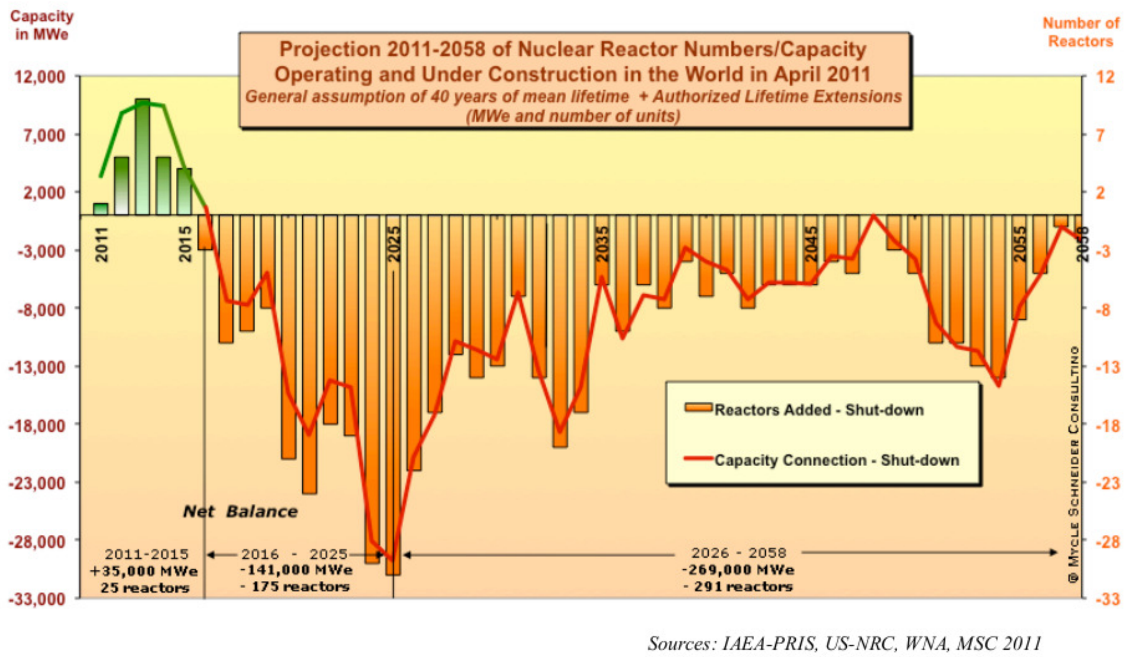

Figure 2. (Schneider et al.: World Nuclear industry status report 2010-11)

According to the reactor vendors, operators and nuclear authorities, the originally planned safety margins were calculated with so much conservatism, which, completed with appropriate operational and maintenance methods that contribute to the conservation of the margins, result in a situation in which the reactors can be operated for 10-20 years longer, beyond the designed lifetime.

Licensing of reactors has two main different approaches. In several countries authorities issue licenses every ten years (e.g. France), after safety approval, with special attention to the condition of the equipment. In other countries, reactors gain their main licenses for 30 or 40 years (e.g. USA), where the number of years could refer to technical aspects, like designed lifetime, but not certainly. In these countries the renewed license gives permission for another certain period, 20 years generally. The process contains safety and environmental issues. It should be noted that in most of these countries, reactor operation is also a subject of safety related licensing in every 10 years.

The basic limitation factor for lifetime extension is safety. The main bottleneck is the condition of the equipment that has safety relevance and due to technical or economical reasons, cannot be replaced or renewed, e.g. the reactor pressure vessel or heat generators. There are worries that the expectations of the industry, regarding the period of time in the reactors can be safely operated beyond the designed lifetime, are overoptimistic. The bathtub curve that describes the proneness of a technical system for failures as a function of time could also be valid in the case of nuclear power plants (see figure 3).

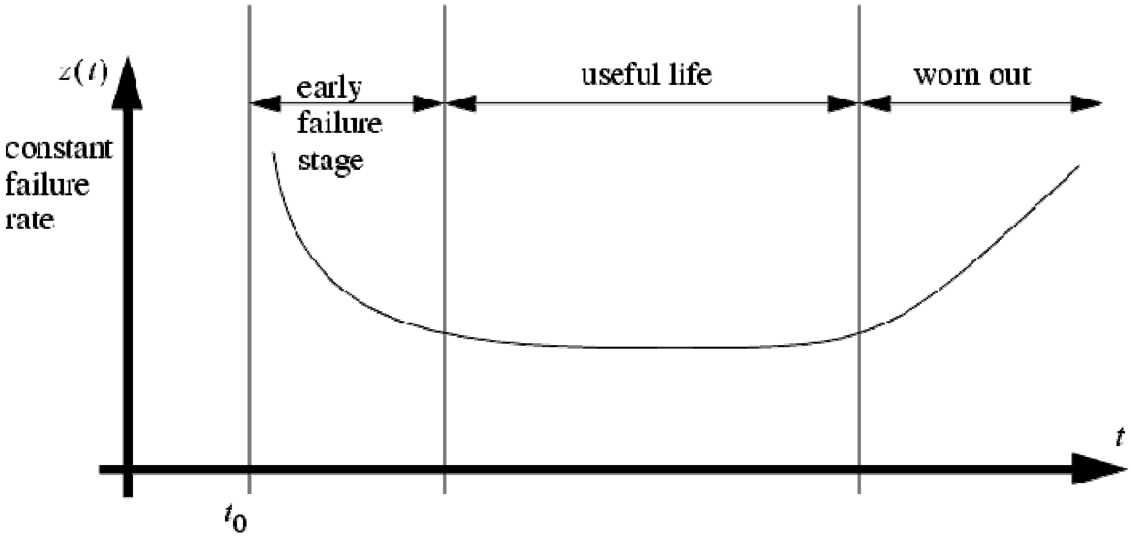

Figure 3. (http://engineeronadisk.com/notes_engineer/systemsa2.html)

Nuclear power plants are complex systems, so tracking the condition of all the equipments is a complicated task. This means that after the reactors pass the designed lifetime, the number of failures could start to grow. With special attention to the fact that there are not too much experiences with operating nuclear reactors beyond the designed lifetime, the argumentation of the industry that the safety related equipments are thoroughly monitored, is not fully reassuring. The concerns are growing due to the Fukushima accident, as it revealed that there could be basic safety problems with the old units, whose design was prepared back in the sixties or seventies.

In the region around Hungary, there are 10 (11) units that are about to extend their lifetime (see table below). The other units in the region (Temelín 1-2, Kozloduy 5-6, Cernavoda 1-2, Mochovce 1-2) are younger, so there are no plans for extending their lifetime yet.

Reactors	Country	Design	Start-up date	Planned retirement date (design lifetime, years)	Planned lifetime extension (years)
Dukovany 1-4	Czech Republic	VVER 440/213	1985-87	2015-17 (30)	20
Bohunice 3-4	Slovakia	VVER 440/213	1984-85	2014-15 (30)	20
Paks 1-4	Hungary	VVER 440/213	1982-87	2012-17 (30)	20
Krsko 1	Slovenia	Westinghouse 212 PWR	1983	2023 (40)	20

As we can see, ten of the concerned units are of the same design, the soviet VVER 440/213 type. The main safety concerns with these units are about the containment system, which is not equal to the full pressure containments that were built at the same time for western designs; the condition of the equipment can be questionable, as the quality of the materials, the construction technology and practice that were available in these countries when the units were built could be below western standards, and the documentation of the construction process is not always reliable in some cases; and the safety culture of the concerned power plants has also been questioned by international reviews, and demonstrated by incidents.

PLEX in Hungary

Hungary was the first case where an environmental impact assessment (EIA) was required for a plant lifetime extension. In this context, in 2004 the Preliminary Environmental Study was published and in March 2006 the Environmental Impact Study. In Nov. 2006 Hungary issued the environmental license for Paks lifetime extension.

3.4 Romania: Risks of the CANDU reactor design

By Ioana Ciuta, Director executive, TERRA Mileniul III, Romania, http://www.terramileniultrei.ro

Introduction

The CANDU (CANada Deuterium Uranium) reactor is a pressurized heavy water reactor of Canadian Design.

Atomic Energy of Canada Limited (AECL) developed the CANDU reactor technology starting in the 1950s. All Canadian nuclear reactors are of the CANDU type but the reactor has also been marketed abroad - until October 2011 AECL marketed and built 34 CANDU facilities worldwide: Canada (22), Argentina (1), Romania (2), South Korea (4), China (2), Pakistan (1) and India (2). In Europe Romania is the only country operating CANDU reactors (at the Cernavoda site).

The main advantage of the CANDU reactor is that it can be operated with natural uranium – so no uranium enrichment is necessary. The CANDU reactor is also recognized for its robustness. However, the Canadian experience at the nuclear power plants of Point Lepreau and Gentilly comes to prove that the CANDU reactor is far from perfect.

This text aims to draw the attention of European stakeholders and Romanian public onto specific technical problems related to CANDU reactors, but also to illustrate some corruption cases linked to the nuclear industry, particularly the Canadian one.

Advantages of the CANDU design

CANDU in Europe is recognized for its robustness, having more strong points than any other type of reactor. The passive features of the CANDU reactor design have a beneficial effect in that they delay the progression of severe accidents, thereby providing an opportunity for operator actions to stabilize the plant and mitigate the consequences. It is said that large CANDU reactors are inherently tolerant of a prolonged loss of engineered heat sinks at decay power levels. This is because two large volumes of water (the moderator and shield water) surround the reactor core and act as in situ passive heat sinks in severe accidents.

Another advantage of the CANDU reactor is that it can be operated with natural uranium, so no uranium-enrichment services have to be bought for that plant. Moreover, if uranium could be mined within the country (e.g. urnanium for the Romanian CANDU reactors is mined in the Romanian Crucea mine), the nuclear fuel cycle could become entirely indigenous. A government might choose that arrangement from the perspective of economics and/or energy security.

Risks associated with the CANDU 6 design, overview

The concept of "risk" encompasses the probability and magnitude of an adverse impact on humans and the environment. Operation of any nuclear power plant creates risks. Plants of the CANDU 6 design pose additional risks that arise from basic features of the design, especially the use of natural uranium as fuel and heavy water as moderator and coolant. Those features create additional risks in two respects.

- First, at a CANDU 6 plant it is comparatively easy to divert spent fuel in order to produce plutonium for nuclear weapons,

- Second. a CANDU 6 reactor could experience a violent power excursion, potentially leading to containment failure and a release of radioactive material to the environment

Risk 1. The risk of diversion of spent fuel

The CANDU 6 design uses natural-uranium fuel and on-line refueling. Thus, CANDU 6 could be a preferred plant choice for a government that contemplates the possibility of deploying a nuclear arsenal.

AECL hopes to sell the CANDU 6 to a number of countries. Presumably, those countries would see advantages to the CANDU 6 that would offset risk issues such as a positive void coefficient and vulnerability to malevolent acts. It appears that the Turkish government sees such advantages. In soliciting bids for construction of new nuclear power plants in Turkey, the Turkish government has stated that it will consider the construction of CANDU-type plants only if they are fueled by natural uranium[33]. The ACR-1000 is excluded by that requirement, but the CANDU 6 is allowed.

Another reason for a government to favor a plant design that uses natural-uranium fuel.

But there is also another consideration that a government would be unlikely to discuss in public: deployment of an indigenous nuclear fuel cycle, featuring reactors that employ on-line refueling, would provide the country with a virtual capability to produce plutonium sufficient for a substantial arsenal of nuclear weapons. The country's government could draw upon that capability at some future date, depending on the government's assessment of the net benefit of establishing a nuclear arsenal.

Canadians must, therefore, consider the risk that AECL's [34] marketing of the CANDU 6 could contribute to the proliferation of nuclear weapons, albeit inadvertently. In contemplating that risk, it should be noted that growth in the number of nuclear-weapon states could increase the probability of nuclear war, in part by expanding the number of decision centers. Canada has experience in inadvertently contributing to nuclear-weapon proliferation, having supplied the CIRUS research reactor to India in the 1950s, with the condition that the reactor be used only for peaceful purposes. In fact, India produced plutonium in CIRUS for its 1974 test of a nuclear weapon, and for subsequent nuclear weapons.

Risk 2: The risk of an unplanned release of radioactive material[35]

In the context of an unplanned, radioactive release, a CANDU 6 plant has many characteristics in common with other nuclear power plants now operating worldwide. Almost all of those plants are in the "Generation II" category, and most (80 percent) are light-water reactors (LWRs) that are moderated and cooled by light water. Plants constructed during the next few decades would be in the Generation III category.

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[33] RISKS OF OPERATING CANDU 6 NUCLEAR POWER PLANTS: Gentilly Unit 2 Refurbishment and its Global Implications, by Gordon R. Thompson, Institute for Resource and Security Studies

[34] Atomic Energy of Canada Limited, nuclear science and technology laboratory

[35] RISKS OF OPERATING CANDU 6 NUCLEAR POWER PLANTS: Gentilly Unit 2 Refurbishment and its Global Implications, by Gordon R. Thompson, Institute for Resource and Security Studies

Any of the nuclear power plants now operating could experience an unplanned release of radioactive material as a result of an accident or a malevolent act. There are plant-specific aspects of the potential for such a release, but also broad similarities.

Flaws discovered in 2001 in the CANDU reactor at Point Lepreau in New Brunswick (Canada) have raised concerns about safety, inspection and management issues associated with the Canadian CANDU reactor design, in Canada and internationally.

Specifically, CANDU reactors essentially identical to the flawed Point Lepreau reactor have already been built in India, Pakistan, South Korea, Argentina, Romania, and China. The flaw consists of a potential for unanticipated sudden Loss of Coolant Accidents ("LOCAs") arising from failures in so-called Feeder Pipes through two mechanisms – one of which has been almost totally ignored by Canada's nuclear regulator, despite already having caused two Feeder Pipe failures at Point Lepreau – the first in 1997 and the second on March 8, 2001.

Energy Probe, an independent non-governmental nuclear watchdog organization in Canada, has reviewed expert evidence establishing that a long-ignored failure mechanism – known as Stress Corrosion Cracking (SCC) – has the potential to cause far more serious failures than the two that occurred at Point Lepreau, and to do so with little warning[36].

Specifically, the two Feeder Pipe cracks at Point Lepreau were both in the axial or "lengthwise" direction, and therefore produced detectable leaks before the pipes broke. But experience with natural-gas pipelines subject to SCC shows that the same mechanism can also produce much more serious cracks in the circumferential or "crosswise" direction, which can produce "guillotine" pipe failures with no prior detectable leaks. Such an event in any two of a CANDU reactor's 760 Feeder Pipes would produce a potentially catastrophic "Beyond Design Basis" loss of coolant accident, or LOCA.

The feeder pipes contain essential cooling water at enormous pressure – approximately 100 times the pressure of a kitchen pressure cooker – and that water would immediately "flash" into steam if the pipes broke, leaving the fuel uncooled. In the CANDU reactor, a well-known design problem means that a loss of coolant inherently causes an increase in the power level, and heat output, of the nuclear fuel, placing enormous pressure on the reactor's emergency shutdown systems. However, even after a successful shutdown, the fuel in a CANDU reactor produces approximately 140,000,000 watts of heat – heat which must be removed by circulating water, or the highly radioactive fuel will overheat and begin to release radioactive gases, or even melt.

Another study, "Exporting Disaster -The Cost of Selling CANDU Reactors", written by David Martin of Nuclear Awareness Project for the Campaign for Nuclear Phaseout, in November 1996, shows that: "The start-up of Cernavoda-1 has been plagued by a number of problems. Perhaps most serious were the various managerial and quality assurance problems caused and aggravated by the Ceausescu regime. AECL staff had condoned the situation for many years, and claim that in 1988 they had threatened to pull out of the project. AECL's resolve was never tested however, since the 1989 revolt intervened, and the project was subsequently restructured.

[36] http://ep.probeinternational.org/2001/06/13/emerging-safety-problem-candu-reactors/

After the restructuring in 1991 – adoption of the new Constitution which changed the basis for the Government and Parliament in Romania – AECL says that 25- 30% of the welds in the reactor had to be repaired.

There are a number of endemic design problems with Cernavoda-1, not the least of which is that it is a reactor with 1960s technology being started-up in 1996. Also, because of earlier grandiose plans for 5 reactors, the control room is segregated into five sections and oversized. In July 1996, it was reported that availability of spare parts for Cernavoda was a serious concern. Notably, the reactor's main process computer is a 1960s-vintage Univac data system, which has not been sold for over 15 years (N.B: this was written in 1996!). Parts have been taken from the computer purchased for Cernavoda-2, as have some valves and other hardware.

In the last 10 years, a number of previously unanticipated safety problems have occurred at different power plants in Canada, all of them requiring expensive corrective action costing millions of dollars each.

For instance, when Gentilly-2[37] was built, nobody thought about the possibility that an accident could kill everybody in the control room of the nuclear reactor, possibly resulting in a catastrophic accident. In early 1990's, AECB/CNSC (Canada's nuclear regulator) discovered that a sudden break in one of the steam pipes passing over the roof of the control room could, in fact, kill everyone inside and make the control room unusable. Obviously, this improbable situation could be extremely hazardous for the population at large. At first, AECB wanted Hydro-Quebec to relocate the steam pipes, but Hydro-Quebec argued that this would be too expensive. Instead they offered to make some substantial alterations to the interior design of the building so as to minimize the effects of such a break in the steam pipes, and to carefully monitor the pipes so as to detect any weakening which might (or might not) occur before such a break would happen. Those corrective actions are still being carried out.

Another example is the LOCA event in Pickering in 1983. Every CANDU reactor has an Emergency Core Cooling System (ECCS) which is supposed to flood the core of the reactor with ordinary water in case of a large LOCA to prevent it from overheating. Sometimes, however, the ECCS is not available. The AECB allows the ECCS to be unavailable for up to eight hours in any given year, and in some cases it is unavailable for a much longer period of time. If a large LOCA were to happen at such a time, serious core damage could occur and a nuclear catastrophe could result.

The first LOCA in a Canadian nuclear generating station was at Pickering, just outside of Toronto, in 1983, when a pressure tube burst without warning in the core of the reactor. A few years earlier, nuclear experts had insisted that a pressure tube could not burst suddenly, because it would begin to leak long before it would break, giving the operators enough time to shut the reactor down and correct the situation. But the experts were wrong.

[37] http://www.ccnr.org/Gentilly_Safety.html#Gentilly

Repairs to the core of the Pickering reactor took four years and cost more than 500 million dollars. All of the pressure tubes had to be replaced, since many of them were showing signs of serious deterioration and some were developing blisters.

Conclusions

Operation of any nuclear power plant creates risks. Plants of the CANDU 6 design pose additional risks that arise from basic features of the design, especially the use of natural uranium as fuel and heavy water as moderator. Those features create additional risks in two respects. First, a CANDU 6 reactor could experience a violent power excursion, potentially leading to containment failure and a release of radioactive material to the environment. Second, spent fuel discharged from a CANDU 6 plant could be diverted and used to produce plutonium for nuclear weapons.

In the long term, nuclear and fossil-fuelled power plants are not alternatives to each other. Rather, they are both part of an environmentally unsustainable approach to the electricity system. There are cleaner, safer, alternatives that are both technically feasible and economically sustainable. In a sustainable energy future, end-use efficiency, co-generation and renewable energy will be phased in at a pace that will ensure an orderly transition as our fossil power plants are phased out. The technological transition will be based on the phenomenal advances already taking place in energy efficiency of buildings and all types of energy-using equipment, and on the rapidly expanding wind, solar and other renewable technologies that are now globally outpacing the growth rates of all other types of power generation.

3.5 Slovak Republic: Safety deficits of the NPP Mochovce

By Patricia Lorenz, June 2012

The NPP Mochovce has been designed in the 1970s in the Soviet Union. Currently 2 reactors are operating (MO 1&2) and 2 "new" reactors are under construction (MO 3&4). Construction of MO 3&4 started already in 1984 – but came to a halt in 1992 due to lack of financial resources. The current construction of the reactors 3 and 4, however, is not based on the very original design, but saw quite many changes, which are not fully known.

Some of the changes are intended to mitigate the known safety deficits of reactors of the WWER 440/V213 type like described in several IAEA documents[38]. Others are designed to enhance the power output of the plant.

But analysis show, that despite these change, the planned reactors MO 3&4 will not reach safety levels of new reactors as 70% of the building structure and 30% of the equipment have already been completed in the 1980s – an adaption to the current state of the art is therefore not possible.[39]

The changes were not discussed during the EIA of MO 3&4. Some changes to the original design are even less in the focus of the interested public and were not answered during the EIA, while they can change the behaviour of the reactor e.g. during accidents significantly.

Below some examples of the changes to the original design are described:

1 Fuel stays longer in the reactor

While the original VVER 440/213 are designed to have 3 year fuel campaigns as the permit of 1986 assumed, the MO34 units are to run on at least 5 year fuel exchange campaign.

2 Higher enrichment of the fuel elements and switch to new fuel elements (Gadolinium II). High burn-up over 50 MWd/kg cause higher fuel tube cladding corrosion and high release of fission gas from the fuel pellets. Both changes induced by the high burn-up can negatively influence the core cooling during nuclear events and accidents.

3 Hydrogen removal system

During an accident, hydrogen develops due to a chemical reaction of metal with water and radiolysis in the core. Under the design basis accident conditions, this is a long term process, which leads sooner or later to a concentration of hydrogen. The intention in newer plants is to prevent this however, it is crucial to determine

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[38] IAEA (1996): IAEA 1996 Safety Issues and their Ranking for WWER-440 Model 213 Nuclear Power Plants, IAEA-EBP-WWER-03
IAEA (1999): Final Report of the Programme on the Safety of WWER and RBMK Nuclear Power Plants IAEA-EBP-WWER-15,

[39] Wenisch et al. (2009): KKW Mochovce Bewertung der Modernisierungsmaßnahmen für das KKW Mochovce 3/4; commissioned by the Wiener Umweltanwaltschaft

the right way. There are two options: catalytic re-combinators or sparkers, which should prevent containment failure. This needs to be assessed carefully.

4 Instrumentation and Control system

The Instrumentation and Control system of a NPP is the heart of the plant. While the original design of the VVER 440/213 from the very early 70ies was of course analogue, the plant now under completion is to be equipped with a new digital I&C.

Unforeseen problems might arise between signals of the analogue equipment and the new I & C. Valve control can go wrong, temperature measurement, pressure, all functions including safety relevant functions of the I & C.

Short Overview over the Slovak National Stress Test Report

In 2011 a new safety assessment took place, the stress test. It is important to point out that ENSREG itself stated that e.g. the design basis of NPP was not part of the stress tests, while the Slovak operator likes to report that its NPP are safe, now that they "passed" the stress test.

The following section is a summary of Dalibor Stráský´s Statement in English on the Slovak stress tests - prepared by Patricia Lorenz.[40]

- All Slovak NPP operate the same reactor type VVER440/213, Bohunice as well as Mochovce 1&2 and 3&4 (under construction). The ENSREG requirements were not fulfilled by the operator. Earthquakes and flooding were the only initiating events examined though Annex I ENSREG stress test requirements also demanded to include other scenarios („… *the assessment of consequences of loss of safety functions is relevant also if the situation is provoked by indirect initiating events, for instance large disturbance from the electrical power grid impacting AC power distribution systems or forest fire, airplane crash*.").

- The National Report of Slovakia only examines the failure of one system at a time, while all other are supposed to continue to function according to programme; a combination of events is excluded with the explanation, that this would require complex analyses.

- Similar to the Czech attitude, also the Slovak Nuclear Authority accepts the term „containment" for the VVER 440/213 reactors. This is not correct, because these „confinements" are not full-pressure containments, pressure relief e.g. in cases of severe accidents takes place in an another building, the Bubbler Condenser.

- An accident core melt is assumed to be solved by cooling the reactor pressure vessel from outside. The reactor cavity door was identified as a weakness – its failure practically cannot be excluded and can lead to large radioactive releases into the environment. This reactor cannot guarantee, that the core melt will be stabilised and reactor shaft integrity kept.

[40] Dalibor Stráský´s complete analyses is available in German and in Czech language: http://www.anschober.at/politik/presse/1428/akw-stresstests

Following analyses, which were announced in previous safety reports, were not conducted:

- Cooling water leak via main cooling pump seals
- Inhomogeneous hydrogen distribution and possible hydrogen concentration in the spent cooling ponds
- Severe accidents in the cooling ponds
- Habitability of the Control Room after a severe accident in the cooling pond

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Useful Links

Joint Project

Joint Project Webpage - http://www.joint-project.org

Links to Joint Project members

Hnuti Duha (CZ) - http://www.hnutiduha.cz/
Calla (CZ) - http://www.calla.cz
South Bohemian Mothers (CZ) - http://www.jihoceskematky.cz/en/
Za Zemiata (BG) - http://www.zazemiata.org
Terra Mileniul III (RO)- http://www.terraiii.ngo.ro/
Energy Club (HU) - http://www.energiaklub.hu/en/
Hungarian Environmental Partnership Foundation (HEPF) - http://okotars.hu/en
Austrian Institute of Ecology (AT) - http://www.ecology.at

Links about Stress Tests

http://www.ensreg.eu/eu-stress-tests

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