ENSREG
European Nuclear Safety Regulators Group

EU Peer Review Report
Implementation of Belarusian Stress Test National Action Plan

September 2021

Contents

1 INTRODUCTION and BACKGROUND

Following the 2011 Fukushima accident, Europe took the lead in carrying out comprehensive risk and safety assessments (stress tests) of nuclear power plants (NPPs) to assess how they could withstand extreme external events.

The results of the EU stress tests provided important technical insights for safety improvements that have been or are well under way to being implemented in all 17 participating countries in order to achieve a higher level of nuclear safety.

The EU stress tests have been carried out in a transparent manner and the results have been actively shared, in the interests of our people and a stronger global safety culture. In addition, the aim is to contribute to a more robust and solid nuclear framework worldwide.

At the time of the original EU stress tests, a number of non-EU countries expressed their interest in following the same peer review process but were not ready to join and immediately submit a report. The European Commission has always indicated its willingness to support non-EU countries, in particular in the EU neighbourhood, in the peer review process in collaboration with the European Nuclear Safety Regulators Group (ENSREG), whenever that country is ready.

In June 2011, Belarus confirmed its willingness to undertake the stress tests voluntarily, which were to be carried out in line with the specifications agreed by the European Commission and ENSREG. Belarus stepped into the process in 2017 when it submitted its national report.

The purpose of this document is to record the results and conclusions of the peer review of the National Action Plan (NAcP) of Belarus. The results and conclusions in this document are based on information received via documents provided by Belarusian counterparts upon ENSREG PRT request, discussions in online meetings between both parties and two visits to the Belarusian nuclear power plant (BelNPP) on 9 and 10 February 2021 and 31 August to 2 September 2021. Information received was verified during the site visits to BelNPP, which included both document reviews, expert discussions and walk downs. The NAcP, the content and implementation status of which is being evaluated, was produced as a result of the EU stress test approach being applied in Belarus.

Due to the Covid-19 pandemic, it was not possible to carry out the peer review of the NAcP as originally planned. The pandemic resulted in limitations on travelling and organising face-to-face meetings, so the PRT was unable to organise a full scope fact-finding mission to Belarus in December 2020, as originally planned. Therefore, the peer review had to be divided into two phases. In the first phase, the goal was to complete the review of issues, which were recognized by PRT as high priority. The second phase had as its goal to complete the review of all issues. The PRT prepared two reports. The focus of the preliminary report issued by the PRT on 18 February and endorsed by ENSREG on 3 March was on evaluating the overall comprehensiveness of the NAcP and the implementation status of recommendations related to the high priority issues. This final report was prepared after the second site visit at the end of the second phase and it contains the assessment and conclusions relating to all issues reviewed in the two phases of the peer review.

It has been emphasised that a stress test exercise remains a targeted process reviewing certain safety aspects of an NPP (see stress test specifications[1]) with the objective of further enhancement of safety. A stress test and the implementation of follow-up actions should not be used to justify or authorise the safe operation of an NPP nor its long-term operation or lifetime extension. Such authorisations have to be in line with the procedures prescribed in the national law and under the full responsibility of the national regulatory authorities.

2 PROCESS OF PEER REVIEW FOR BELARUS

The peer review of the national report was completed in 2018. The first step was a desktop peer review of the report that led to questions being presented to and answers being received from the Belarusian nuclear regulatory authority, Gosatomnadzor (GAN). The second step consisted of visiting BelNPP by the team of experts to follow-up their lines of enquiry.

The PRT issued a report (PRT 2018 report) assessing the national report (NR) and providing recommendations for increasing safety in BelNPP[2].

In 2019, GAN submitted an NAcP, converting recommendations in their national report and the stress test peer review report into concrete actions to enhance safety together with a timeline for implementation.

2.1 Peer review of the NAcP

The peer review of the Belarusian NAcP began after GAN provided the PRT with an updated NAcP in January 2020[3]. It was the second peer review of an NAcP (after Armenia in 2019) since the two workshops that took place in 2013 and 2015 to review of the NAcPs during the 'first wave' of stress tests, i.e. EU Member States, Switzerland and Ukraine.

The objective of the peer review was to consider how the actions in the NAcP were developed from the national report, the stress test PRT's recommendations and other relevant recommendations and to ensure that all the recommendations were appropriately addressed. The peer review also considered whether adequate progress was made in implementing the actions identified.

Despite having the same objective and rules as the workshop reviews, the review of the Belarusian NAcP differed from those in two main areas:

- it covered
    - the NAcP, as developed following the national report and the stress test PRT's recommendations, and
    - the information on its implementation after approximately a year since its official publication;
- it was divided into two phases due to the Covid-19 pandemic.

As with the national stress test report, the peer review of the NAcP started with a desktop exercise, with questions prepared by a team of experts and ENSREG members. A team of 12 was established

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[1] http://ensreg.eu/node/289/

[2] http://www.ensreg.eu/document/belarus-stress-test-final-report

[3] https://gosatomnadzor.mchs.gov.by/upload/iblock/f65/natsplan-stress_testy.rar

from the experts nominated by ENSREG[4]. The European Commission provided a rapporteur to assist the team. Their review led to a total of 93 questions[5] on the NAcP's content that were submitted to GAN on 24 July 2020. GAN subsequently provided written responses on 30 October and 30 November 2020.

On 24 November 2020, the PRT provided GAN with a first draft of its report. It was based on the written answers received from GAN to the PRT's questions and the online discussions seeking to obtain further clarification on the written answers. Due to the Covid-19 pandemic, a full fact-finding mission to Belarus planned for December 2020 including expert meetings and a site visit had to be cancelled. An updated draft report focussing on high priority issues was provided to GAN on 22 December 2020 and used as a basis for further work in phase 1. A hybrid fact-finding mission with online expert meetings and a site visit focusing on the implementation status of high priority issues was conducted in January and February 2021. The full fact-finding mission to Belarus took place 31 August to 2 September 2021. The goal of the latter was to discuss the status of all recommendations, particularly those not addressed in the preliminary report, and to evaluate and verify their implementation status. The second fact-finding mission was prepared in several online meetings combined with provision of further information in writing. This final report on the peer review of the NAcP provides a record of all the findings made during the two phases of the peer review.

2.2 Experience in Belarus, site visit

The peer review of the Belarusian NAcP presented some specific features. The country visit was conducted in two steps instead of one single fact-finding mission. The reason for this was the request to review a number of issues prior to the start of the commercial operation of Unit 1 despite the rampant Covid-19 pandemic. All activities during the two country visits to Belarus were conducted on the BelNPP site. This choice was made, in order to minimize both travel and meetings during the Covid-19 pandemic.

The PRT had a positive experience in Belarus. The careful preparation of the two site visits in online meetings helped the PRT to fine-tune its technical queries and its Belarusian counterparts to better understand the needs of the PRT, which led to higher effectiveness of work on site. The time set aside for the two missions was appropriate, allowing sufficient time to engage with counterparts, review necessary documents and visit locations necessary for forming an informed judgment on the Belarusian NAcP and its current implementation status.

GAN and BelNPP staff together with other experts involved (the Belarusian team), made themselves available, and were helpful to the PRT, as it sought to get a good understanding of the Belarusian NAcP and the country's progress with implementation of the actions. Communication between the teams was supported by interpreters, which made interaction easy in the animated, intensive discussions.

The visits were very informative. The PRT were able to observe all areas of the plant that they had expressed an interest in seeing, including: the reactor building, main control room, emergency

[4] The team was later expanded by four experts to ensure sufficient representation during the phase 1 country visit.

[5] Whereby all sub-questions relating to one NAcP action or PRT recommendation were counted as one question. This is in line with the practice adopted earlier in the NAcP peer review. The total number of sub-questions was 245.

control room, simulator, emergency centre, buildings housing safety systems, diesel generators, and flooding protection and fire brigade. Drawings, procedures and other documentation were also reviewed.

2.3 Peer review report structure

The PRT sought to follow the reporting template adopted by ENSREG for the workshops of 2013 and 2015. This report has chapters aligned to the 2012 stress tests template, covering the following topics:

i) assessment of the NAcP's structure;
ii) assessment of the NAcP's content;
iii) peer review conclusions.

The report contains some additional details explaining the process adopted, as well as a short summary of the findings for each of the three topic areas. It also includes a set of tables recording each action and a short evaluation of its implementation by the PRT. The comprehensive assessment together with further recommendations on how to achieve the safety improvements addressed in the NAcP are contained in the Appendix below – '*PRT Assessment of Belarusian National Action Plan*'. This Appendix forms an integral part of this report. It includes evaluation on all recommendations.

3 ASSESSMENT OF THE STRUCTURE OF NATIONAL ACTION PLAN

GAN produced the NAcP on behalf of Belarus in 2019 to address the findings of the stress tests in line with the principle of intelligent ownership as recommended in the PRT 2018 report. The sources used for the preparation of the NAcP were:

- National Report – Belarus Stress Test National Report – 2017;
- ENSREG Peer Review of Belarus Stress Tests – June 2018;
- comments and proposals received from the environmental organisation Ecohome (via letters nr 46 (of 18 May 2018) and nr 130 (of 10 October 2018).,

As a result of the EU stress tests, ENSREG issued a report – '*Compilation of Recommendations and Suggestions from the Review European Stress Tests – July 2012'*. In addition, an extraordinary meeting was organised in August 2012 by the Contracting Parties to the Convention on Nuclear Safety. This meeting resulted in the issuing of the '*Summary Report of the 2nd Extraordinary Meeting of the Contracting Parties to the Convention on Nuclear Safety – August 2012'*. The conclusions from these reports are typically used in compiling action plans.

The PRT noted that the two references mentioned above (ENSREG 2012 report and CNS Summary report) have not been used as explicit references in the Belarusian NAcP. The PRT considers that this deviation did not significantly impact to overall quality of the peer review with regard to the content of the NAcP or the review process due to following reasons. The bases of the review are the relevant IAEA safety requirements and WENRA Safety Reference Levels. Both the IAEA safety requirements and WENRA Safety Reference Levels have been updated prior to commencement of the Belarus Stress tests and were therefore considered when conducting the peer review and while setting recommendations in the 2018 PRT report. Updating of the IAEA safety requirements and WENRA Safety Reference Levels took due account of the two references mentioned above.

The NAcP contains a range of actions based on the recommendations made in the peer review. The structure of the NAcP is in line with that suggested by ENSREG:

- Part I - external hazards, loss of safety systems and severe accident management;
- Part II - national organisation, emergency preparedness and emergency response, and international cooperation;
- Part III gives the list of measures aimed at implementing all the recommendations contained in parts I – II.

An update to the NAcP was issued in January 2020. This contains information about the state of implementation of the NAcP actions and tasks. These are listed in detail in the Appendix below along with the PRT evaluation of each action and task.

4 ASSESSMENT OF THE CONTENT OF NATIONAL ACTION PLAN

This chapter evaluates the comprehensiveness of the NAcP: whether the NAcP addresses all recommendations from the 2018 PRT report and whether the proposed actions meet the intent of the recommendations. In addition, an evaluation of how the recommendations were implemented is carried out.

The results and conclusions in this chapter are based on information received via documents provided by Belarusian counterparts, discussions in online meetings between both parties and the two fact-finding missions to BelNPP in February and August-September 2021.

In sections 4.1 – 4.3, the individual actions of the Belarusian NAcP and their basis – the recommendations of the 2018 PRT report - are listed for each of the three topics, followed by a brief description of the most important contents of the NAcP. Detailed comments on the individual actions and recommendations of the NAcP can be found in the Appendix PRT '*Assessment of Belarusian National Action Plan'*.

General remark

As stated in the 2018 PRT report, the plant under review in Belarus is a new NPP. Therefore, the PRT experts considered that highest safety standards should be taken into account during the stress test process for Belarus even though the construction licence for BelNPP was issued before WENRA established its approach for new reactors. The 2013 WENRA report on the '*safety of new NPP designs'* stipulates that for new NPP designs 'Accident sequences with core melt resulting from external hazards which would lead to early or large releases should be practically eliminated'. WENRA further specifies '*For that reason, rare and severe external hazards, which may be additional to the general design basis, unless screened out (…), need to be taken into account in the overall safety analysis'*. WENRA further states that '*rare and severe external hazards are additional to the general design basis and represent more challenging or less frequent events. This is a similar situation to that between Design Basis Conditions (DBC) and Design Extension Conditions (DEC); they need to be considered in the design, but the analysis could be realistic rather than conservative'.*

These WENRA safety expectations require the external hazards in the plant design to be considered broadly and extensively, as well as the consideration of events with occurrence probabilities below 10^{-4} per year in the safety demonstration.

4.1 Natural hazards

The Belarusian NAcP contains actions linked to 12 PRT recommendations that concern natural hazards (Topic 1).

Earthquakes

Out of the 12 recommendations related to natural hazards, nine actions are related to earthquake (reference to PRT's recommendations of 2018 in parenthesis).

- No. 2: Review of the seismic PSA taking into account the probabilistic seismic hazard assessments (PSHA) of 2018 and 2020 and ensure that appropriate safety upgrading measures are implemented to conform with Western European Nuclear Regulators Association (WENRA) safety objectives for new NPPs which were taken as a reference by the PRT (R-1).
- No. 1: A comprehensive margin assessment based on the hazard curve from the PSHA and fragility evaluations, taking into account the more precise seismotectonic model, should be carried out to ensure all structures, systems and components (SSCs) margins with respect to the design basis and beyond are adequate in order to ensure their integrity and function in line with their role in support of defence-in-depth (DiD) levels (R-2).
- No. 3: The regulator should ensure that the seismic resistances of SSCs credited for coping with accident conditions (DiD levels 3 and 4) induced by a seismic event are adequate enough to carry out their function (R-3).
- No. 4: Clarify the nature of the 1908 Gudogay seismic event and update the seismicity catalogue for the region in which BelNPP is located (R-4).
- No. 5: Extend the number of stations in the seismic observation network to also cover the Quaternary Oshmiyansky fault (planning and implementation of the network) (R-5).
- No. 7: Provide free access to the data recorded by the seismic observation network (R-6).
- Annex 1, line 7: Implement the measures and actions defined in the Section 3.2.4 of the NR (R-7).
- Nos 1, 2, and 3: Reconsider the adequacy of seismic margins of SSCs for beyond design basis earthquakes of the plant equipment ultimately needed for prevention of core melt (R-12) and large releases (R-18).

External flooding

Out of the 12 recommendations related to natural hazards, two actions are related to external flooding:

- Annex 1, line 8: Ensuring that plant measures against water ingress into safety-related buildings and underground galleries are robustly designed and implemented (R-8);
- Annex 1, line 8: Ensuring that the plant site can be drained via the surface by gravity (R-10).

Extreme weather

There is one action related to extreme weather:

- Annex 1, line 8(a): Having specific operating procedures for extreme weather in place (R-9).

Summary on Topic 1 - Natural hazards

Based on the review of the NAcP against the 2018 PRT report recommendations and other available information it can be concluded that PRT's recommendations related to the Topic 1 issues were reflected in the NAcP.

Verification of the adequacy of the design basis earthquake

In the 2018 PRT report, the PRT recommended that GAN should consider the 2018 PSHA results in the seismic safety evaluation of the plant and ensure appropriate safety upgrading measures are implemented. According to GAN, the 2018 PSHA was reviewed and found acceptable for the physical start-up. For the operating licence, the licensee was requested to prepare '*a more precise* *seismographic model, adequately corresponding to the geodynamic conditions of Belarus'*. This led to the updated 2020 PSHA that accounts for the re-assessment of the Gudogay earthquake (R-4) and improved seismotectonic modelling. The differences between the 2018 PSHA and the 2020 PSHA are small in the area of the occurrence frequency of 10^{-4} per year, mean, free field, which is decisive for determining the DBE.

The 2020 PSHA uses input data that are updated compared to those used for the 2018 PSHA[6], which formed the basis of the stress tests peer review in 2018. It accounts for the location of the site in the intracontinental East European Platform with generally low seismicity. The differences between the 2018 PSHA and the 2020 PSHA with respect to input parameters were explained during the site visit to BelNPP. The resulting hazard values for the exceedance frequency of 10^{-4} per year, mean, free-field, which is decisive for determining the DBE, differ only slightly between PSHA 2018 and 2020. During the licensing process for the commercial operation of unit 1 of BelNPP GAN has reviewed and assessed the 2020 PSHA and its underlying hazard assessment and endorsed it on 02 June 2021. The DBE value is fixed in the 'general part of the operational licence' which applies to both units of BelNPP.

Results of the 2020 PSHA are summarized in a table contained in the document '*Appendix R-2_Заключение отчета.pdf*'. It shows the PGA values in g for annual non-exceedance probabilities of 10^{-2}, 10^{-3}, 10^{-4}, 10^{-5}, and 10^{-6} per year for the 5%, 16%, 50%, 84% and 95% percentile as well as for the mean hazard value ('*Средняя*'):

Non-exceedance	16%	16%	50%	50%	Mean	Mean	84%	84%	95%	95%
probability	Rock	Free Field	Rock	Free Field	Rock	Free Field	Rock	Free Field	Rock	Free Field
10^{-2}	0.0015	0.0024	0.0028	0.0046	0.0050	0.0082	0.0100	0.0148	0.0241	0.0366
10^{-3}	0.0062	0.0096	0.0106	0.0161	0.0284	0.0406	0.0570	0.0800	0.0777	0.0962
10^{-4}	0.0168	0.0257	0.0263	0.0392	0.0883	0.1059	0.1729	0.1795	0.1937	0.2015
10^{-5}	0.0359	0.0524	0.0469	0.0675	0.1997	0.1900	0.2885	0.2346	0.3716	0.3003
10^{-6}	0.0527	0.0817	0.0735	0.1018	0.3908	0.2580	0.4820	0.3157	0.6456	0.3706

The 2020 PSHA shows for the DBE, which is the value for the exceedance frequency of 10^{-4} per year, mean, free field, a PGA_H of 0.1059 g. This DBE value and its underlying hazard curve of the 2020 PSHA are also used as a basis for the seismic margin assessment and for considerations with respect to DEC.

The PRT considers the selection of the DBE from the 2020 PSHA from the hazard level 10^{-4} per year, mean, free-field, is in line with internationally used approaches.[7] It is also in line with the references used during the peer review of the EU stress tests. The DBE and its underlying hazard curve of the 2020 PSHA are appropriate for the BelNPP site. They reflect the current state of knowledge. The engineering design basis for seismic category 1 SSCs is 0.12 g. This is above the DBE value (0.1059 g).

Actions taken and implemented to verify the adequacy of the design basis earthquake meet the intent of the 2018 PRT recommendation. The recommendation is therefore considered closed.

[6] 2018 PSHA: Topical Report Belarus NPP Calculation of seismic hazard curves etc. Schmidt Institute of Physics of the Earth of the Russian Academy of Sciences, Report No. 01 / 2018-03-10.

[7] '*Report WENRA Safety Reference Levels for Existing Reactors 2020. 17.02.2021*'; '*Guidance Document Issue TU: External Hazards Guidance on Seismic Events 10.01.2020*'.

Assessment of 2020 PSHA seismic resistances and margins

The 2020 PSHA with its hazard curve mean free field is the basis for all seismic considerations and assessments down to very low exceedance frequencies. Reference for the seismic margins is the DBE value with a PGA_H of 0.1059 g. The engineering design basis for seismic category 1 SSCs is 0.12 g. This is slightly above the DBE value. The category 1 SSCs are thus sufficiently designed against the DBE.

The seismic resistance of the SSCs for seismic events beyond the DBE was determined by comprehensive fragility analyses. These analyses were performed according to seismic walk downs of the plant and on basis of detailed design documents. The fragilities were assessed with a set of different acceptable methods using seismic responses of buildings and structures. These assessments showed for the safety relevant SSCs required for safe shutdown and cooling down of the BelNPP power units seismic resistances of at least 0.17 g, evaluated by the method of high confidence of low probability of failure (HCLPF)[8].[9] A seismic resistance of 0.17g represents a safety margin of about 60% with respect to the DBE and corresponds to an occurrence probability lower than 10^{-4} but higher than 10^{-5} per year.

The PSA method was used to assess the adequacy of seismic margins of the SSCs that are necessary to cope with seismic design extension conditions (DEC)[10].

For BelNPP a seismic PSA level 1 and a full-scope PSA level 2 (for all initiating events) are available[11] and were accepted by GAN after independent expert assessment. The seismic PSA level 1 revealed a point value of $7.71*10^{-7}$ per year for the nuclear fuel damage frequency (NFDF) for seismic events taking into account all operational states. The full-scope PSA level 2 resulted in a point value of $8.68*10^{-8}$ per year for the large release frequency (LRF) taking into account all operational states and all initiating events and all radioactive sources of the core and the spent fuel pool. Furthermore, the in-depth considerations of the PSAs show that there are no significant weak points or cliff edges in the seismic design. At the time of the second country visit the PRT was informed about the existence of additional calculations that confirmed the cited numbers above. The results of the seismic PSA level 1 and full-scope PSA level 2 demonstrate compliance with the risk-related numerical criteria specified in the Belarusian regulatory requirements: NFDF less than 10^{-5} per year and LRF less than 10^{-7} per year. The NFDF and LRF values are also in line with international expectations. The numerical LRF values resulting from seismic PSA (SPSA) and PSA Level 2 suggest that the probability of large or early releases initiated by earthquake can be regarded as extremely low.

Precautions have also been taken against indirect effects of earthquake. The measures taken in respect to fire prevention and fire protection include for instance minimising fire loads, avoidance of ignition sources, spatial separation, fourfold redundant design of important systems, automatic fire

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[8] ‘*Демонстрация безопасности Белорусской АЭС при косвенных последствиях землетрясения*’ (Belarusian NPP safety demonstration of indirect earthquake-induced consequences) of 14 June 2021 received from GAN on 16 June 2021 in Russian. Tables used in this report are from the updated version of 27 August 2021.

[9] With the understanding that the value 0.17 g for the reactor protection system applies to the control rod insertion system (the mechanical part).

[10] In this PRT report, the term design extension condition (DEC) in connection with external hazards has the same meaning as the term beyond design basis event (BDBE) used in the IAEA safety standards.

[11] ‘*Reassessment of seismic PSA (SPSA)*’ - All cited data in respect to the seismic PSA level 1 and the full-scope PSA level 2 were presented and explained during expert discussion (VC) on 25 January 2021.

detection and firefighting as far as appropriate. The measures taken minimise the risk of fire ignition by detecting fires quickly and by limiting their consequences. Furthermore the design principle that failure/damage of lower-level seismic resistance category equipment shall not cause a failure of a higher seismic resistance category equipment' was followed. Precautions have been taken against 'flying objects' that could result from damaged equipment working at high pressure. These protective measures and elements exclude possible effects on SSCs critical to safety from damaged equipment classified to lower classes of earthquake resistance. Measures were also taken to protect against internal flooding through facilities for rapid detection of damage, protective lining of potentially affected areas, structural measures such as spatial separation, barriers and controlled capture or drainage of spilled liquids.

With respect to the hazard of earthquake induced fire the PRT makes the following two observations:

- Parts of the fire extinguishing systems in buildings housing active safety systems are seismic category 2 or 3 and therefore not qualified to sustain a design basis earthquake. In case of a seismic-induced fire the fire extinguishing systems could fail and thus the level of fire protection of some safety systems could be reduced.
- The housing of the on-site fire brigade is qualified to sustain an OBE (0.06 g). In case of an earthquake beyond 0.06 g fire brigade building could be damaged and the fire brigade could therefore be unable to fight earthquake-induced fires in due mission times.

With regard to the safety significance of the observations related to earthquake induced fire, the PRT would like to note the following. A fire caused by an earthquake is possible as demonstrated by the global operating experience. However, precautions have been made at BelNPP to prevent, limit and mitigate such fires as explained above. Consequently, the risk that a fire caused by an earthquake would result in the failure of all four physically separated active safety system trains at the same time can be considered low. In addition, should all four active safety trains become inoperable due to fire (or other common cause reasons) the safety of the reactor is not endangered because in such cases heat removal from the reactor can be achieved by the passive safety systems. These systems are seismic category 1 and can take care of the heat removal without additional measures for the first 24 hours, and longer with additional measures by the plant personnel. This provides time for the plant to recover from the fire.

With regard to the safety significance of seismic robustness of the fire brigade building related to supporting safety functions, the PRT would like to note the following. The fire engines housed in the fire brigade are planned to be utilised as mobile pumps needed to supply water to the tanks of the SG PHRS or to the spent fuel pool in case of failure of the JNB50 pump. Due to the amount of water available in the passive heat removal systems, there is no immediate need for the fire engines to be operable. During the site visits the PRT was informed that if the fire brigade at the site is destroyed or inoperable due to any reason, similar fire engines are available at various locations outside the site and can reach the site within the time limits (within 24 hours). Although this is considered possible by the PRT, this is not fully in line with the EU stress test criteria.[12]

The actions taken due to PRT 2018 recommendations (to perform a comprehensive seismic margin assessment based on the hazard curve of the 2020 PSHA, and to ensure that the seismic resistances

[12] The stress test requirements specify that for the analysis of loss of off-site power and loss of ultimate heat sink, it shall be assumed that *'the site is isolated from delivery of heavy material for 72 hours by road, rail or waterways. Portable light equipment can arrive to the site from other locations after the first 24 hours'*.

of SSCs credited for coping with accident conditions (DiD levels 3 and 4) induced by a seismic event are adequate to ensure their performance), meet the intent of PRT recommendations and have been implemented. However, for the further enhancement of safety of the BelNPP, the PRT encourages qualifying the relevant parts of the fire extinguishing system to seismic category 1[13] and retrofitting the housing of the on-site fire brigade to the level of the DBE. These measures will increase the capability to mitigate potential damage caused by seismic induced fires. The latter will also provide the necessary protection for the mobile fire engine driven pump needed to supply water to the tanks of the SG PHRS or to the spent fuel pool in case of failure of the JNB50 pump – see chapter 4.2, sub-section '*Additional measures for enhancing the reliability of the JNB50 subsystem*'. The recommendation is considered closed except as regards the findings on the fire-fighting systems and the housing of the fire trucks.[14]

Nature of the Gudogay seismic event of 1908

In the 2018 PRT report, the PRT noted that the assessment of the DBE was challenged by the fact that earthquake catalogues for the east Baltic region indicate that several earthquakes with epicentral macroseismic intensity of I_0=7 occurred over the last 100 years within the area. According to these catalogues, the closest I_0=7 earthquake occurred only 25 km from the NPP site in Gudogay 1908.

During the February site visit to BelNPP the PRT took note of a comprehensive report on the seismological assessment of the Gudogay 1908 earthquake[15]. Reviews of the instrumental data available from 1908 did not reveal indications for the occurrence of a strong earthquake at Gudogay. Records from the Pulkovo station exclude the occurrence of an earthquake of M=4.5 or higher, but do not exclude the possible occurrence of an earthquake with a magnitude below the threshold of M=4.5. Taking these records as an upper limit of the magnitude of a possible event at Gudogay and considering contemporary reports on the intensity to be correct the event was assessed with 3.5-4.0 / I_0=6. The event was included in the updated earthquake catalogue accordingly.

Actions taken and implemented meet the intent of the 2018 PRT recommendation to investigate the Gudogay 1908 seismic event and update the earthquake catalogue used for seismic hazard assessment. The recommendation is therefore considered closed.

Seismic observation network

The seismic observation network around BelNPP currently consists of a number of temporary seismic stations. During the February site visit to BelNPP it was confirmed that the existing network was complemented by temporary stations in the vicinity of Gudogay and the Oshmiyansky in 2020. At the NPP site a seismic monitoring system is in operation that consists of 14 seismographs in each power unit. The monitoring system ensures automatic shutdown of the reactors in case ground motion exceeds the OBE level of PGA_H = 0.06 g. The PRT sees such a system as a suitable measure for triggering an early shutdown in the event of an earthquake.

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[13] As required by the WENRA Safety Reference Levels for Existing Reactors 2020, Issue SV (Internal Hazards), Reference Level SV 5.6 and footnote 84.

[14] The stress test requirements specify that for the analysis of loss of off-site power and loss of ultimate heat sink, it shall be assumed that *'the site is isolated from delivery of heavy material for 72 hours by road, rail or waterways. Portable light equipment can arrive to the site from other locations after the first 24 hours'*.

[15] G. Aronov (2019): *'Investigate the nature of the 1908 Gudogay seismic event'* (in Russian)

The currently installed temporary network of seismic stations will be replaced by a permanent station network after the selection of appropriate sites with low seismic noise level. The full replacement of the temporary network by a permanent one is expected to be completed by 2025.

It is acknowledged that the seismic observation network is being built up and optimised with the participation of high-level specialised institutions. This is expected to result in a professional and appropriate monitoring of local seismicity and potential seismic sources, including the Oshmiyansky fault zone.

The actions taken to meet the recommendation to extend the number of seismic stations to also monitor Oshmiansky fault zone is considered fulfilled. Transformation of the current temporary network into a permanent one is ongoing. The recommendation is therefore considered closed.

The PRT was further informed that consideration is given to making the data obtained from the seismic observation network available to the scientific community and, where appropriate, to the public. The PRT encourages all concerned parties to provide free and unrestricted access to the data recorded by the seismic observation network for scientific purpose to profit from research results that better constrain the seismotectonic model for future updates of the PSHA. Actions planned and being implemented meet the intent of the 2018 PRT recommendation. Implementation is planned to be completed in 2025 in connection with the expansion of the monitoring network. However, decisions on providing access to the data are still pending, and therefore this recommendation remains open.

External flooding

The two PRT recommendations in the field of external flooding were issued in 2018 because the progress of construction works and the lack of inspections results at that time did not allow to assess these topics.

Plant measures against water ingress into safety related buildings and underground galleries

Waterproofing works of buildings and structures are completed at unit 1, and are planned to be fully finalized at unit 2 by December 2021. Independent verification of waterproofing of buildings and structures is performed by the State Construction Inspectorate (under the umbrella of Gosstandard) and results are provided to GAN on a monthly basis. These inspections have resulted in a number of findings which have been corrected.

The PRT identified a number of rainwater infiltrations into safety-related buildings and underground galleries in unit 1. They are known by the plant and will be repaired before the end of 2021. The plant has also identified water infiltrations in unit 2, where construction works are still ongoing. It is planned that all measures against water ingress will be completed in unit 2 by December 2021.

During the plant walk down, the PRT noted that the South wall of the UKD building (auxiliary safety systems building) is less robustly protected against water ingress through entrances. The PRT further encourages the plant to review and increase the robustness of the volumetric protection of the South wall of the UKD building

In conclusion, action taken to address the recommendation shows satisfactory progress to date. Actions implemented and planned meet the intent of the 2018 PRT recommendation. Complete implementation of all necessary actions is expected by December 2021 for both units. The recommendation remains open.

Site drainage arrangements for evacuation of surface water

The site drainage arrangements for evacuation of surface water have been completed on the whole site.

The site is built on a flat platform higher than the nearby countryside elevation in most directions, with surrounding field slightly higher than the platform only in the North-West corner. Rainwater is prevented to flow down from this direction to the site platform by two ditches running outside along the site periphery and also by presence of elevated roads acting as barriers.

All plant safety-related buildings are built at a comparable elevation on the flat platform without very significant slope. Rainwater percolating through the ground around safety related buildings is drained through the UGS system and pumped back to the cooling towers.

On the periphery of the site platform, ditches collect and prevent excessive rainwater accumulation in the large grass areas. Rainwater coming from the roads, from the roofs and through the surface ditches in the green areas, is collected through the UGU system and discharged after treatment to the cooling towers or the Viliya river. In case of loss of outside power, UGU pumps are supplemented by several diverse backup mobile pumps.

Actions implemented and planned meet the intent of the 2018 PRT recommendation. This recommendation is considered closed.

Extreme weather - Operating procedures in place for extreme weather conditions

Numerous aspects of plant operation under extreme weather conditions are included in operating procedures which are in place at the plant. This namely includes the numerous measures as part of the transition to winter operation mode or routine walk downs to check snow accumulation on building roofs following heavy snowfalls.

The plant also developed an emergency procedure covering the effects of relevant extreme weather conditions. This procedure was put in place in 2019 and describes the necessary actions in case of extreme scenarios. Entry into this emergency procedure can namely be triggered by an alert from the national meteorological service. BelNPP confirmed that these procedures have been trained and exercised.

The actions implemented meet the intent of the 2018 PRT recommendation. This recommendation is considered closed.

4.2 Loss of safety systems

Regarding loss of safety systems (Topic 2), the NAcP of Belarus comprises six actions dealing with measures to increase the reliability of electrical power supply for safety relevant consumers as well as water supply for the heat removal under a DEC situation.

The NAcP of Belarus provides a general description of measures for Topic 2 – loss of safety systems (SBO and loss of ultimate heat sink) – explaining the actions listed in Table 4 of the NAcP.

The actions presented in Table 4 of NAcP and listed below reflect the recommendations of the 2018 PRT report.

- No. 8 – Consideration of the desirability of equipping the NPP with alternative stationary AC power sources (for BDBA), taking into account the adopted safety concept for BelNPP (taking into consideration the passive safety systems providing autonomy of operation) (R-11).
- No. 9 – Assessment of the reliability of the SG PHRS after installation of another redundant pump in addition to JNB50AP001, compared with the characteristics of the existing system (R-13).

- No. 10 – Implementation of necessary organizational and technical actions in accordance with the results of assessment in point 9 (R-13)
- No. 12 – Development for further implementation of technical and organizational measures ensuring restoration of water supply in time necessary to prevent severe accidents arising in the open reactor condition in the case of a SBO (R-14).
- No. 13 – Assessment of the reliability of auxiliary power supply to safety-related consuming sources, from an emergency standby auxiliary transformer SN (ARTSN) 110/10 KW, with a power of 16 MVA, which can be connected to a cable line 110 kV in the Viliya substation and assessment of Viliya substation's resistance to internal and external events (R-15).
- No. 11 – Implementation of organizational and technical measures for stationary connection of one DG set to each BelNPP power unit - unit 1 - 01.01.2020; unit 2 - 01.01.2021 (n/a);

Action No. 12 (corresponding to PRT recommendation R-14) has been reviewed under Topic 3 as it also addresses PRT recommendation R-19.

Summary on Topic 2 – loss of safety function

Based on the review of the NAcP against the 2018 PRT report recommendations it can be concluded that the PRT's recommendations related to the Topic 2 issues were reflected in the NAcP. The NAcP also included one other item added upon a decision made by the plant operator and the designer complementing the PRT recommendations and contributing to their comprehensiveness.

Availability of an alternative permanent power source to supply the necessary power in design extension conditions

Recommendation No. R-11 results from the consideration of IAEA SSR 2/1, Requirement 68: Design for withstanding the loss of off-site power, paragraphs 6.44A and 6.44C. The design of BelNPP provides passive safety systems aimed at preventing a fuel melt accident also under DEC with SBO. Those passive safety systems are actuated and operate without external power supply, while power is required only for measurements and control devices. The required power is provided by a secured power supply of the channel 7 busbar, equipped by batteries with a discharge period of 24 hours. Re-charging from an external source must be initiated before batteries are fully depleted. That would be provided by the mobile MDGs 10/20XKA70 which are permanently connected to this busbar. Both units of BelNPP are identical in their design and function and equipped by identical safety devices, including also one MDG of 500 kW for each unit. If necessary, each of the permanently connected MDGs can be disconnected from its respective unit's channel 7 busbar and moved to the other unit, should the 10XKA70 or 20XKA70 located there fail. By this concept, the IAEA SSR-2/1 Requirement 68, paragraphs 6.44A and 6.44C are fulfilled. The necessary emergency operational procedures describing the relevant steps to disconnect the respective MDG from the permanent connection and to move it to the other unit of the NPP in case of necessity have been prepared. They ensure that the time required for conducting these steps (disconnection from channel 7 busbar of one unit – transport to the other unit – connection to the channel 7 busbar of the other unit) is sufficient to provide for a complete replacement of the failed MDG with no loss of function of the devices supplied by the channel 7 busbar. Also, for the very unlikely situation of a simultaneous loss of the entire range of external power sources (8 mains) combined with the loss of all redundant power sources (4 DG of the emergency power supply) and the loss of two alternative power sources MDG 10/20XKA70 administrative solution have been taken. They are described in the Appendix under R-11.

During the PRT Mission NPP staff explained the operational steps to disconnect the MDG XKA70 at one unit and move it to the other unit. This procedure will be practised regularly as a training exercise for the personnel.

The 2018 PRT report mentions that an additional use of mobile means should be further considered as a valuable component of operational accident management. This remark is from the generic requirements in the ENSREG Compilations of Recommendations and Suggestions from July 2012 resulting from the original stress tests in the EU. While evaluating the relevance of this generic recommendation to BelNPP it needs to be acknowledged that BelNPP is equipped with passive safety systems for cooling of the containment and fuel in the reactor. These passive systems are in addition to standard active safety systems for the same purpose. In this regard, use of mobile means is not as significant safety measure as it may be for other reactor designs, without passive safety systems in place. However, BelNPP has incorporated mobile means to supply electricity and cooling water to ensure cooling of the fuel in the very unlikely event where fixed safety systems do not work. These are implemented via the use of fire engine driven mobile pumps to supply water for the SG and C PHRS storage tanks of the LCU system and via MDGs 10/20XKA70 to supply electricity to channel 7 (note, that these MDGs can also be cross-connected between units in case of need as explained above). Further, there is a possibility to provide additional diesel engines from outside the site in case of MDG failure. The PRT considers that the possibility to use mobile means meets the intent of generic recommendation from ENSREG Compilations of Recommendations and Suggestions.

Actions taken and implemented meet the intent of the 2018 PRT recommendation. This recommendation is considered closed.

Additional measures for enhancing the reliability of the JNB50 subsystem

For the associated actions No. 9 and No. 10, BelNPP developed a technical solution to be applied in both units of the NPP. The proposal is that an alternative mobile device will be used to replenish the SG PHRS and containment (C) PHRS as well as the spent fuel pool under SBO conditions instead of using a permanently installed redundant JNB50 pump. Should the existing 10/20JNB50AP001 pump fail, a mobile fire engine driven pump would be connected using two installed hook-up connectors from the JNB50 system located outside the steam chamber building UJE of each unit. Via this connection, water will be transported from the makeup water system (LCU tanks 10/20LCU01,02,03,04BB001), which were originally envisaged for this purpose, in case of an SBO.

As stated by the NPP, the pipelines, the vents (fixtures) and the pump of the JNB50 system for the feed of the SG PHRS tanks or the spent fuel pool are classified as seismic category 1. The tanks, heat exchanger and the vents of the SG PHRS JNB system also belong to seismic category 1. Therefore, also in case of an earthquake the functionality of the system is ensured.

A basis for evaluation and application is provided in the WENRA documents that were developed for new reactors after the Fukushima accident. In particular, the 2013 report from WENRA's Reactor Harmonisation Working Group (WENRA/RHWG) – '*Safety of new NPP designs*' – sets the objectives for sufficient redundancy for active components such as the JNB50 system. In WENRA's safety reference levels Issue F 4.7 an expectation is set: '*There shall be sufficient independent and diverse means including necessary power supplies available to remove the residual heat from the core and the spent fuel*'.

Taking into account the status on engineering and construction of BelNPP during the 2018 peer review, the PRT considers that the prepared alternative technical solutions improves safety of the

BelNPP. Although this alternative does not provide a permanent redundancy to the JNB50 pump, it fulfils the expected safety function and provides diversity to a permanently installed JNB50 pump.

The technical and organizational rules and procedures for connecting and operating the mobile firefighting pump are provided in instructions. In order to ensure the permanent operability, the necessary equipment, i.e. the firefighting vehicle with pump equipment, undergoes checks according to the '*Rules of technical support in the authorities and divisions of the extraordinary situations of the Republic of Belarus*' and the procedure for connecting the vehicle is practised periodically in training drills.

The presence and the arrangement of the technical mobile devices and the operability of the connecting point have been surveyed by the PRT during the February and September site visits to BelNPP and, also the existence of respective documents describing the measures to be taken and the conditions for these have been checked by the PRT.

The essential prerequisite for implementation of this solution is the availability of the mobile equipment at all times, which must not be endangered by external impacts such as extreme weather conditions or earthquake. This has been checked during the September site visit (see Topic 1).

Actions taken and implemented meet the intent of the 2018 PRT recommendation. This recommendation is considered closed, provided that availability of the mobile equipment needed for pumping can be ensured at all times. Reference is made to '*Assessment of 2020 PSHA seismic resistances and margins'* under 4.1 as regards the fire-fighting systems and the housing of the fire trucks.

Appropriateness of Viliya substation as a backup alternative power supply

Recommendation R-15 concerns the assessment of the reliability of the additional Viliya substation as a backup alternative power supply, if the external power supply by the national grid fails. In the 2018 PRT report it was recommended to demonstrate the availability of this sub-station to serve as an additional source for the off-site power supply under operational states (DiD level 1 and 2) by the demonstration of the reliability of these off-site power sources in seismic conditions. The NAcP describes that this assessment must be carried out to declare the available equipment as appropriate for the necessary safety relevant case.

Information received from GAN in the course of the peer review states that the sub-station Viliya has been qualified regarding the resistance to withstand external events such as earthquake and severe weather impacts. The information confirms that the structures and equipment of the sub-station Viliya are designed to withstand an earthquake of 6 at the scale MSK-64, possible impacts from the wind and cables glaze-icing.

The sub-station Viliya avails of an automatic firefighting alarm system, which provides for the collection, processing, displaying and sound signaling, recording and forwarding information on the state of fire loops of buildings, fire alarms for people, signal forwarding from the installation to the Centre of Operative Management of the Ministry for Emergency Situations via GSM communications as well as to the dispatching station of the local power station in Ostrovets via telecommunications.

Also mechanical or thermal impacts from lightning to the connection of the emergency service transformer of 110/10kV with the power of 16 MVA to the sub-station Viliya could be excluded since the transmission line cable (of 2.6 km) is laid in a channel made from reinforced concrete. This also ensures exclusion of the damage from fallen trees or other mechanical damage of various different origins.

Mechanical calculations for wires and structures of the open switchgear of 110 kV is done taking into consideration possible impacts from the wind and cables glaze-icing.

The qualification of the availability of Viliya sub-station to serve as an additional source for the off-site power supply under operational states (DiD level 1 and 2) has been proven as stated in the information received from GAN.

Actions taken and implemented meet the intent of the 2018 PRT recommendation. This recommendation is considered closed.

Item included in the NAcP without explicit link to a specific PRT recommendation

Completing the permanent connection of a mobile diesel generator (MDG) to channel 7

In the answers provided to PRT's written questions, GAN stated that the associated action No. 11 '*Implementation of organisational and technical measures for stationary connection of one DG set to each NPP power unit*' was fully implemented for unit 1. As originally planned and presented in the national report as well as discussed during the peer review of 2018, the MDG in each unit (10/20XKA70) serves as the electricity support for the BDBA consumers (Russian terminology) which are served via channel 7. According to GAN's answers, the MDG supports:

- electric gate valves and valves of the JNB, JEF, KTP, FAK systems;
- hydrogen monitoring devices in the containment (the JMU system);
- emergency instrumentation;
- radiation monitoring devices;
- the BDBA panel located in the main control room (MCR);
- the JNB50AP001 pump; and
- the illumination of the operator's workplace above the BDBA panel.

Reflecting the 2018 PRT recommendation the MDG (10/20XKA70) at unit 1 has been connected and will be connected at unit 2 permanently to the buses of channel 7 by means of a flexible cable to the assembly 10/20BKS12GH570 at the outer wall of the 10/20UJE.

To provide for the function of the mobile equipment in adherence to the '*Regulations for checks and tests of safety relevant systems'*, the personnel of BelNPP carry out required checks (tests) of the MDG station 10/20XKA70 according to the schedule and programmes, approved by the chief engineer of the NPP:

- Tests with the nominal power with a connected specific load device (once a month);
- Comprehensive check with a connection of the DG on the 0.4kV section of channel 7 I&C system (once a year).

The presence and the arrangement of the MDG 10XKA70 in unit 1 and the permanent connection to the connecting point 10BKS12GH570 have been surveyed by the PRT during the site visits in February and September and the existence of respective documents describing the measures to be taken for assuring the operability have been checked by the PRT. Similar measures will be completed at unit 2 in the course of the construction and commissioning.

Actions taken and implemented meet the objective of the NAcP and the action is considered closed.

4.3 Severe accident management

Recommendations to further enhance the safety of BelNPP reflected the fact that the design of the plant includes a number of advanced hardware features to cope with severe accidents and that the organisation of emergency planning and response, including onsite/offsite coordination, had been developed prior to the NPP construction.

The NAcP Table 4 includes nine actions that can be assigned to the topic of severe accident management. The items listed below are not copied verbatim from the NAcP, but they are simplified to characterise their key objectives (the numbering of the items is the same as in the NAcP).

- No. 12 - Prevention and mitigation measures for severe accidents under open reactor conditions (R-19).
- No. 14 – Assessment of adequacy of provisions for practical elimination of early or large radioactive releases (R-16).
- No. 17 – Evaluation of adequacy and/or enhancement of means for depressurization of the reactor coolant system (R-17).
- No. 19 – Review and/or enhancement of habitability of control areas (MCR and ECR) during a severe accident combined with SBO (R-21).
- No. 20 – Review of the effectiveness of the emergency ventilation system of the containment annulus in beyond design basis accidents (R-22).
- No. 21 – Development, validation and implementation of symptom based EOPs and SAMGs (R-23).
- No. 15 – Refilling of the secondary side of SG to protect integrity of SG tubes and to prevent fission product releases by-passing the containment.
- No. 16 – Qualification of devices for depressurization of the RCS under severe accident conditions.
- No. 18 – Evaluation of adequacy and/or enhancement of instrumentation needed for management of severe accidents.

In parentheses in the bullets above, there are numbers representing six particular recommendations (R-16, R-17, R-19, R-21, R-22, R-23) formulated by the PRT after the review of the national report. There were two other PRT recommendations resulting from the review of the management of severe accidents, namely:

- R-13 (recommending the installation of a redundant pump in addition to the JNB50AP001 pump for refilling heat exchangers of PHRS and the spent fuel pool (SFP)); and
- R-18 (recommending a demonstration of adequate seismic resistance of plant equipment ultimately needed for preventing early or large radioactive releases).

The status of implementation of these two items is evaluated in this report within, respectively, the Topic 2 and Topic 1 reviews.

Another recommendation derived from the PRT report was the need for experimental demonstration of the effectiveness of the innovative SG PHRS and C PHRS. This action was not explicitly included in the NAcP, but it was addressed by the plant designer, as confirmed in the Appendix to this report.

Other actions of the NAcP (No. 15, 16, 18) were added afterwards upon a decision made by the plant operator and the designer. These actions complement the recommendations explicitly listed in the PRT report and the status of their implementation is also reviewed.

Summary on Topic 3 - severe accident management

Based on the review of the NAcP against 2018 PRT report recommendations, it can be concluded that all PRT's recommendations related to Topic 3 were reflected in the NAcP. The NAcP also included 3 other items added upon a decision made by the plant operator and the designer complementing the PRT recommendations and contributing to their comprehensiveness.

Development, validation and implementation of symptom-based EOPs and SAMGs

The symptom based EOPs and SAMGs have been developed, validated and implemented before plant commissioning, in accordance with the PRT recommendation. Relevant training documents and advanced simulation tools, including a full-scope simulator with severe accident simulation capabilities are used in the training. EOPs and SAMGs and simulation of their implementation are included in the capabilities of the simulator. EOPs and SAMGs are periodically reviewed. Actions taken and implemented meet the intent of the 2018 PRT recommendation. This recommendation is considered closed.

Evaluation of adequacy and/or enhancement of means for depressurisation of the reactor coolant system

It is recognised that safety implications of high-pressure severe accident sequences for BelNPP are less significant than for other reactor designs due to the depressurisation effect of passive heat removal capability by the SG PHRS. Nevertheless, there are further independent means to ensure depressurisation under severe accident conditions including a dedicated control line for opening pressurizer valves from the main control room, and multiple venting lines connected to the reactor coolant system. Actions taken and implemented meet the intent of the 2018 PRT recommendation. This recommendation is considered closed.

Review and/or enhancement of habitability of control areas (MCR and ECR) during a severe accident combined with SBO

The available design provisions adequately ensure the habitability of control places within the plant, including in situations involving station blackout conditions, for a sufficiently long period of time (more than 3 days, taking into account realistic number of persons present) allowing the staff to carry out actions for safe shutdown and cooldown of the plant. Actions taken and implemented meet the intent of the 2018 PRT recommendation. This recommendation is considered closed.

Prevention and mitigation measures for severe accidents under open reactor conditions

The PRT concluded that should an SBO potentially develop into a severe accident in the open reactor, this could not start earlier than about 2 hours after the loss of cooling, possibly further delayed by additional 7 hours using coolant from the hydro accumulators. A severe accident could be prevented by the use of low-pressure ECCS pumps if the power supply is successfully recovered. If the preventive actions fail, the accident could evolve into a severe accident at low pressure, with molten corium relocated to the core catcher with the heat removal through the containment passive heat-removal system. Even if such a situation develops under open containment conditions, actions needed for re-establishing containment isolation can be performed significantly earlier than the time needed for transition into a severe accident. It is thus ensured that there would be no significant radioactive releases and no radiation risk to the public. Actions taken and implemented meet the intent of the 2018 PRT recommendation and the recommendation is considered closed. Nevertheless, to further enhance the preventive part of accident management, the plant is encouraged to look for additional possibilities to deliver coolant into the reactor in order to provide more time before the fuel in the open reactor is damaged.

Assessment of adequacy of provisions for practical elimination of early or large radioactive releases

Assessment of practical elimination of early or large radioactive releases has been described in the special document '*R-16 Appendix*' developed by BelNPP in accordance with relevant IAEA safety standards and WENRA recommendations. The approach includes the list of conditions potentially resulting in early or large releases, followed by description of the design and operational provisions for their prevention and mitigation, verified by deterministic analysis. It is completed by probabilistic analysis demonstrating very low residual risk. Actions taken and implemented meet the intent of the 2018 PRT recommendation. This recommendation is considered closed.

Review of the effectiveness of the emergency ventilation system of the containment annulus in beyond design basis accidents

In the exchange of information with BelNPP it was confirmed that the issue of emergency ventilation of the containment annulus has been considered in the plant design. Results of conservative calculations of the source term for the reference scenario submitted to the PRT demonstrated that in absence of the ventilation, in very unlikely severe accident combined with SBO, compliance with the radiological acceptance criteria is ensured and the releases are low.

BelNPP has conducted a review to study the effectiveness of the emergency ventilation system of the containment annulus in beyond design basis accidents. The comparison analysis has shown that the annulus ventilation would further reduce the radioactive releases from 6 TBq to about 1 TBq of Cs-137. PRT notes that the radioactive releases are well below the acceptance criteria without the annulus ventilation. Having a possibility for annulus ventilation would constitute as a further enhancement of safety. The PRT leaves it up to BelNPP and GAN to consider whether such an enhancement would be practicably reasonable. Actions taken and implemented meet the intent of the 2018 PRT recommendation. This recommendation is considered closed.

Experimental demonstration of the effectiveness of the innovative SG PHRS and C PHRS

In response to the recommendation the PRT was provided with information about the objectives, scope and results of the commissioning tests aimed at verification of functioning of the passive heat removal systems (from the steam generators, from the containment), regarding time of initiation as well as heat removal capacity of the systems. The commissioning tests have confirmed design parameters, without identification of any unexpected behaviour of the systems. The summary of the quantitative results of the commissioning tests (both for 10JNB and 10 JMP systems) were provided to PRT. Actions taken and implemented meet the intent of the 2018 PRT recommendation. This recommendation is considered closed.

Items included in the NAcP without explicit link to a specific PRT recommendation

Refilling of the secondary side of SG to protect integrity of SG tubes and to prevent fission product releases by-passing the containment

The PRT acknowledges decision of BelNPP to consider flooding of the secondary side of the steam generators as a specific item in the NAcP due to its importance for prevention of the potential containment by-pass accident scenario. The sources of coolant for flooding, the means available for delivery of coolant to the steam generators and the necessary actions are covered by several (including symptom based) EOPs. A combination of a severe accident with steam generator tube rupture was included among the conditions to be practically eliminated in 2018 PRT relevant recommendation and is covered in BelNPP *'R-16 Appendix'* document assessing practical elimination. Actions taken and implemented meet the objective of the NAcP as an additional component contributing to the intent of the 2018 PRT recommendation on implementation of the symptom-based emergency procedures (EOPs and SAMGs) and the action is considered closed.

Qualification of devices for depressurization of the RCS under severe accident conditions

It was recognized by BelNPP that in addition to the capacity and independence, qualification of the devices for depressurization is an important issue. In the responses to the PRT's questions, it was confirmed that the means for reducing the pressure in the primary circuit (PRZ safety valves, including an additional control line and the emergency gas removal system) were developed in line with the relevant codes and standards, including qualification for the harsh environmental conditions (temperature, pressure) in the primary circuit, as well as in the containment. Actions taken and implemented meet the objective of the NAcP as an additional component contributing to the intent of the 2018 PRT recommendation on independent means of reactor coolant system depressurization in case of a severe accident.

Evaluation of adequacy and/or enhancement of instrumentation needed for management of severe accidents

All parameters needed for management of design extension conditions and severe accidents are presented in a special control panel in the MCR. Ranges of measured parameters are sufficient for severe accident management. Essential parts of the instrumentation for severe accidents are independent from instrumentation for design basis accidents. Availability of adequate instrumentation and a special control panel in the MCR and associated equipment for management of severe accidents was recognized as a good practice by the IAEA pre-OSART mission in 2019. Actions taken and implemented meet the objective of the NAcP as an additional component contributing to the intent of the 2018 PRT recommendation on implementation of the symptom based procedures and guidelines

5 SCHEDULE FOR IMPLEMENTATION, TRANSPARENCY AND COMMENDABLE ASPECTS

5.1 The schedule of the implementation of the NAcP

The NAcP indicates for each action the period of planned implementation. The NAcP and the updated NAcP (in its Annex 2) contain descriptions of the status of each action. ENSREG and the PRT considered original planned deadlines in the NAcP unnecessarily long for some actions and encouraged GAN and BelNPP to expedite the implementation of the actions. GAN and BelNPP have accelerated the implementation of the NAcP.

At the time of the second site visit in August-September 2021, the implementation of the NAcP is ongoing. Actions relating to 18 recommendations have been completed in line with the intent of the relevant recommendations. Actions relating to 4 recommendations are under implementation close to completion in line with the intent of the relevant recommendation.[16] Recommendation related to

[16] In addition to PRT 2018 recommendations, the PRT identified 4 actions in the NAcP which can be linked to the 2018 recommendations and were therefore evaluated in this report. All 4 actions can be considered closed.

the extension of the number of stations of the seismic observation network and opening the data of the network to scientific fora is planned to be implemented by 2025. This schedule is considered rather long and the PRT encourages GAN and BelNPP to expedite the process. It is noted by the PRT that temporary seismic network is already operational.

As a conclusion, the PRT considers that the implementation of the NAcP has progressed well. While some actions are being implemented, the PRT encourages GAN to follow, review and update the NAcP regularly to ensure that safety enhancements of the BelNPP are implemented in a timely manner. The PRT has, while reviewing the NAcP, identified some areas where further safety enhancement could be achieved. The PRT encourages its Belarusian counterparts to consider, in the spirit of continuous safety improvement, incorporating these measures in the updated NAcP and to report on the status of implementation regularly[17].

5.2 Transparency of the NAcP

There are several activities organized by the Belarusian side which could be considered as demonstration of transparency. First of all, it is their willingness to take part in the stress test exercise and to be subjected to several peer review missions.

GAN published the NAcP on its website immediately after adoption. GAN has likewise published information about various steps in the peer review process. Press statements on the subject have been made available on the GAN website and press briefings organised. The peer review of the NAcP has enjoyed ample coverage in Belarusian media.

The PRT held an online event addressed to NGOs working in Belarus after phase 1 of the peer review to share information about the process and answer participants' questions. GAN was represented in this event.

5.3 Commendable aspects (good practices, experiences, interesting approaches) and challenges

The PRT would like to commend that, in spite of the provisions for high safety level of an advanced plant design, the Belarusian side volunteered to take part in the stress test and accepted PRT missions, particularly in the circumstances of the Covid-19 pandemic and ongoing commissioning activities of unit 1. It is also noted that Belarus and GAN have over the years invited several international peer review missions to provide support in ensuring safe implementation of their nuclear energy programme. It is well known to all countries and their regulators that because of international peer review missions, areas for further improvement are identified. This is why peer review missions are utilised as a strong contributor to continuous safety improvement.

During the peer review the PRT identified the following commendable practices with regard to natural hazards, loss of safety functions and severe accident management.

- Natural hazards – Although the area where BelNPP site is located is an area with low seismic activity, an earthquake monitoring system is in operation at the BelNPP site ensuring automatic shutdown of the reactor when a seismic impact reaches set criteria (the OBE level of PGA_H = 0.06g). BelNPP has also conducted a new PSHA in the construction phase and

[17] ENSREG member states have agreed to report through ENSREG WG 1 every two years until full implementation of the NAcP and have their reports published on the ENSREG website.

prepared a seismic PSA and a full scope level 2 PSA for the safety demonstration for the operating licence phase.

- Loss of safety functions – The plant design with both active and passive safety systems provides for additional safety against different types of hazards jeopardizing loss of cooling and loss of electricity. Despite having active and passive safety systems, provisions have been made at the BelNPP to utilise both on- and off-site mobile means to support safety functions in case of loss of cooling and loss of electricity.
- Severe accident management – BelNPP has developed a comprehensive system of symptom based EOPs and SAMGs based on proven design at the existing plants but with due consideration of all innovative design features. In addition, BelNPP has a full-scope simulator including severe accident sequence and management simulation capabilities which are rather rare in currently operating plants. A dedicated report has been developed for demonstrating practical elimination of early and large radioactive releases, according to the current IAEA safety standards and WENRA recommendations.

The PRT highlights that although responsibility for safety rests fully on the licensee, regulatory oversight of the construction, commissioning and operation of a new plant is an essential part of independent verification of safety. This is a challenge for a young authority without many years of nuclear power oversight experience. As described above, GAN has utilised international peer reviews to support development of the regulatory framework in Belarus. The PRT encourages GAN to continue utilising peer review missions, publish the reports and continue engaging with regulators regulating similar type of nuclear power plants.

6 PEER REVIEW CONCLUSIONS

The purpose of this report is to record the results and conclusions of the peer review of the NAcP of Belarus. The results and conclusions in this document are based on information received via documents provided by Belarusian counterparts, discussions in online meetings between these parties and the site visits to BelNPP in February and August-September 2021. The conclusions and results in this report have been verified during these two site visits.

The Covid-19 pandemic prevented the peer review of the NAcP from being carried out as planned, with a single full scope fact-finding mission to Belarus. The pandemic resulted in limitations on travelling and in organising face-to-face meetings. As a result, most meetings were conducted online and the peer review was divided into two phases. Both phases included a mission to the BelNPP. As instructed by the Stress Test Board, the PRT completed the first phase of the peer review, focusing on recommendations related to high priority issues, in February before BelNPP started commercial operations. The second phase, addressing all recommendations, was finalised after the full fact-finding mission to BelNPP that was carried out 31 August to 2 September 2021.

The status of all recommendations has been discussed in depth in chapter 4 and in the appendix of this report. Based on the evaluation of the comprehensiveness of the NAcP, actions decided and status of their implementation, the following general conclusions and observations can be made. All PRT 2018 recommendations have been reflected in the NAcP. All actions decided by GAN and BelNPP meet the intent of the PRT 2018 recommendations. Out of 22 recommendations of the PRT 2018 report 17 have been fully implemented and can be considered closed.[18] Actions related to 5 recommendations are being implemented meeting the intent of the PRT recommendations. GAN and BelNPP have expedited the implementation of several actions compared to the original schedule and are encouraged to continue likewise with the remaining actions (qualification of fire extinguishing system and fire brigade building, extending seismic monitoring network and providing access to information, and review and enforcement of the robustness of the volumetric protection of relevant buildings). As a conclusion, the PRT considers that the implementation of the NAcP has progressed well.

With regard to **Natural Hazards** particular attention has been paid to the seismic safety at the site. Although the site is in an area with low seismic activity, there are few historical seismic records in the region. To ensure seismic safety at BelNPP, the plant has been equipped with seismic monitoring system which automatically shuts down the reactor in case ground motion exceeds 0.06 g. The design basis earthquake of the BelNPP (0.1059g) has been defined and evaluated in line with international expectations and considered appropriate for the BelNPP. The seismic resistance of the SSCs for seismic events beyond the design basis earthquake has been determined by comprehensive fragility analyses and seismic PSA. The results of the analyses demonstrated compliance with the risk-related numerical criteria specified in the Belarusian regulatory requirements and meet international expectations for new NPPs. Provisions have been and will be made at the BelNPP against extreme weather phenomena and flooding.

Precautions have been taken against indirect effects of earthquakes. The PRT observed that parts of the fire extinguishing systems in buildings housing active safety systems are not qualified to sustain a design basis earthquake. Further, the on-site fire brigade building is qualified for the OBE (0.06 g), which is below design basis earthquake. Observations question the ability of fire protection concept at BelNPP to mitigate fires induced by earthquakes, which may render active safety systems inoperable. However, the PRT notes that a fire in the building housing safety systems does not directly endanger reactor safety because heat removal from the reactor can be achieved by the passive heat removal systems. Nevertheless, the PRT encourages BelNPP to consider enhancing safety of the plant by qualifying the fire extinguishing system protecting active safety systems to seismic category 1 and retrofitting the housing of the on-site fire brigade to the level of the DBE. The latter will also provide necessary protection for the mobile fire engine driven pump needed to supply water to the tanks of passive heat removal system.

With regard to **Loss of safety systems** further safety improvements have been implemented at the BelNPP although the design of the plant benefits from having both active and passive safety systems for cooling of the reactor core and the containment. The improvements include for instance enhancing the water supply to the passive heat-removal systems with additional redundant pumping capacity, and enhancing the reliability the of power supply of mobile diesel generators by establishing a permanent cable connection between the mobile diesel generators and the plant units, as well as possibility to cross connect mobile diesel generators between the units in case of need. The PRT did not identify any areas for further safety enhancements but highlights that particular attention at BelNPP needs to be paid in ensuring availability of mobile means in all conditions.

[18] In addition to PRT 2018 recommendations, the PRT identified 4 actions in the NAcP which can be linked to the 2018 recommendations and were therefore evaluated in this report. All 4 actions can be considered closed.

With regard to **Severe accident management** actions have been taken to ensure and enhance BelNPP's capabilities to prevent and mitigate severe accidents, to demonstrate practical elimination of early or large radioactive releases and limitation of radiological impacts of severe accidents to the plant vicinity, in accordance with the current IAEA safety standards and WENRA recommendations. The main achievements include development and implementation of a comprehensive system of symptom based EOPs and SAMGs covering all operating regimes and plant states, and considering events initiated both in the reactor and in the spent fuel pool. Other actions include demonstration of adequacy of design features such as means for reactor depressurization to avoid high pressure core melt scenarios, provisions for ensuring habitability of control places during severe accidents combined with station blackout, dedicated instrumentation for management of severe accidents, and means for prevention and mitigation of severe accidents in an open reactor. Related to the last issue, the PRT encourages BelNPP to explore additional possibilities to deliver coolant into the reactor to provide more time before damage of the fuel in the open reactor.

The PRT underlines that all recommendations formulated in its report as a result of the 2018 Stress Test Peer Review (2018 PRT report) are important and encourages GAN to follow, review and update the NAcP regularly to ensure that safety enhancements of the BelNPP are implemented in a timely manner. The PRT has, while reviewing the NAcP, identified some areas where further safety enhancement could be achieved. In the spirit of continuous safety improvement, openness and transparency, the PRT encourages its Belarusian counterparts to incorporate these measures in the updated NAcP and GAN to publish regular reports on the NAcP's content and status of its implementation.

Significant progress has been made in the implementation of the NAcP at BelNPP. Nevertheless, work on ensuring and enhancing safety is a continuous process. New information, experience and knowledge will arise both from domestic and international operating experience, safety research, development of science and technology. Information and experience shall be systematically followed, collected, analysed and used for instance for training of the regulator's and operator's personnel, improving plant design, the EOPs and SAMGs, and national regulations. BelNPP and GAN are encouraged to engage with other NPPs and regulatory bodies internationally and continue utilising international peer review services and other support programmes.

• APPENDIX

PRT Assessment of Belarusian National Action Plan

1. Earthquakes

Action (Source[19]:)	PRT recommendation, action in NAcP and status in NAcP update of January 2020	Implementation and evaluation of action
R-1, PRT p. 68; NAcP 4-2	**Recommendation:** The regulator should consider the PSHA 2018 results in the beyond design basis safety evaluation of the plant and ensure the implementation of appropriate safety upgrading measures. The results of the PSHA may require an update of the protection concept with respect to seismic impacts to conform with WENRA safety objectives for new nuclear power plants which were taken as a reference by the PRT. **Action:** Review the results of the seismic PSA-2018 in the assessment of NPP safety and determine the need for	**Implementation:** The design basis earthquake (DBE) was originally established in line with NP-031-01 and the seismic hazard map GSZ-97-D26 revealing a DBE (exceedance frequency 10^{-4} per year) of Intensity 7° MSK-64 = 0.10 g PGA_H. In 2018, a new PSHA was carried out to develop a seismic PSA (2018 PSHA) which revealed a DBE of about 0.1 g for the occurrence probability of 10^{-4} per year. The 2018 PSHA also developed hazard curves reaching frequencies well below 10^{-4}. The PRT deemed this study as conforming with the current state of science and technology while it expressed reservations regarding the older hazard studies that were in line with Russian and Belarusian regulatory standards, but different from international guidelines. The PRT consequently suggested that the 2018 PSHA results should be used for any further evaluation of the seismic margin of the plant. According to GAN, the 2018 PSHA was reviewed and found acceptable for the physical start-up of the BelNPP. For the operating license, the licensee was requested to prepare '*a more precise seismographic model, adequately corresponding to the geodynamic conditions of Belarus*'. This led to the updated 2020 PSHA. The 2020 PSHA has been compiled by the Russian Institute of Physics of the Earth in Moscow. Some of the results are presented in the document '*Appendix R-2_Заключение отчета.pdf*'. The 2020 PSHA was consulted by the PRT during the site visit. Here, the new free-field peak ground acceleration (PGA) is noted with 0.1059 g at hazard level 10^{-4} per year, mean value. GAN accepted the PGA_H value of 0.1059 g as the seismic design basis (DBE) and the underlying 2020 PSHA in

[19] The brackets indicate the sources of the respective action.

- NR: National Report - Stress Test for Belarussian Nuclear Power Plant – 2017,
- PRT: EU Peer Review Report of the Belarussian Stress Tests - June 2018,
- EU: ENSREG '*Compilation of Recommendations and suggestions - Peer review of stress tests performed on European nuclear power plants', 26/07/2012,*
- NAcP: number of Recommendation of the National Action Plan of Belarus, 2019,
- p: page.

Action (Source[19]:)	PRT recommendation, action in NAcP and status in NAcP update of January 2020	Implementation and evaluation of action
	appropriate actions in order to improve safety. **Status:** Belarusian NPP developed a PSA in cooperation with the General Contractor: PSA-2018 Level 1 and PSA-2018 level 2 for Unit 1 of Belarusian NPP as part of the licensing package. The materials for PSA-2018 Level 1 and PSA-2018 Level 2 for Unit 1 of Belarusian NPP are reviewed by experts as part of a safety report with a view to obtaining a licence to operate Unit 1. The licensing procedure for that Unit is ongoing.	the operational license that was issued for Block 1 of BelNPP on 02 June 2021. According to GAN, the values are also binding for unit 2 of BelNPP. The DBE value of 0.1059 g and the underlying PSHA results have also been used as the basis for evaluating seismic margins to cope with DECs[20] as required by IAEA and WENRA reference documents. **Evaluation:** In the 2018 PRT report, the PRT recommended that GAN should consider the 2018 PSHA results in the beyond design basis safety evaluation of the plant and ensure appropriate safety upgrading measures are implemented. According to the NAcP (p. 31), GAN instead requested the licensee to prepare '*a more precise seismographic model, adequately corresponding to the geodynamic conditions of Belarus*'. This led to the updated 2020 PSHA. The differences between the 2018 PSHA and the 2020 PSHA with respect to input parameters were explained during the site visit in February 2021. The 2020 PSHA is based on an up-to-date probabilistic seismic hazard assessment, adopting a logic tree approach. According to information obtained during the review, the 2020 PSHA uses input data that are updated compared to those used for the 2018 PSHA, which formed the basis of the stress tests peer review in 2018. Both studies seem only differing by the assumed soil properties, while source zones models and ground motion prediction equations are apparently identical. According to GAN, the 2018 PSHA did not take into account the detailed site response analyses with respect to input seismic motion, while the 2020 PSHA took it into account according to modern standards including non-linear behaviour of soil profile. The differences between the 2018 PSHA and the 2020 PSHA are only minor for the hazard values derived for the exceedance frequency of 10^{-4} per year, mean, free-field, which is decisive for determining the DBE. During the Phase 1 Country Visit GAN envisaged that the value resulting from the 2020 PSHA as DBE with 0.1059 g could be accepted as DBE.

[20] In this PRT report, the term design extension condition (DEC) in connection with external hazards has the same meaning as the term beyond design basis event (BDBE) used in the IAEA safety standards.

Action (Source[19]:)	PRT recommendation, action in NAcP and status in NAcP update of January 2020	Implementation and evaluation of action
		Selecting the DBE from one of the above-mentioned PSHAs for the hazard level 10^{-4} per year, mean, free-field, is in line with internationally used approaches. It is also in line with the references used during the peer review of the EU stress tests. The engineering design basis for seismic category 1 SSCs of BelNPP is 0.12 g. The engineering design level therefore envelopes the envisaged DBE value of 0.1059 g derived from the 2020 PSHA. The envisaged DBE value and the underlying hazard assessment is used as a basis for the seismic margin assessment for DEC. During the licensing process for the commercial operation of unit 1 of BelNPP GAN has reviewed and assessed the 2020 PSHA and its underlying hazard assessment and endorsed it on 02 June 2021. The DBE value is fixed in the 'general part of the operational license' with applies to both units of BelNPP. Actions taken and implemented meet the intent of the 2018 PRT recommendation. The recommendation is therefore considered closed.
R-2, PRT p. 68 NAcP 4-1	**Recommendation:** A comprehensive margin assessment based on the hazard curve from the PSHA and fragility evaluations should be performed, to justify the adequacy of the margins of all SSCs with respect to the design basis and beyond for ensuring their integrity and function in accordance with their role in support of Defence-in-Depth (DiD) levels. **Action:** Carry out additional studies on the construction of seismic hazard curves, to clarify the safety	**Implementation:** <u>Hazard assessment</u> The 2020 PSHA (for more details see R-1) is approved by GAN, who endorsed 2020 PSHA as the basis for all further seismic considerations (see R-1 above). The 2020 PSHA revealed a PGA_H value of 0.1059 g for the DBE (mean value in the free-field with a probability of occurrence of 10^{-4} per year). This DBE value and its underlying hazard curve down to exceedance frequencies of less than 10^{-6} per year are used as the basis for the seismic margin assessment for seismic impacts beyond DBE. <u>Seismic impacts up to DBE</u> The SSCs important for the seismic safety of the plant were assigned to seismic category 1 and designed accordingly. The engineering design basis for seismic category 1 SSCs is 0.12 g. This is slightly above the DBE value (0.1059 g). The protection against seismic effects up to the DBE is thus ensured for SSCs of seismic category 1. <u>Seismic impacts beyond DBE</u> Based on the DBE with a PGA of 0.1059 g and its underlying hazard curve (mean, free-field), a

Action (Source[19]:)	PRT recommendation, action in NAcP and status in NAcP update of January 2020	Implementation and evaluation of action
	margins of NPP structures, systems and components (SSCs), taking into account the more precise seismotectonic model. Correct the seismic Probabilistic Safety Analysis (PSA) for which initial data will come from adjusted seismic hazard curves, including the assessment of safety margins for parts of safety-critical systems. Determine the need for a comprehensive assessment of seismic risk on the basis of more refined seismic hazard curves and existing equipment safety margins. **Status:** The State enterprise "Belorusskaya AES" (hereinafter: "Belarusian NPP") set the budget for work on this item, conducted competitive tender procedures and selected the contractors to work on the construction of a seismotectonic	comprehensive seismic margin assessment beyond the DBE and the engineering value of 0.12 g was carried out. The following tables 1-4 out of two studies of June and August 2021[21] provided by BelNPP give overview about the seismic resistances of the safety relevant systems in g (9.81 m/s^2) evaluated by the method of High Confidence of Low Probability of Failure (HCLPF). Values are provided for 5% probability of failure and 95% confidence. Seismic margins are denoted in g and % as compared to the DBE (0.1059 g). The tables list HCLPF values of SSCs that are relevant for Defence in Depth (DiD) levels 3 and 4 with regard to the safety functions that are important on these DiD levels. Table 1 — List of DiD Level 3 SSCs for safe shutdown and cooling down of BelNPP to eliminate nuclear fuel damage

Table 1 — List of DiD Level 3 SSCs for safe shutdown and cooling down of BelNPP to eliminate nuclear fuel damage

System	HCLPF, g	**Seismic margin** under the BDBA conditions, beyond the site's DBE,	
		g	%
Reactor protection system	0.17	0.0641	60
ECCS hydraulic tank system (JNG-2)	0.37	0.2641	249
Emergency boron injection system (JDH)	0.37	0.2641	249
High pressure emergency injection system (JND)	0.37	0.2641	249
Low pressure emergency injection system (JNG-1)	0.24	0.1341	114
Emergency gas removal system (KTP)	0.37	0.2641	249
Borated water storage system (JNK)	0.37	0.2641	249
EFWP + FAARU (LBU)	0.37	0.2641	249
Spent fuel pool cooling system (FAK)	0.24	0.1341	114

[21] Демонстрация безопасности Белорусской АЭС при косвенных последствиях землетрясения (Belarusian NPP safety demonstration of indirect earthquake-induced consequences) of 14 June 2021 received from GAN on 16 June 2021 in Russian. Tables used in this report are from the updated version of 27 August 2021.

Action (Source[19]:)	PRT recommendation, action in NAcP and status in NAcP update of January 2020	Implementation and evaluation of action
	model and refinement of the seismic hazard curves, taking into account the alternative seismotectonic model. Work on the construction of a seismotectonic model and refinement of the seismic hazard curves, taking into account the alternative seismotectonic model, is currently ongoing. Deadline for completion of the work: March 2020. The deadline for adjusting the PSA for seismic impacts, taking into account the revised seismic hazard curves, has been postponed until December 2020.	(see tables below)

Residual heat removal system (JNA)	0.37	0.2641	249
MSIV (LBA)	0.37	0.2641	249
Emergency power supply system (EPS)	0.22	0.1141	107
Technological safety control system (TSCS; in Russian — USBT)	0.24	0.1341	114
System of cooling intermediate circuit of important consumers (KAA)	0.24	0.1341	114
Technical water supply system for safety systems (PE)	0.25	0.1441	136
Ventilation systems, air conditioning of the operation building (SAC)	0.17	0.0641	60
Ventilation and air conditioning systems of modular electrical buildings (SAD)	0.25	0.1441	136
Building ventilation systems for cooling water installations (SAG)	0.25	0.1441	136
Ventilation systems of the safety building in the controlled access area (KLG)	0.25	0.1441	136
Primary circuit overpressure protection system (JEF)	0.37	0.2641	249

Table 2 — List of level 3 SSCs to prevent a large accidental release

System	**HCLPF, g**	**Seismic margin** under the BDBA conditions, beyond the site's MCE,	
		g	%
Annulus ventilation system (KLC)	0.25	0.1441	136
Sprinkler system (JMN)	0.13 (0.37)*	0.0241 (0.2641)	23 (249)
Hydrogen removal system from the containment dome (JMT)	0.25	0.1471	139
Emergency power supply system (EPS)	0.22	0.1141	107
Technological safety control system (TSCS; in Russian — USBT)	0.24	0.1341	114
System of cooling intermediate circuit of responsible	0.24	0.1341	114

Action (Source[19]:)	PRT recommendation, action in NAcP and status in NAcP update of January 2020	Implementation and evaluation of action

consumers (KAA)			
Technical water supply system for safety systems (PE)	0.25	0.1441	136
Ventilation systems, air conditioning of the operation building (SAC)	0.17	0.0641	60
Ventilation and air conditioning systems of modular electrical buildings (SAD)	0.25	0.1441	136
Building ventilation systems for cooling water installations (SAG)	0.25	0.1441	136
Ventilation systems of the safety building in the controlled access area (KLG)	0.25	0.1441	136
Primary circuit overpressure protection system (JEF)	0.37	0.2641	249

* — The chemical storage tanks to fix volatile forms of iodine of the JMN system, as shown in Table 2, have a seismic resistance of 0.13 g. Under BDBE conditions, the factor defining radiation consequences is the integrity of the containment. Thus, the seismic impact — at which the JMN system can depressurize the containment — is 0.37 g.

Table 3 — List of level 4 SSCs to control BDBE to eliminate nuclear fuel damage

System	**HCLPF, g**	**Seismic margin** under the BDBA conditions, beyond the site's MCE,	
		g	%
SG PHRS (system of passive heat removal from steam generator (SPOT PG)) (JNB)	0.37	0.2641	249
System of water emergency use from VI inspection cavity (JNB90)	0.37	0.2641	1249
EPS BDBA	0.17	0.0641	60
MCS BDBA	0.24	0.1341	114

Table 4 — List of level 4 SSCs to control BDBE to prevent large early radioactive releases

System	**HCLPF, g**	**Seismic margin** under the BDBA conditions, beyond the site's MCE,

<table>
<tr><th>Action (Source[19]:)</th><th>PRT recommendation, action in NAcP and status in NAcP update of January 2020</th><th>Implementation and evaluation of action</th></tr>
<tr><td></td><td></td><td>
<table>
<tr><th></th><th></th><th>g</th><th>%</th></tr>
<tr><td>SG PHRS (system of passive heat removal from steam generator (SPOT PG)) (JNB)</td><td>0.37</td><td>0.2641</td><td>249</td></tr>
<tr><td>C PHRS (Containment Passive Heat Removal System (SPOT ZO)) (JMP)</td><td>0.19</td><td>0.0851</td><td>80</td></tr>
<tr><td>Containment hydrogen removal system (JMT)</td><td>0.25</td><td>0.1471</td><td>139</td></tr>
<tr><td>System of water emergency use from VI inspection cavity (JNB90)</td><td>0.12 (0.37)**</td><td>0.0141 (0.2641)</td><td>13 (249)</td></tr>
<tr><td>Core melt retention system (melt trap) (JMR)</td><td>0.60</td><td>0.4941</td><td>466</td></tr>
<tr><td>Emergency gas removal system (KTP)</td><td>0.37</td><td>0.2641</td><td>249</td></tr>
<tr><td>EPS BDBA</td><td>0.17</td><td>0.0641</td><td>60</td></tr>
<tr><td>MCS BDBA</td><td>0.24</td><td>0.1341</td><td>114</td></tr>
</table>
** - The JNB90 system, as shown in Table 4, has a concentrated alkali storage tank with seismic resistance of 0.12 g as far as the iodine fixation function is concerned. Seismic resistance of the rest of the system elements responsible for heat removal from the melt trap under BDBA is 0.37 g.
The seismic margin for a leak-tight containment is stated with 0.51 g if minor inelastic deformation is allowed (NR, p. 64).
The safety relevant SSCs required for safe shutdown and cooling of the BelNPP power units have seismic resistances of at least 0.17 g[22], which results in safety margins of about 60% with respect to the DBE.
The adequacy of the seismic design in respect to seismic events beyond the DBE, and thus the seismic design of the plant in respect to DEC, was evaluated by means of a seismic PSA (SPSA), PSA level 1 and a full-scope PSA level 2[23] using the 2020 PSHA hazard curve.
</td></tr>
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[22] With the understanding that the value 0.17 g for the reactor protection system applies to the control rod insertion system (the mechanical part).

[23] '*Reassessment of seismic PSA (SPSA)*' - All cited data in respect to the seismic PSA level 1 and the full-scope PSA level 2 were presented and explained during expert discussion (VC) on 25 January 2021.

Action (Source[19]:)	PRT recommendation, action in NAcP and status in NAcP update of January 2020	Implementation and evaluation of action
		Evaluation: The seismic resistance of the SSCs was determined by comprehensive fragility analyses. These analyses were performed according to seismic walk downs of the plant and on the basis of detailed design documents. The fragilities were assessed with a set of different technically approved methods using seismic responses of buildings and structures. The seismic margins of the SSCs were determined on basis of the hazard curve of the 2020 PSHA. The hazard curves of the 2020 PSHA cover seismic events down to an occurrence probability of 10^{-7} per year. For the determination of seismic margins, the hazard curve mean, free-field is used (according to mostly applied international practice). The PRT considers the 2020 PSHA with its hazard curve (mean, free-field) and its DBE value with a PGA_H of 0.1059 g for the occurrence probability of 10^{-4} year is an appropriate and adequate basis for the assessment of seismic margins for the BelNPP site. A seismic PSA (SPSA) level 1 and a full-scope PSA level 2 was used to assess the adequacy of seismic margins of the SSCs that are necessary to prevent damages from seismic events also beyond the DBE and to cope with seismic design extension conditions (DEC) to prevent core damage and large radioactivity releases. The SPSA level 1 is based on the 2020 PSHA dividing the hazard curve into 5 intervals for the subsequent use in the SPSA-model. Each interval was assigned the corresponding PGA and the corresponding exceedance frequency (the details are shown in the following table). Table 5 – Hazard curve intervals used in the SPSA-model

Hazard curve interval	PGA, g	Freq, 1/year
S_1	0.12	4.91E-04
S_2	0.203	1.01E-05
S_3	0.242	2.06E-06
S_4	0.275	6.82E-07
S_5	0.308	3.16E-07

The seismic PSA level 1 and the full-scope PSA level 2 had the following results:

Action (Source[19]:)	PRT recommendation, action in NAcP and status in NAcP update of January 2020	Implementation and evaluation of action
		Based on the information provided the seismic PSA level 1 revealed a point value of $7.71*10^{-7}$ per year for the Nuclear Fuel Damage Frequency (NFDF) for seismic events taking into account all operational states. The seismic PSA level 1 indicates that the risk is well balanced between the two operational states: power operation and outages with a slightly higher risk during outages. The consideration of the single contributions of the 5 hazard curve intervals to the overall result shows a comparatively good balance across all intervals with a peak of just under 40% in interval 2 (exceedance frequency 10^{-5} per year). The highest fractional contributions to the NFDF comes from the ventilation systems of the following buildings: UCB (I&C), UBS (EPSS and DGs), UKD (water injection safety systems) and UQC (essential service water system). The highest single contribution is 19% (UCB (I&C)), and the total sum of these fractional contributions is approximately 75% of the total contribution. The lower seismic margin of the ventilation system of the UCB building (hosting I&C) with a seismic resistance of 0.17 g compared to the other ventilation systems with 0.25 g represents a certain imbalance in the seismic design and can be considered a relative weak point irrespective of the low NFDF of the whole plant. The numerical NFDF value of 7.71E-07 1/year resulting from the seismic PSA suggests that the fuel damages both in the core and in the spent fuel pool initiated by earthquake can be regarded extremely unlikely and indicates that the relevant SSCs have sufficient seismic margins to fulfill their function in the different levels of DiD. During the site visit in August/September 2021 the PRT was informed about the existence of additional PSA calculations and the availability of a full-scope PSA level 1 (for all initiating events). The new calculations showed similar results, which confirmed the cited numbers of January 2021[24]. The full-scope PSA level 2 resulted in a point value of $8.68*10^{-8}$ per year for the large release frequency (LRF)

[24] '*Reassessment of seismic PSA (SPSA)*' - All cited data in respect to the seismic PSA level 1 and the full-scope PSA level 2 were presented and explained during expert discussion (VC) on 25 January 2021.

Action (Source[19]:)	PRT recommendation, action in NAcP and status in NAcP update of January 2020	Implementation and evaluation of action
		taking into account all operational states, all initiating events and all radioactive sources of the core and the spent fuel pool. During the site visit, GAN informed that PSA Level 2 takes into account all relevant release paths and that the above reported value is an integral value that also includes Large Early Releases. The results of the full-scope PSA level 2 show that seismic events have the highest fractional contribution to the overall risk, at just under 40%, but that the risk profile also in respect to potential radioactivity releases is comparatively balanced. The results of the PSA level 1 and 2 demonstrate compliance with the risk-related numerical criteria specified in the Belarusian regulatory requirements: NFDF less than 10^{-5} per year and LRF less than 10^{-7} per year. The NFDF and LRF values of BelNPP are also in line with international expectations. As overall safety objectives for new nuclear reactors today, it is expected that the integral CDF does not exceed 10^{-5} and the integral LRF does not exceed 10^{-6} per year. These values are met. Furthermore, the PSAs indicate that there are no significant weak points or cliff edges in the seismic design besides the identified weak point of the relatively low seismic resistance of parts of the ventilation systems. According to the results of the PSAs (level 1 and 2) and based on the hazard curve from the 2020 PSHA and the fragility evaluations the margins of all SSCs relevant to safety are sufficient to achieve adequately low CDF and LRF frequencies. This includes the securing of the necessary integrity and function of the SSCs in accordance with their role in support of defence-in-depth levels. The verifications were carried out by using state-of-the-art seismic margin assessment, SPSA, PSA level 1 and 2. Actions taken and implemented meet the intent of the 2018 PRT recommendations to perform a comprehensive seismic margin assessment based on the hazard curve of the 2020 PSHA, and to ensure that the seismic resistances of SSCs credited for coping with accident conditions (DiD levels 3 and 4) induced by a seismic event are adequate to ensure their performance are fulfilled except for the findings on the fire extinguishing systems and the housing of the fire brigade (see R-3 below). This recommendation is considered closed.
R-3, PRT p. 68 NAcP 4-3	**Recommendation:** The regulator should ensure that the seismic resistances of SSCs	**Implementation:** The assessment of the seismic resistance of the safety relevant SSCs was finalised during the commissioning and reviewed by GAN.

Action (Source[19]:)	PRT recommendation, action in NAcP and status in NAcP update of January 2020	Implementation and evaluation of action
	credited for coping with accident conditions (DiD levels 3 and 4) induced by a seismic event are adequate to ensure their performance. **Action:** Based on the completion of the actions in point 1, assess the characteristics of seismic stability of SSCs to ensure their function in an accident situation (levels DiD 3 and 4). **Status:** As part of the commissioning works, ATOMTECHENERGO AO is assessing the seismic stability of safety-critical equipment using the 'Programmes for determining the dynamic characteristics and seismic stability of safety-critical equipment'. The work is expected to be completed by 31 March 2020. As part of the adjustment to the	**Evaluation:** The evaluation is carried out separately for seismic impacts up to the DBE and for seismic impacts beyond the DBE. Since indirect seismic effects can have a considerable safety significance, the precautionary measures taken in both areas against damage caused by such effects are also investigated and evaluated here. This comprises earthquake-induced fires, earthquake-induced internal flooding, earthquake-induced interactions of SSCs having lower seismic category with items in seismic category 1 and housing of mobile means. Seismic resistance up to the DBE In phase 1 of this peer review the PRT has only reviewed and assessed the situation up to the seismic resistance necessary to cope with a DBE (defence in depth level 3). The engineering design basis for seismic category 1 SSCs is PGA_H = 0.12 g. This is above the DBE value of PGA_H = 0.1059 g. The engineering design of the seismic category 1 SSCs envelopes the DBE value. The seismic resistance of the SSCs to cope with seismic impacts up to the DBE are adequate. Seismic resistance beyond the DBE GAN's written answers to the PRT questions and additional information prepared during the country visits gave a comprehensive overview of the seismic category 1 SSCs. It was shown that the safety relevant SSCs required for safe shutdown and decay heat removal after a shutdown and to prevent large accidental releases have seismic resistances of at least 0.17 g [25]. The value corresponds to a recurrence probability below 10^{-4} and higher than 10^{-5} per year and a safety margin of about 60% in respect to the DBE (for more details see tables 1 and 2 of R-2). Furthermore the adequacy of the seismic design of the plant and the adequacy of the seismic margins of the safety-relevant SSCs with respect to seismic impacts greater than the DBE (BDBE) were evaluated by PSAs

[25] With the understanding that the value 0.17 g for the reactor protection system applies to the control rod insertion system (the mechanical part).

Action (Source[19]:)	PRT recommendation, action in NAcP and status in NAcP update of January 2020	Implementation and evaluation of action
	seismic PSA (Point 1 of the National Plan), work on seismic stability analyses is in hand. The results will form the basis for a list of components, and the probabilistic parameters of their seismic damage to Unit 1 will be determined. (The work is being done by "TsKTI-VIBROSEYSM OOO" and "ATOMPROYEKT AO" and is scheduled for completion by 31 May 2020.	level 1 and 2 (for more details see R-2). In respect to defence in depth level 4 the insofar necessary SSCs have sufficient seismic margins to largely prevent nuclear fuel damage and large early radioactivity releases even in case of a seismic event beyond the DBE (for more details see tables 3 and 4 of R-2). The seismic resistance of the SSCs to cope with seismic impacts beyond the DBE are adequate. <u>Indirect effects of earthquake</u> At the request of the PRT, GAN submitted a comprehensive document on indirect effects of earthquake in June 2021[26]. This report notes that the safety assessment of indirect effects of earthquakes at the BelNPP is also based on the hazard assumptions of the PSHA 2020, which were accepted and approved by the GAN. The hazard curve of the PSHA 2020 is the basis for the seismic requirements and the determination of the DBE with a PGA_H of 0.1059 g. Furthermore, it also determines the seismic hazards beyond the DBE (BDBE). The seismic resistances given in the report were determined using the HCLPF method. The reference value for the seismic margins of the individual safety systems mentioned there is the DBE (for more details see tables in R-2). The following measures taken in the design of BelNPP not only serve to ensure the general safety and robustness of the plant in case of an earthquake, but also help to largely exclude indirect earthquake effects in case of seismic impacts up to the DBE and mitigate them in case of BDBE: • The basic design of the NPP applies the multi-train principle ensuring a 4-safety-train structure of the protective, supporting and controlling safety systems, furthermore physical separation, whereby all 4 safety trains are spatial separated to ensure protection against common cause failures. • Importance was given to fire prevention and fire protection. The measures taken include for instance minimization of fire loads, avoidance of ignition sources, spatial separation, fourfold

[26] '*Демонстрация безопасности Белорусской АЭС при косвенных последствиях землетрясения*' (Belarusian NPP safety demonstration of indirect earthquake-induced consequences) of 14 June 2021 received from GAN on 16 June 2021 in Russian. Tables used in this report are from the updated version of 27 August 2021.

Action (Source[19]:)	PRT recommendation, action in NAcP and status in NAcP update of January 2020	Implementation and evaluation of action
		redundant design of important systems, automatic fire detection and firefighting as far as appropriate. The measures taken minimise the risk of fire ignition, by detecting fires quickly and by limiting their consequences. These measures also prevent or mitigate the consequences of indirectly earthquake-triggered fires. • The design principle 'failure/damage of lower-level seismic resistance category equipment shall not cause a failure of a higher seismic resistance category equipment' was applied. • At the NPP site an earthquake monitoring system is in operation that ensures automatic shutdown of the reactor when a seismic impact reaches the level of PGA_H = 0.06 g (OBE level). • The seismic resistance of seismic category 1 SSCs is designed with 0.12 g. This is slightly above the value of the DBE with a PGA_H of 0.1059 g. Safety relevant SSCs required for safe shutdown and decay heat removal after the shutdown and to prevent large accidental releases have seismic resistances of at least 0.17 g[27]. This represents a 60% seismic margin in respect to the DBE (0.1059 g). • The design includes protection elements and design measures against flying objects that could result from damaged equipment working at high pressure. These protective design measures and elements exclude eventual effects on SSCs critical to safety from damaged equipment classified to lower classes of earthquake resistance. • Measures were also taken to protect against internal flooding through facilities for rapid detection of damage, protective lining of potentially affected areas, structural measures such as spatial separation, barriers and controlled capture or drainage of spilled liquids. • Mobile equipment (including that used to supplement the JNB-50 pump) and for firefighting / fire protection is located and housed separately from the plant. However, with respect to the hazard of earthquake induced fire the PRT makes the following two

[27] With the understanding that the value 0.17 g for the reactor protection system applies to the control rod insertion system (the mechanical part).

Action (Source[19]:)	PRT recommendation, action in NAcP and status in NAcP update of January 2020	Implementation and evaluation of action
		observations: • Parts of the fire extinguishing systems protecting SSCs important to safety are seismic category 2 or 3 and therefore not qualified to sustain a design basis earthquake. In case of a seismic-induced fire it could happen that the fire extinguishing systems would fail and safety systems could be jeopardized by fire. However, in such extreme conditions heat removal from the reactor can be achieved by the passive heat removal systems. • The housing of the on-site fire brigade is only qualified to sustain an OBE (0.06 g). In case of an earthquake beyond 0.06 g fire brigade building could be damaged and the fire brigade could therefore be unable to fight earthquake-induced fires in due mission times. Actions taken and implemented meet the intent of the 2018 PRT recommendation '*to ensure that the seismic resistances of SSCs credited for coping with accident conditions (DiD levels 3 and 4) induced by a seismic event are adequate to ensure their performance*' except for the findings on the fire extinguishing systems and the housing of the fire brigade. For further enhancement of safety of the BelNPP, the PRT encourages qualifying the relevant parts of the fire extinguishing system to seismic category 1[28] and retrofitting the housing of the on-site fire brigade to the level of the DBE. These measures will increase the capability to mitigate potential damage caused by seismic induced fires. The latter will also provide the necessary protection for the mobile fire engine driven pump needed to supply water to the tanks of the SG PHRS or to the spent fuel pool in case of failure of the JNB50 pump – see chapter 4.2, sub-section '*Additional measures for enhancing the reliability of the JNB50 subsystem*'. The recommendation is considered closed except as regards findings on the fire-fighting systems and the housing of the fire trucks.[29]

[28] As required by the WENRA Safety Reference Levels for Existing Reactors 2020, Issue SV (Internal Hazards), Reference Level SV 5.6 and footnote 84.

[29] The stress test requirements specify that for the analysis of loss of off-site power and loss of ultimate heat sink, it shall be assumed that *'the site is isolated from delivery of heavy material for 72 hours by road, rail or waterways. Portable light equipment can arrive to the site from other locations after the first 24 hours'*.

Action (Source[19]:)	PRT recommendation, action in NAcP and status in NAcP update of January 2020	Implementation and evaluation of action
R-4, PRT p.68 NAcP 4-4	**Recommendation:** The PRT is aware of the different interpretations of the 1908 seismic event published in seismological literature and catalogues. Keeping this in mind, the PRT recommends performing a study on this seismic event to clarify its nature and completing a review of the zoning and seismic catalogues. **Action:** Perform R&D entitled "Exploring the nature of the Gudogay seismic event of 1908 and updating the seismicity catalogue for the region in which Belarusian NPP is located". **Status:** The Geophysical Monitoring Centre of the National Academy of Sciences of Belarus has carried out research entitled "Exploring the nature of the Gudogay seismic event of 1908". The findings were sent to Belarusian NPP for further implementation of Point 4 of the Plan, with a view to updating the	**Implementation:** In the Peer Review Report of the Belarus Stress Tests, the PRT noted that the DBE is challenged by the fact that earthquake catalogues for the east Baltic region indicate that several earthquakes with an intensity of I_0=7° occurred over the last 100 years within the area. According to the maps TKP 45-3.02-108-2008 and GSZ-97-D an occurrence probability per year for such events is thought to be 10^{-4}. If correct, these data contradict the cited hazard maps. The closest I_0=7° earthquake listed in the SHEEC catalogue occurred only 25 km from the NPP site (Oshmyansky 1908). During the country visit, the National Academy of Sciences of Russia indicated its doubt over whether these events ever happened. However, evidence from a contemporary newspaper (Nasha Niva № 3, January 15 (28), 1909), presented by GAN during the videoconference of 21 August 2020 suggests that at least one such event occurred. According to Annex 2 of the NAcP, the deadline for exploring the nature of the Gudogay 1908 earthquake was 15 December 2019. The update of NAcP Annex 2 lists the task as completed. **Evaluation:** The NAcP (Table 4, No. 4) lists 31 December 2022 as the deadline for completing the task '*Study of the nature of the Gudogay seismic event of 1908 and update the seismicity catalogue for the region of the Belarusian NPP location*'. The study on the Gudogay 1908 event has been promptly completed before the envisaged deadline. The corresponding report by Aronov 2019 was presented during the site visit in February 2021. According to this report, a review of instrumental earthquake records from Pulkovo did not reveal indications for the occurrence of a strong earthquake at Gudogay. It is concluded that the records at Pulkovo, which is located in a distance of about 600 km from Gudogay, exclude the occurrence of an earthquake of M=4.5 or higher, but do not exclude the possible occurrence of an earthquake with a magnitude below the threshold of M=4.5. According to this evidence and considering contemporary newspaper reports from Gudogay the intensity of the event was therefore assessed with 3.5-4.0 / I_0=6. The report by Aronov, however, leaves it open if local newspapers prove the event or only just 'echo' the Messina earthquake that happened at the same time. During the country visit in August-September 2021 it was confirmed that the results of the report were used to update the earthquake catalogue. The low magnitude/intensity of the possible Gudogay earthquake does

Action (Source[19]:)	PRT recommendation, action in NAcP and status in NAcP update of January 2020	Implementation and evaluation of action
	catalogue of seismicity in that location.	not necessitate updates of the PSHA and seismic PSA as there are no significant differences with the catalogue used for the PSHA completed in March 2020. Actions taken and implemented meet the intent of the 2018 PRT recommendation to investigate the Gudogay 1908 earthquake and update the earthquake catalogue used for seismic hazard assessment. The recommendation is considered closed.
R-5, PRT p. 68 NAcP 4-5 Planning of the network (part 1 of R-5, PRT p. 68)	**Recommendation:** Extend the number of stations of the seismic observation network to also cover the Quaternary Oshmiyansky fault. **Action:** Perform R&D on the "Assessment of the optimal location and resolution of the local seismic monitoring network in the region of the Belarusian NPP site location to monitor possible geodynamic activity in the Oshmiyansky fault zone". In the light of the results of the R&D exercise, take the necessary measures with the option of increasing the number of stations. **Status:** Belarusian NPP issued a call for technical and commercial proposals for implementation of	**Implementation:** According to Annex 2 of the NAcP, the deadline for completing this task is 31 December 2022. The update of Annex 2 of the NAcP claims the issuance of a call to implement the task is '*in hand*'. Seismicity in the near-region of the BelNPP is currently monitored by a network of temporary stations including seismographs in the vicinity of Gudogay and the Oshmiyansky fault. During the country visits the PRT also took note that the BelNPP is monitored by 14 seismic stations at the BelNPP site which initiate automatic scram and trigger emergency systems in case of the occurrence of an Operating Base Earthquake (OBE; 0.06 g). **Evaluation:** The task of issuing a call to plan and implementing a local seismic observation network has been completed. During the February 2021 site visit it was confirmed that temporary stations in the vicinity of Gudogay and the Oshmiyansky fault have been established in 2020. Work to convert the temporary network into a permanent one is ongoing (see also part 2 of R-5 below) The PRT was further informed that the BelNPP is monitored by 14 seismic stations at the BelNPP site which initiate automatic scram in case of the occurrence of an Operating Base Earthquake (OBE). Actions taken to establish a temporary seismic observation network that also covers the Oshmiyansky fault meet the intent of the 2018 PRT recommendation. Transformation of the current temporary network into a permanent one is ongoing. The plan is to have this action completed in 2025. Actions taken, implemented and planned meet the intent of the 2018 PRT recommendation. The recommendation is considered closed.

Action (Source[19]:)	PRT recommendation, action in NAcP and status in NAcP update of January 2020	Implementation and evaluation of action
	the work. Proposals were received from the State University "TsGM" of the National Academy of Sciences of Belarus and IFZ "RAS" (Schmidt Institute of Terrestrial Physics of the Russian Academy of Sciences).	
R-5 PRT p. 68 NAcP 4-6 Implementation of the network (part 2 of R-5, PRT p. 68)	**Recommendation:** Extend the number of stations of the seismic observation network to also cover the Quaternary Oshmiyansky fault. **Action:** Implement a permanent (fixed) local seismic observation network for the operating period of Belarusian NPP to monitor the stability of the parameters for the design basis and obtain objective, up-to-date information on changes in the geodynamic situation in the area of the facility including: - search for and selection of places (from among 20-25 alternative locations) within a radius of 30 km of the site of Belarusian NPP for the placement of observation	**Implementation:** According to Annex 2 of the NAcP, the deadline for completing the task is 1 January 2025 with interim steps to be achieved between 2020 and 2024. The action is under implementation. Seismicity in the near-region of the BelNPP is currently monitored by a network of temporary stations including two additional seismographs in the vicinity of Gudogay and the Oshmiyansky fault. The currently installed temporary network of seismic stations will be replaced by a permanent station network after the selection of appropriate sites with low seismic noise level. The full replacement of the temporary network by a permanent one is expected to be completed by 2025. During the country visits the PRT also took note that both units of BelNPP are equipped with 14 seismic detectors each, forming an industrial protection system. It was explained that 8 detectors trigger automatic shut-down (at OBE = 0.06 g) while 6 detectors are used for monitoring purposes. **Evaluation:** It is acknowledged that the seismic observation network is being built up and optimised with the participation of high-level specialised institutions. This is expected to result in a professional and appropriate monitoring of possible geodynamic activity, including the Oshmiyansky fault zone. An efficient and comprehensive seismic observation network in the vicinity of BelNPP in Ostrovets is necessary as only a rather limited set of geodynamic data are available for this region. To adequately assess the seismic risks, a qualified longer-term observation is necessary. See also the statement to Recommendation R-5, PRT p. 68, NAcP 4-5.

Action (Source[19]:)	PRT recommendation, action in NAcP and status in NAcP update of January 2020	Implementation and evaluation of action
	points; - preparatory work; - construction and auxiliary works (including design work appropriate to the selected location); - purchase of basic and auxiliary equipment, its installation and configuration at the observation points and at the Data Collection and Processing Centre. Implement connections to reserve power supplies, equipment security alarms and other, related work, preparation and debugging of software, commissioning and operation of the system. **Status:** Belarusian NPP issued a call for technical and commercial proposals for implementation of the work. Proposals were received from the State University "TsGM" of the National Academy of Sciences of Belarus and IFZ "RAS".	The actions planned meet the intent of the 2018 PRT recommendation. Transformation of the current temporary network into a permanent one is ongoing and to be completed by 2025. This recommendation is considered closed.
R-6, PRT p. 68 NAcP 4-7	**Recommendation:** Provide free access to the data recorded by the seismic	**Implementation:** The seismic monitoring network near BelNPP will be further developed in the coming years (see

Action (Source[19]:)	PRT recommendation, action in NAcP and status in NAcP update of January 2020	Implementation and evaluation of action
	observation network for scientific purpose to profit from research results that had better constrain the seismotectonic model for future updates of the PSHA. **Action:** Perform R&D (“Study of international experience in conducting research with observational data from a seismic observation network monitoring in the area where a nuclear power plant is located and developing technology and a procedure for processing data from the Belarusian network”). **Status:** Belarusian NPP issued a call for technical and commercial proposals for implementation of the work. Proposals were received from the State University “TsGM” of the National Academy of Sciences of Belarus and IFZ “RAS”.	Recommendation R-5 above). The NAcP envisages the development of technologies and procedures for accessing data from the seismic observation network in the region where the BelNPP is located. Based on this work, it should then be possible to provide open access. However, at this stage it has not yet been decided how and to what extent the data will be accessible, nor the extent to which there will be direct access. In line with the seismic safety work plan, currently it is envisaged that the operator of the nuclear power plant will only carry out the following in 2020-2024: – a study on the international normative documents on providing scientific research using seismological data in areas with NPP sites, – a study on international experience in information access to seismological monitoring systems in areas with NPP sites, – the development of appropriate technologies and procedures for scientific access to the results of seismological monitoring in the region where the BelNPP is located using the possibilities offered by the current information channels and information security; and – experimental testing of these technologies and processes. According to current plans, a decision on how data can be accessed, and which data should be accessed, will be taken by the end of 2022. However, the observation network will not yet be fully established by then, as it will only be fully installed by early 2025. Therefore, data from the fully deployed seismic network will not be available before that date. **Evaluation:** Free, complete, and rapid access, especially for the scientific community, to the data obtained from the local seismic observation network currently being set up is important. By means of free access, GAN and the licensee will benefit from research results that better constrain the seismotectonic model for future updates of the PSHA. Furthermore, free access to the data provided by the local seismic observation network creates transparency

Action (Source[19]:)	PRT recommendation, action in NAcP and status in NAcP update of January 2020	Implementation and evaluation of action
		regarding seismic events in the vicinity of BelNPP and is thus also an important confidence-building measure. Therefore, such access should be granted at the technically earliest possible time for all already installed and operating monitoring stations. Actions planned and being implemented meet the intent of the 2018 PRT recommendation. Implementation is planned to be completed in 2025 in connection with the expansion of the monitoring network. However, decisions on providing access to the data are still pending, and therefore this recommendation remains open.
R-7, PRT p. 68 NAcP Annex 1, line 7	**Recommendation:** Implement the measures and actions defined in the Section 3.2.4 of the NR. **Action:** As part of preparation for commissioning, seismic probabilistic safety assessment 1 has been drawn up (requirements under the licensing process). Currently, as part of the implementation of Measure 1 in table 4, the seismic probabilistic safety assessment 1 is being amended, and a seismic probabilistic safety assessment 2 is being drawn up. As part of commissioning, the seismic resistance of the design of systems and components vital to	**Implementation:** In Section 3.2.4 of the NR the following improvement measures were proposed: *'The following organizational and technical measures are proposed to moderate the consequences of earthquakes exceeding the design values:* *1. To perform analysis of the documents under development on the personnel actions under accidents when seismic impact exceeds the design one. As required, to add the documents on the personnel actions providing diagnostic of the NPP, restoration of normal operation conditions, restoration of safety functions and prevention or limitation of the core damage consequences to the Process Regulations, Reactor Plant Emergency Operating Procedure, Severe Accident Management Guidelines (SAMG) and the Beyond Design Basis Accidents Management Guideline (BDBAMG) as well as to the Personnel Protection Plan under Accidents;* 2. *PSA development. It is proposed to reassess seismic margins for the equipment and pipelines referred to seismic category 1 by the results of the Belarusian NPP finished construction and commissioning using the SMA method specified in EPRI-NP-6041 and IAEA NS-G-2.13.'* These measures and actions were carried out during commissioning. **Evaluation:** 1. Successful execution of the EOP and SAMG actions requires (in addition to sufficient robustness of necessary equipment and of control places) accessibility of certain areas outside the buildings under

Action (Source[19]:)	PRT recommendation, action in NAcP and status in NAcP update of January 2020	Implementation and evaluation of action
	safety is being evaluated using the 'Method for validating the dynamic characteristics of NPP power unit systems and elements which are vital to safety'. As part of the drafting of the seismic probabilistic safety assessment, the seismic resistance of equipment is being evaluated using the SMA methods set out in EPRI-NP-6041 and NS-G-2.13. Following the evaluation, to develop and implement measures for improving the seismic resistance of equipment, if necessary. **Status:** n/a	potentially harsh conditions caused by serious external hazards (such as earthquake). Feasibility of such actions (in particular refiling of the heat exchanger tanks of the passive heat removal systems) was discussed during the site visits. Procedures are in place and personnel trained. 2. A seismic PSA level 1 and a full-scope PSA level 2 are available and approved by GAN. The seismic PSA level 1 and the full-scope PSA level 2 had the following results: The seismic PSA level 1 revealed a point value of $7.71*10^{-7}$ per year for the nuclear fuel damage frequency (NFDF) for seismic events taken into account all operational states. The full-scope PSA level 2 resulted in a point value of $8.68*10^{-8}$ per year for the large release frequency (LRF) taken into account all operational states and all initiating events and all radioactive sources of the core and the spent fuel pool. The results of the PSAs level 1 and level 2 demonstrate compliance with the risk-related numerical criteria specified in the Belarusian regulatory requirements: NFDF less than 10^{-5} per year and LRF less than 10^{-7} per year. The NFDF and LRF values of BelNPP are also in line with international expectations in respect to prevent core damage and large radioactivity releases. Furthermore, the in-depth considerations of the PSAs show that there are no significant weak points or cliff edges in the seismic design. The applied methods for seismic margin assessments comply with the state of the art. The results of the margin assessment show sufficient seismic resistances for the seismic relevant SSCs to perform their functions. For more details in respect to the PSAs and the seismic resistances of the SSCs and the findings see R-2 and R-3. Actions taken and implemented meet the intent of the 2018 PRT recommendation. This recommendation is considered closed.
R-12, PRT p. 70 NAcP 4-1, 4-2, 4-3	**Recommendation:** The adequacy of margins of SSCs for beyond design basis earthquakes of the plant	**Implementation** The adequacy of margins of SSCs for beyond design basis earthquakes of the plant equipment ultimately needed for prevention of core melt was assessed. The seismic resistance of the seismically relevant SSCs was evaluated by fragility analyses that revealed

Action (Source[19]:)	PRT recommendation, action in NAcP and status in NAcP update of January 2020	Implementation and evaluation of action
	equipment ultimately needed for prevention of core melt should be reconsidered and the robustness of the systems increased, if necessary, based on the results of seismic PSA under preparation. **Action:** Carry out additional studies on the construction of seismic hazard curves, to clarify the safety margins of NPP structures, systems and components (SSCs), taking into account the more precise seismotectonic model. Correct the seismic Probabilistic Safety Analysis (PSA) for which initial data will come from adjusted seismic hazard curves, including the assessment of safety margins for parts of safety-critical systems. Determine the need for a comprehensive assessment of seismic risk on the basis of more refined seismic hazard curves and existing equipment safety margins. Review the results of the seismic	HCLPF (High Confidence of Low Probability of Failure) values for the relevant SSCs (see R-2 above). The seismic margins of the SSCs were determined using the hazard curve of the 2020 PSHA (mean, free field) and as reference its DBE value with a PGA_H with 0.1059 g. The adequacy of the seismic margins to prevent core melt in case of beyond design basis earthquakes was assessed by means of a seismic PSA level 1. For more details, see R-2. **Evaluation:** The seismic resistance of the SSCs were determined by comprehensive fragility analyses. These analyses were performed according to seismic walk downs of the plant and on basis of detailed design documents. The fragilities were assessed with a set of different technically approved methods using seismic responses of buildings and structures. The seismic margins of the SSCs were determined on basis of the hazard curve (mean, free-field) of the 2020 PSHA with its reference value for the DBE with a PGA_H of 0.1059 g. The adequacy of the seismic margins was evaluated by a seismic PSA level 1 and a full-scope PSA level 2. To assess the adequacy of the seismic margins to prevent accidents with core melt the results of the seismic PSA level 1 are important. The seismic PSA level 1 resulted in a point value of $7.71 \cdot 10^{-7}$ per year for the nuclear fuel damage frequency (NFDF) for seismic events taken into account all operational states. The results demonstrate compliance with the risk-related numerical criteria specified in the Belarussian regulatory requirements: less than 10^{-5} per year. The NFDF value of BelNPP meet also international expectations in respect to core melt / core damage frequency. In summary it can be stated that based on the hazard curve from the 2020 PSHA and the fragility evaluations the seismic PSA level 1 shows, that the seismic margins of all SSCs relevant to prevent damages with core melt are adequate. Furthermore, it can be stated that the necessary SSCs have sufficient seismic margins to prevent core damage caused by seismic events. For more details in respect to the PSAs, see R-2.

Action (Source[19]:)	PRT recommendation, action in NAcP and status in NAcP update of January 2020	Implementation and evaluation of action
	PSA-2018 in the assessment of NPP safety and determine the need for appropriate actions in order to improve safety. Based on the completion of the actions in point 1, assess the characteristics of seismic stability of SSCs to ensure their function in an accident situation (levels DiD 3 and 4) **Status:** The State enterprise “Belorusskaya AES” (hereinafter: “Belarusian NPP”) set the budget for work on this item, conducted competitive tender procedures and selected the contractors to work on the construction of a seismotectonic model and refinement of the seismic hazard curves, taking into account the alternative seismotectonic model. Work on the construction of a seismotectonic model and refinement of the seismic hazard curves, taking into account the alternative seismotectonic model,	Actions taken and implemented meet the intent of the 2018 PRT recommendation. This recommendation is considered closed.

Action (Source[19]:)	PRT recommendation, action in NAcP and status in NAcP update of January 2020	Implementation and evaluation of action
	is currently ongoing. Deadline for completion of the work: March 2020. The deadline for adjusting the PSA for seismic impacts, taking into account the revised seismic hazard curves, has been postponed until December 2020. Belarusian NPP developed a PSA in cooperation with the General Contractor: PSA-2018 Level 1 and PSA-2018 level 2 for Unit 1 of Belarusian NPP as part of the licensing package. The materials for PSA-2018 Level 1 and PSA-2018 Level 2 for Unit 1 of Belarusian NPP are reviewed by experts as part of a safety report with a view to obtaining a licence to operate Unit 1. The licensing procedure for that Unit is ongoing. As part of the commissioning works, ATOMTECHENERGO AO is assessing the seismic stability of safety-critical equipment using the ‘Programmes for determining the dynamic characteristics and	

Action (Source[19]:)	PRT recommendation, action in NAcP and status in NAcP update of January 2020	Implementation and evaluation of action
	seismic stability of safety-critical equipment'. The work is expected to be completed by 31 March 2020. As part of the adjustment to the seismic PSA (Point 1 of the National Plan), work on seismic stability analyses is in hand. The results will form the basis for a list of components, and the probabilistic parameters of their seismic damage to Unit 1 will be determined. (The work is being done by "TsKTI-VIBROSEYSM OOO" and "ATOMPROYEKT AO" and is scheduled for completion by 31 May 2020.	

2. Flooding

Action (Source[30]:)	PRT recommendation, action in NAcP and NAcP update	Implementation and evaluation of action
R-8, PRT p. 69 NAcP Annex 1, line 8	**Recommendation:** The Regulatory Body should check that plant measures against water ingress into safety related buildings and underground galleries are robustly designed and implemented **Action:** Monitoring and oversight over the construction of the foundations, their waterproofing, and the flooding of building structures, is carried out systematically as part of oversight functions, in accordance with the requirements laid down in construction norms and rules. At the stage of acceptance of the completed Belarusian NPP buildings, a comprehensive evaluation of the conformity of buildings and equipment is planned, including their waterproofing, design documentation and the requirements of the Technical Normative Legal Acts (Технические нормативные правовые акты).	**Implementation:** BelNPP indicated that plant measures against water ingress into safety related buildings and underground galleries have been fully implemented at unit 1, whereas similar measures are ongoing at unit 2 and are planned to be fully finalized by December 2021. According to GAN, these works have been covered by the inspection programme of national competent authorities. Independent verification of waterproofing of buildings and structures is performed by the State Construction Inspectorate (under the umbrella of Gosstandard) and results are recorded and provided to GAN on a monthly basis. This inspection programme includes the following steps: • verification of documentation: including documents on the quality of materials used, instructions and technical documentation, • qualification of personnel carrying out the relevant work, and • acceptance of completed work (documents confirming the correctness and quality of the work carried out). Inspections carried out during the construction works, covering the place of work itself, work preparation, the sequence of work for compliance with instructions, technical

[30] The brackets indicate the sources of the respective action:

- NR: National Report - Stress Test for Belarussian Nuclear Power Plant - 2017,
- PRT: EU Peer Review Report of the Belarussian Stress Tests - June 2018,
- EU: ENSREG '*Compilation of Recommendations and suggestions - Peer review of stress tests performed on European nuclear power plants', 26 July 2012*,
- NAcP: number of Recommendation of the National Action Plan of Belarus, 2019,
- p: page

Action (Source[30]:)	PRT recommendation, action in NAcP and NAcP update	Implementation and evaluation of action
	Status: n/a	documentation and interviews. These inspections identified a number of findings (such as some water infiltrations in plant buildings) which have been adequately corrected. **Evaluation:** This PRT recommendation was issued in 2018 because the progress of construction works and the lack of inspections results at that time did not allow to assess this topic. Meanwhile, construction and waterproofing works have been completed fully at unit 1 and partly at unit 2. During the plant walk down in unit 1, the PRT however noted a few water puddles (up to appr. 10 m^2) at several places in safety-related underground galleries and buildings, due to rainwater infiltration through openings in an access hatch or through inter-building seals. These issues have also been identified by BelNPP and are all expected to be repaired by the constructor by end December 2021. A number of water infiltrations into safety-related buildings and underground galleries have also been identified by the plant in unit 2, acknowledging the fact that construction works are still ongoing there. It is expected that all measures against water ingress will be completed in unit 2 by December 2021. During the plant walk down, the PRT noted that all entrances to the 10UBS building (EDG building) are adequately elevated by at least 15 cm above the nearby platform, with systematic sloping down around all external walls in order to evacuate water. This seems a robust contribution to the volumetric protection of the 10UBS building. The PRT noted that a different configuration is used for the South wall of the 10UKD building (auxiliary safety systems building), where the three outside entrances are almost not elevated above the nearby platform and where the surrounding sloping is much less significant or systematic. On the East side, this building is surrounded by a water collector that prevents water accumulation around the external wall. The South wall does not have such a protective arrangement. The volumetric protection of the South wall of the UKD building is less robust that the one of UBS, and the PRT therefore

Action (Source[30]:)	PRT recommendation, action in NAcP and NAcP update	Implementation and evaluation of action
		encourages the plant to review and further enhance the protection against external water ingress through the South wall entrances to the UKD building. In conclusion, action taken to address the recommendation shows satisfactory progress to date. Actions implemented and planned meet the intent of the 2018 PRT recommendation. Complete implementation of all necessary actions is expected by December 2021 for both units. This recommendation remains open.
R-10 PRT p. 69 NAcP Aug 2019, Annex 1, line 8	**Recommendation:** During the plant visit, the site was under construction, so the PRT could not confirm the final civil work of the site and the adequacy of the drainage arrangements. It should be ensured that the plant site can be drained via the surface by gravity (streets, catch water ditches). **Action:** Monitoring and oversight over the construction of the foundations, their waterproofing, and the flooding of building structures, is carried out systematically as part of oversight functions, in accordance with the requirements laid down in construction norms and rules. At the stage of acceptance of the completed Belarusian NPP buildings, a comprehensive evaluation of the conformity of buildings and equipment is planned, including their waterproofing, design documentation and the requirements of the Technical Normative Legal Acts (Технические нормативные правовые акты). **Status:** n/a	**Implementation:** The site drainage arrangements for gravitational evacuation of surface water have been completed on the whole site. **Evaluation:** The site is built on a platform higher than the nearby countryside elevation in most directions, with surrounding field slightly higher than the platform only in the North-West corner. Rainwater flowing down from this direction to the site platform is prevented by two ditches running outside along the site limit. The roads running along the North and West site limits are higher than the surrounding field and therefore also act as another barrier against potential rainwater flowing down to the site in the NW corner. The ground in the site area has low permeability. On the site platform, ditches collect and prevent excessive rainwater accumulation in the large grass areas (South, East and West sides). The area around the safety related buildings is almost flat, with the highest elevation located between both unit reactor buildings (+179,40m) and the lowest elevations around 50 cm lower. All plant safety-related buildings are built at a comparable elevation on this flat platform without very significant slope. Rainwater coming from the roads, from the roofs and through the surface ditches in the green areas, is collected through the UGU system. The UGU system discharges this water to the cooling towers or the Viliya river after treatment. The UGU system

Action (Source[30]:)	PRT recommendation, action in NAcP and NAcP update	Implementation and evaluation of action
		consists of 3 stations each equipped with 2 immersed pumps (with flow capacity ranging from 280 to 170 m3/hr per pump). In case of loss of outside power these pumps would be lost and would be supplemented by backup mobile pumps: 2 gasoline pumps for the whole site (60 m3/hr each), one diesel driven pump (250 m3/hr), and 14 electrical immersible pumps. During the construction phase, mobile pumps have been used successfully during power shortages to ensure rainwater evacuation by the UGU system. The UGU system is covered by preventive maintenance and monthly periodic tests. Groundwater around safety related buildings is drained through the UGS system and pumped back to the cooling tower. Globally, these are robust arrangements to drain rainwater from the site and to prevent excessive accumulation of rainwater on the site platform. Actions taken and implemented meet the intent of the 2018 PRT recommendation. This recommendation is considered closed.

3. Extreme Weather

Action (Source[31]:)	PRT recommendation, action in NAcP and status in NAcP update of January 2020	Implementation and evaluation of action
R-9 PRT p. 69 NAcP Aug 2019, Annex 1, line 8(a)	**Recommendation:** It was stated during the country visit that operational procedures for extreme weather conditions are under development. The PRT recommends having specific operating procedures in place before commissioning of the Belarusian NPP. **Action:** As part of licensing, the documents demonstrating the safety of the Belarusian NPP are analysed by experts. These documents include operational documentation comprising operational procedures in extreme weather conditions. **Status:** n/a	**Implementation:** A plant procedure has been developed and put in place. It covers namely extreme weather conditions such as extreme cold temperatures, high wind and tornadoes, high snow, high temperature and heavy precipitations. **Evaluation:** Numerous aspects of plant operation under extreme weather conditions are included in operatiing procedures in place at the plant. This includes for instance the numerous measures as part of the transition to winter operation mode (such as bypass mode of the safety cooling ponds) or routine walk downs to check snow accumulation on building roofs following heavy snowfalls. The plant also developed an emergency procedure covering the effects of relevant extreme weather conditions. This procedure was put in place in 2019 and includes the necessary response in case of extreme scenarios. This includes for instance plant actions that would be necessary following consequential destruction of buildings or extreme cold temperatures. The entry into this emergency procedure can be for example triggered by an alert that would be received from the national meteorological service (previsions of high wind / heavy precipitation / heavy snowfall / very low or high

[31] The brackets indicate the sources of the respective action:

- NR: National Report - Stress Test for Belarussian Nuclear Power Plant - 2017,
- PRT: EU Peer Review Report of the Belarussian Stress Tests - June 2018,
- EU: ENSREG '*Compilation of Recommendations and suggestions - Peer review of stress tests performed on European nuclear power plants', 26 July 2012*,
- NAcP: number of Recommendation of the National Action Plan of Belarus, 2019,
- p: page.

Action (Source[31]:)	PRT recommendation, action in NAcP and status in NAcP update of January 2020	Implementation and evaluation of action
		temperatures / …). The use of these procedures is included in the training programme of operations personnel. In 2020, a large exercise was organized using this emergency procedure, an extreme cold temperature and loss of outside power scenario, using the emergency procedure. The actions taken and implemented meet the intent of the 2018 PRT recommendation. This recommendation is considered closed.

4. Station black out and loss of ultimate heat sink

Action (Source[32]:)	PRT recommendation, action in NAcP and status in NAcP update of January 2020	Implementation and evaluation of action
R-11 PRT p. 70 NAcP 4-8 And PRT p. 63-64; NR p. 52	**Recommendation:** The PRT recommends that an alternative permanent power source to supply the necessary power in design extension conditions should be provided. This alternative AC power supply should include necessary connecting points, to protect electrical power systems against the simultaneous failure of off-site and emergency AC power supplies. [PRT] The additional use of mobile means should be further considered as a valuable component of operational accident management. **Action:** Assess the expediency of equipping the NPP with an alternative stationary power source (for BDBA), taking into account the safety concept adopted for the AES-2006 project (taking into consideration the passive safety systems providing autonomy of operation).	**Implementation:** On the basis of the IAEA Safety Standard SSR 2/1 rev. 1, Requirement 68: *'Design for withstanding the loss of off-site power'* the 2018 PRT Report recommended that an independent alternative power source physically separated from the emergency power supply shall be implemented. The connection time of the alternative power source shall be consistent with the depletion time of the battery. This is in line with the recommendation of the National Report of Belarus for BelNPP, which required that the possibility of an '*UPS recharging*' should be considered (see NR p. 150). The information received from GAN in the course of the peer review confirms that the operator would like to treat the MDGs 10XKA70 and 20XKA70 installed at both units as mobile devices. Even if those devices are permanently connected with the respective channel 7 busbar to both units to comply with the recommendations of the 2018 PRT Report (see also action NAcP 4-11), it nevertheless remains possible to disconnect and move them within a very short time. The provision is that in the case that one MDG fails while required, the other MDG can be disconnected from its permanent connection, moved to the location to replace the failed MDG and connected with the respective channel 7 busbar.

[4] The brackets indicate the sources of the respective action:

- NR: National Report - Stress Test for Belarussian Nuclear Power Plant - 2017,
- PRT: EU Peer Review Report of the Belarussian Stress Tests - June 2018,
- EU: ENSREG '*Compilation of Recommendations and suggestions - Peer review of stress tests performed on European nuclear power plants', 26 July 2012*,
- NAcP: Number of Recommendation of the National Action Plan of Belarus, 2019,
- p: page.

Action (Source[32]:)	PRT recommendation, action in NAcP and status in NAcP update of January 2020	Implementation and evaluation of action
	Status: Belarusian NPP issued a call for technical and commercial proposals for implementation of the work. Proposals were received from JSC "ASE" AO. (10 May 2020) Undertake organisational and technical measures for stationary connection of one DG set to each NPP power unit. Unit 1: done; Unit 2: 01.01.2021.	The procedures for the personnel actions to move the MDG from their permanently connected location to the other unit has been prepared and issued – '*Procedure to use the mobile MDG 20XKA70 from Unit 2 for Unit 1 in case of a BDBA if it is impossible to use MDG 10XKA70*' as Procedure No.588/42PTs-21 and the '*Procedure to use the mobile MDG 10XKA70 from Unit 1 for Unit 2 in case of a BDBA if it is impossible to use MDG 20XKA70*' as Procedure No.5887/42PTs-21. According to the Procedures, the time to perform the actions described may not exceed 24 h since the occurrence of the DEC issue at the affected unit. The design ensures the time of 72 h during which the nuclear installation is maintained safe without the intrusion of the operator which is significantly longer than the time necessary for the respective 'cross-usage' of the MDG. **Evaluation:** According to SSR 2/1 rev.1: Requirement 68, '*Design to withstand the loss of external power supply*', No. 6.44 A 6.44C and 6.44D, the design shall include an emergency power supply system which would provide for the necessary power supply in case of DEC. The design must be independent from the original intended emergency power supply and assure that a core melt accident, as well as damage of the spent fuel stored in the respective spent fuel pool, could be avoided under DEC caused by a SBO. The availability of MDGs 10/20XKA70 in the design of NPP Belarus meets these requirements. GAN stated that also, independently from the absence of direct instructions for the readiness for the very improbable event of simultaneous loss of the entire range of all external power sources (8 mains), loss of all redundant power sources (4 DG of the emergency power supply) and loss of two alternative power sources MDGs, nevertheless, while taking into account the design and administrative provisions, the following solutions were provided: – A redundant possibility to provide for the main function (heat removal) which can be performed under DEC conditions with the help of MDG and firefighting

Action (Source[32]:)	PRT recommendation, action in NAcP and status in NAcP update of January 2020	Implementation and evaluation of action
		devices. The heat removal can be provided by the supply of water to the spent fuel pool and to the SG PHRS tanks from the firefighting devices under conditions of the loss of MDG's of unit 1 and 2 or of the pump JNB50AP001 (which corresponds to SSR 2/1 rev.1. Issue 6.44A: To provide for integrity of the reactor coolant system and to prevent damage to the reactor core and spent fuel). – There is a possibility to use outside MDG with a capacity of 400 kW (including those which are located in the City Molodechno (1 device, the distance to the site is about 100 km), in the City Minsk (2 devices), in the City Borisovo (2 devices) which are located on a mobile platform and if necessary, can be delivered to the site of NPP Belarus according to Issue 7 of the Ordinance no. 567/19PO-21 "On industrial facilities of the sector sub-system in the State system of prevention and elimination of emergency situations at the State entity NPP Belarus". Thus, taking into account the available possibilities for redundancy of the heat removal function under DEC, no redundancy of the design MDG's which are available and located at the site are planned. Actions taken and implemented meet the intent of the 2018 PRT recommendation. This recommendation is considered closed.
R-13, PRT p. 70 NAcP 4-9, 4-10	**Recommendation:** Despite the system autonomy of the passive heat removal system (PHRS) which is designed to cope with SBO scenarios the SG PHRS, the C PHRS tanks and the spent fuel pool are refilled with water using a single low -pressure pump JNB50AP001 (only 1 pump per unit is designed). [...] Owing to the importance of ensuring the functionality of SG PHRS in SBO, the PRT recommends enhancing the reliability by installing an additional redundant pump.	**Implementation:** Responding to the PRT's questions on Recommendation R-13, GAN stated that instead of the recommended second redundant JNB50 pump being an alternative technical measure, a mobile DG powered firefighting pump was chosen. Should the existing 10/20JNB50AP001 pump fail, a mobile fire engine driven pump would be connected using two installed hook-up connectors from the JNB50 system located outside the steam chamber building UJE building of each unit (at elevations +0.690 and +0.730). Via this connection, water will be transported from the makeup water system (LCU tanks 10/20LCU01,02,03,04BB001), which were originally envisaged

Action (Source[32]:)	PRT recommendation, action in NAcP and status in NAcP update of January 2020	Implementation and evaluation of action
	Action: NAcP 4-9: Assess the improvement in the reliability of the passive heat removal system (PHRS SG) after installation of a further redundant pump in addition to JNB50AP001, compared with the characteristics of the existing system. NAcP 4-10: Based on the results of the assessment in Point 9, carry out the necessary organisational and technical measures. **Status:** Belarusian NPP issued a call for technical and commercial proposals for implementation of the work. Proposals were received from JSC "ASE" AO.	for this purpose, in case of an SBO. The suction side of the firefighting pump will be connected to the tanks 10/20LCU02,03BB001 by means of the fixture 10/20JNB50AA001,002,005,006, and the pressure side of the firefighting pump will be connected to the fixture 10/20JNB50AA003,004. By bypassing the 10/20JNB50AP001 pump, with this connection the supply of deionized water to the SG PHRS tanks as well as the spent fuel pool will be performed. The volumetric capacity of the 10/20LCU02,03BB001 tanks is 700 m^3 each. If necessary, the tanks 10/20LCU01,04BB001, which each have the same 700 m^3 capacity, can also be connected to the suction side of the firefighting pump. The temperature in LCU tanks is held automatically at the range of 20-÷25°C. If necessary, additional water could be provided from other reserves available at the NPP site with an amount of 170400 m^3. For this purpose, the suction side of the firefighting pump would be connected to the vessels or basins of the resources via flexible tubes. These reserves, without any replenishment from off-site sources, would allow the LCU tanks to be fully refilled many times, and which would ensure the safety of the power unit by the function of the SG PHRS tanks as well as replenishment of the spent fuel pool during not less than 240 days. The required piping, valves and external connecting points allowing connection of the mobile fire engine driven pump have been installed at unit 1. Implementation at unit 2 is expected prior to unit commissioning. **Evaluation:** Based on the requirements of the 2013 WENRA Report '*Safety of new NPP designs*', the SG PHRS can be considered as Level 3.b equipment of the DiD concept '*Control of accident to limit radiological releases and prevent escalation to core melt conditions under postulated multiple failure events*'. This corresponds also to the rating in compliance with the DiD of IAEA TECDOC 1791, where either the rating as Level 3.b or as Level 4.a '*Control of design extension conditions to prevent core melt*' was given.

Action (Source[32]:)	PRT recommendation, action in NAcP and status in NAcP update of January 2020	Implementation and evaluation of action
		Regarding level 3b, the above WENRA Report highlights that systems designed to comply with the WENRA objective O2 – '*Accidents without core melt*' – should have *'sufficient redundancy of active components to reach adequate reliability*' (WENRA report, p. 21). While applying the requirements highlighted in the WENRA Report, installing an alternative mobile option for refilling the SG PHRS and the SFP cannot be considered as complying with the WENRA requirements. Therefore, the installation of a pump redundant to the JNB50 pump was advised, unless it can be demonstrated that without such a pump there can still be a sufficiently reliable supply of coolant. The engineering and design of the NPP began as early as in 2006, i.e. prior to the Fukushima accident and was adapted step-by-step to new safety requirements, which were developed and internationally agreed upon after Fukushima. Initially, the JNB50 pump was intended to be a single device. Therefore, the single failure concept was not applied for the components of SG PHRS, which is a BDBA system (Russian terminology) according to the classification provided in the design. This was also reported to the PRT by the designer and the future operator during the review of the national report in 2018. By the time the national report was reviewed, BelNPP was under construction and the engineering was completed. Therefore, the constructor and the operator – also in agreement with GAN – refused to accept the PRT's proposal, even as early as 2018 when the peer review was being carried out. However, they expressed that they were prepared to give thought to compensating measures and to implementing them. This was reflected in Actions 4-9 and 4-10, which the operator sees as implemented in the presented concept. Observing the status of engineering and the conceptual initial situation of BelNPP, which was effective by the time of the peer review of the national report in 2018, the PRT can consider these proposed and implemented technical solutions as a safety improvement. Although not providing a permanently available redundancy to the installed JNB50 pump, the proposed technical solution together with a mobile redundancy, provides

Action (Source[32]:)	PRT recommendation, action in NAcP and status in NAcP update of January 2020	Implementation and evaluation of action
		diversity and reliability. The essential prerequisite is the availability of the firefighting equipment at all times, which must not be endangered by external events as extreme weather or earthquake. This has been addressed under topic 1. Instructions describing detailed requirements and steps to be performed for handling the equipment in case of an event have been presented to the PRT. This includes also the timely connection of the mobile firefighting pump to the safety building. The PRT considers the chosen solution as an appropriate measure in order to address the recommendation, under the condition that the above-mentioned prerequisite is satisfied. Actions taken and implemented meet the intent of the 2018 PRT recommendation. This recommendation is considered closed.
R-14, PRT p. 70 NAcP 4-12	**Recommendation:** The PRT recommends a suitable alternative solution is implemented to ensure that restoration of water supply is achieved within necessary time to prevent core damage. **Action:** Develop, for subsequent implementation, technical and organisational measures ensuring restoration of the water supply in time to prevent serious accidents occurring in an open reactor in the event of a total loss of external and emergency power supply to the power unit. **Status:** Belarusian NPP issued a call for technical and commercial proposals for implementation of the work. Proposals were received from JSC IC "ASE".	**Implementation:** See description in R-19. **Evaluation:** See PRT statement in R-19.
R-15, PRT	**Recommendation:**	**Implementation:**

Action (Source[32]:)	PRT recommendation, action in NAcP and status in NAcP update of January 2020	Implementation and evaluation of action
p. 70 NAcP 4-13	The PRT recommends that analysis is undertaken to demonstrate the reliability of these off-site powers sources in seismic condition. **Action:** Assess the reliability of the auxiliary power supply to responsible consumers, from a 110/10 KW emergency standby auxiliary transformer with a power of 16 MVA which can be connected via a 110 kV cable to the "Viliya" substation; and assess the "Viliya" substation's stability in the face of internal and external events. **Status:** Belarusian NPP issued a call for technical and commercial proposals for implementation of the work. Proposals were received from the State Enterprise Belenergo.	This recommendation concerns the qualification (appropriateness) of the additional substation Viliya to serve as a backup alternative power supply if the external power supply by the national grid fails. In 2018 PRT report it was recommended to demonstrate the availability of this sub-station to serve as an additional source for the off-site power supply under DiD level 1 and 2 conditions by the demonstration of the reliability of these off-site power sources in seismic conditions. The NAcP describes that the qualification of the substation must be carried out to declare the available equipment as appropriate for the necessary safety relevant case. A possible risk potential for the operability of the sub-station could arise through external events as earthquake, natural hazards and fire caused by external reasons. In order to counter this, the substation was designed and qualified. The information received from GAN in the course of the peer review confirms that the structures and equipment of the sub-station Viliya are designed to withstand an earthquake of 6 at the scale MSK-64. According to the state standard GOST 6249-52 the calculation of structures for seismicity is made for design-basis earthquakes of 7 and higher at the scale MSK-64. Therefore, earthquake of the force 6 are deemed as not dangerous for the serial equipment and structures of the sub-station Viliya. It is further stated that the connection of the emergency service transformer of 110/10kV with the power of 16 MVA to the sub-station Viliya is provided by a cable transmission line (of 2.6 km, in a reinforced concrete cable channel) which excludes the impact of a lightning, damage from fallen trees or other mechanical damage to ETL. Mechanical calculations for wires and structures of the open switchgear of 110 kV is done taking into consideration possible impacts from the wind and cables glaze-icing. The sub-station Viliya avails of an automatic firefighting alarm system, which provides for the collection, processing, displaying and sound signalling, recording and forwarding information on the state of fire loops of buildings, fire alarms for people, signal forwarding from the installation to the Centre of Operative Management of the Ministry for Emergency Situations via GSM communications as well as to the

Action (Source[32]:)	PRT recommendation, action in NAcP and status in NAcP update of January 2020	Implementation and evaluation of action
		dispatching station of the local power station in Ostrovets via telecommunications. Assessment completed and relevant information has been provided to the PRT. **Evaluation:** Written information received from GAN in the course of the peer review states that the sub-station Viliya has been qualified regarding the resistance to withstand external events as earthquake and weather impacts. The seismic design for a seismic load that corresponds to intensity I=6 / PGA = 0.05 g and is therefore below the DBE of 0.1059 g that applies to the BelNPP site in general. This is in line with the intention of the BelNPP to use Viliya substation as an additional power line for operational states (DiD levels 1 and 2). It was never foreseen, to use it under accident conditions (DiD level 3 and 4). For the intended objective the qualification has been proven. Beside the other 7 external power supply lines connected to the site, Viliya substation offers an additional external source to help maintain the plant in operational states (DiD levels 1 and 2) and to prevent escalating into accident conditions (DiD levels 3 and 4). Actions taken and implemented meet the intent of the 2018 PRT recommendation. This recommendation is considered closed.
NAcP 4-11	**Action:** Take organisational and technical measures for the stationary connection of one MDGU to each nuclear power unit. **Status:** Unit 1: Belarusian NPP made the necessary adjustments to the design documentation, installed a stationary connection line for the mobile diesel generator unit (hereinafter: 'MDGU') and a distribution device (connection point) on the	**Implementation:** Under NAcP Action 4-11, it is envisaged that each unit will be equipped with a mobile DG with a permanent connection, while the mobility of DG will be preserved. This has already been completed for unit 1**.** **Evaluation:** The MDG in each unit (10/20XKA70) provides electricity to the channel 7 busbar for supporting the BDBA consumers (Russian terminology) of each unit. Reflecting the 2018 PRT recommendation, the MDG (10XKA70) at unit 1 has been connected and (20XKA70) will be connected at unit 2 permanently to the buses of the

Action (Source[32]:)	PRT recommendation, action in NAcP and status in NAcP update of January 2020	Implementation and evaluation of action
	wall of building 10UJE. The MDGU is located at the entrance inspection point of the Belarusian NPP construction site. Installation of the MDGU is scheduled for 28 February 2020. Unit 2: The necessary adjustments to the project documentation have been made. The equipment is at the manufacturing stage. (10 May 2020) Undertake organisational and technical measures for stationary connection of one DG set to each NPP power unit. Unit 1: done; Unit 2: 01.01.2021.	channel 7 by means of a flexible cable. The cable connects the MDGs and the assembly 10/20BKS12GH570. Protection of the cable from external hazards is provided by its installation in an underground metallic fire-resistant tray, which is zinc coated, with a coat thickness of 80 µm. The assembly 10/20BKS12GH570 is located on the outer wall of the building 10/20UJE. The construction of the assembly provides for protection of the integrated commutation device from external impacts. In the assembly 10/20BKS12GH570 there is a load switch made by the manufacturer ABB. Functionality of the mobile equipment will be checked in adherence to the '*Regulations for checks and tests of safety relevant systems*'. The personnel of NPP Belarus is carrying out required checks (tests) of the MDG stations 10/20XKA70 according to the schedule and programmes, approved by the chief engineer of the NPP. The presence and the arrangement of the MDG 10XKA70 in unit 1 and the permanent connection to the connecting point 10BKS12GH570 have been surveyed by the PRT during the February and September site visits and the existence of respective documents describing the measures to be taken for assuring the operability have been checked by the PRT. Actions taken and implemented meet the objective of the NAcP the action is considered closed.

5. Severe Accident Management

Action (Source[33]:)	PRT recommendation, action in NAcP and status in NAcP update of January 2020	Implementation and evaluation of action
R-16, PRT p. 71 NAcP 4-14	**Recommendation:** While it is recognised that several advanced safety features are implemented in the design, the overall concept of practical elimination of early and large releases should be more explicitly reflected in an updated plant safety case. Attention should be also devoted to the practical elimination of severe accidents in the spent fuel pool or severe accidents potentially combined with the containment by-pass. **Action:** Assess the adequacy of design solutions ensuring: - practical elimination of early or severe radioactive releases; - practical elimination of severe accidents in the spent fuel storage pool; - practical elimination of containment by-pass events during severe accidents.	**Implementation:** In response to the PRT recommendation, the BelNPP has prepared in September 2021 and updated in August 2021 a special document – ‘*R-16 Appendix’*, following the recommendations in the WENRA document ‘*Report- Practical Elimination Applied to New NPP Designs - Key Elements and Expectations’*. The approach starts with a listing of all conditions (challenges) that could potentially lead to early or large releases, followed by demonstration of practical elimination of such conditions, in particular those that could lead to damage or bypass of the containment and those with an open containment. In the latest revision of the ‘*R-16 Appendix’* the BelNPP followed the approach introduced in the IAEA safety standards and WENRA guidance documents. For each of the challenges, the demonstration of practical elimination includes definition of the problem, description of the measures implemented, summary of relevant deterministic analyses, finished with final assessment of the adequacy of the measures. The *‘R-16 Appendix*’ also includes demonstration of practical elimination of a severe accident taking place in the spent fuel pool, with its essential part based on a sufficient time margin to the onset of the fuel to uncover in the pool.

[33] The brackets indicate the sources of the respective action:

- NR: National Report - Stress Test for Belarussian Nuclear Power Plant - 2017,
- PRT: EU Peer Review Report of the Belarussian Stress Tests - June 2018,
- EU: ENSREG ‘*Compilation of Recommendations and suggestions - Peer review of stress tests performed on European nuclear power plants’, 26 July 2012*’,
- NAcP: Number of Recommendation of the National Action Plan of Belarus (NAcP), 2019,
- p: page.

Action (Source[33]:)	PRT recommendation, action in NAcP and status in NAcP update of January 2020	Implementation and evaluation of action
	Status: Belarusian NPP issued a call for technical and commercial proposals for implementation of the work. Proposals were received from JSC IC "ASE".	Attention was paid to the implementation of defense in depth, to seismic resistance of the equipment at level 4 of defense and to availability of power supply. According to the approach, the design and operational measures necessary to prevent early or large radioactive releases are required to be implemented, independently of the probability of the individual challenges. The challenges due to sudden heterogeneous insertion of reactivity, caused by injection of non-borated water to the reactor core or by penetration of secondary coolant into the primary circuit were also addressed. Similarly, the possibility of sudden reactor pressure vessel rupture during operation at full power was also addressed. Results of PSA level 1 and level 2 are summarized with confirmation of the low frequency of individual challenges. Since the PSA level 2 report demonstrates the total frequency of the large release to be below 10^{-7}/year (8.68E-8/year), it means that frequency of each individual scenario is significantly below this value (which is usually accepted as sufficiently low frequency used for demonstration of practical elimination). The report assessing practical elimination of early or large radioactive releases was originally planned to be prepared in accordance with the NAcP schedule in few years, but it was prepared for the review for the plant visit in August-September 2021. **Evaluation:** The approach taken by the BelNPP in the latest revision of the '*R-16 Appendix*', making reference to the guidance available in the WENRA document '*Report- Practical Elimination Applied to New NPP Designs - Key Elements and Expectations*' is also consistent with the IAEA Safety Guide SSG-2 (Rev. 1) and the IAEA TECDOC-1791 and is therefore acceptable. It includes the list of conditions potentially resulting in early or large releases, followed by description of the design and operational provisions, complemented by deterministic and probabilistic confirmation of adequacy of provisions with very low residual risk. In accordance with the agreement, a new update of '*R-16 Appendix*' has been developed and it was reviewed during the plant visit in August-September. The report

Action (Source[33]:)	PRT recommendation, action in NAcP and status in NAcP update of January 2020	Implementation and evaluation of action
		was found acceptable by the PRT. Actions taken and implemented meet the intent of PRT 2018 recommendation. Recommendation is considered closed.
R-17, PRT p. 71 NAcP 4-17	**Recommendation:** Consideration should be given to the installation of independent means of reactor coolant system depressurisation, or special attention should be given to reliable functioning of existing means under severe accident conditions. **Action:** Carry out a review confirming the adequacy of technical devices envisaged for reducing pressure in the primary circuit under serious accident conditions (in order to eliminate damage resulting from high pressure). **Status:** Belarusian NPP issued a call for technical and commercial proposals for implementation of the work. Proposals were received from JSC IC "ASE".	**Implementation:** The main objective of this measure is to prevent the ejection of molten corium from the ablated/penetrated RPV at high pressure (prevention of HPME). Such an ejection could happen in the event of a severe accident in combination with the RCS being kept at high pressure; usually pressure below 2 MPa is considered as sufficiently low. In BelNPP design, a conservatively lower value of 1 MPa was used. Although the safety implications of such conditions for BelNPP are less significant than for other reactor designs due to the depressurisation effect of heat removal through SG PHRS, there are technical means and procedures to carry out depressurisation of the reactor under severe accident conditions. At present, there are two ways to carry out depressurisation after transition from EOPs to SAMGs. • An operator from the MCR or ECR could open the pressuriser (PRZ) valves. These valves are also used for DBAs. However, they are connected to the additional (dedicated) control line developed and implemented at the NPP to manage design extension conditions. • Valves on gas evacuation (venting) lines could be opened in combination with one PRZ valve. In total, there are 10 venting lines connected to different parts of the RCS (reactor, PRZ, SGs). The studies aimed at verifying the venting capacity of these lines are ongoing. Both means can be used also should the power supply be lost, since the power to open the valves comes from the batteries or Channels 7 and 8 of power supply. After opening the valves no further operator actions are needed for depressurisation. As confirmed by BelNPP, the supporting analysis demonstrated that there is sufficient time to carry out these actions. Two types of unlikely accidents have been considered for determination of the design capacity of the depressurisation system: severe accidents caused either

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		by an SBO combined with loss of all heat exchangers of the passive heat removal system, or SBO combined with ruptures of all steam lines. **Evaluation:** For typical existing PWR, the measure for depressurising the primary coolant system is essential, particularly as regards being able to deal with a severe accident caused by an SBO accident. Because of the required independence between the levels of defence, the best solution for intentional depressurisation in the event of a severe accident for typical PWRs is to use an independent (dedicated) depressurisation system (a system different from the pressuriser safety valves) or at least ensure the availability of independent means for opening a PRZ safety valve when the electrical power supply is completely lost. In the case of BelNPP, residual heat removal resulting in depressurisation of the RCS in the event of an SBO is ensured via passive means (SG PHRS). In the event of an LBLOCA, one of the consequences is depressurisation. For severe accidents caused by small or medium LOCA combined with failure of the active ECCS, depressurisation of the RCS below 1 MPa is always achieved by a combined effect of a break and SG PHRS with sufficient time margin before beginning of fuel melting and thus no other intentional depressurisation is needed. Nevertheless, even in the very unlikely case, that it will be needed, there are independent means for depressurising the RCS in the event of a severe accident at high RCS pressure (dedicated control line for opening 2 PRZ valves, or 1 valve in combination with opening the RCS's venting lines). Actions taken and implemented meet the intent of the 2018 PRT recommendation. This recommendation is considered closed.
R-18, PRT p. 71 NAcP 4-1, 4-2, 4-3	**Recommendation:** The adequacy of margins of SSCs for beyond design basis earthquakes of the plant equipment ultimately needed for prevention of large releases in case of a severe accident	**Implementation** The adequacy of margins of SSCs for beyond design basis earthquakes of the plant equipment ultimately needed for prevention of large releases in case of a severe

Action (Source[33]:)	PRT recommendation, action in NAcP and status in NAcP update of January 2020	Implementation and evaluation of action
	should be reconsidered and the robustness of the systems increased, if necessary, based on the results of seismic PSA under preparation. **Action:** Carry out additional studies on the construction of seismic hazard curves, to clarify the safety margins of NPP structures, systems and components (SSCs), taking into account the more precise seismotectonic model. Correct the seismic Probabilistic Safety Analysis (PSA) for which initial data will come from adjusted seismic hazard curves, including the assessment of safety margins for parts of safety-critical systems. Determine the need for a comprehensive assessment of seismic risk on the basis of more refined seismic hazard curves and existing equipment safety margins. Review the results of the seismic PSA-2018 in the assessment of NPP safety and determine the need for appropriate actions in order to improve safety. Based on the completion of the actions in point 1, assess the characteristics of seismic stability of SSCs to ensure their function in an accident situation (levels DiD 3 and 4). **Status:** The State enterprise “Belorusskaya AES” (hereinafter: “Belarusian NPP”) set the budget for work on this item, conducted competitive tender procedures and selected the contractors to work on the construction of a seismotectonic model and refinement of the seismic hazard curves, taking	accident was assessed. The seismic resistance of the seismically relevant SSCs was evaluated by fragility analyses. The seismic margins of the SSCs were determined using the hazard curve of the 2020 PSHA (mean, free field) and as reference its DBE value with a PGA_H with 0.1059 g. The adequacy of the seismic margins to prevent large radioactivity releases in case of beyond design basis earthquakes was assessed by means of a full-scope PSA level 2. For more details, see R-2 **Evaluation:** The seismic resistance of the SSCs were determined by comprehensive fragility analyses. These analyses were performed according to seismic walk downs of the plant and on basis of detailed design documents. The fragilities were assessed with a set of different technically approved methods using seismic responses of buildings and structures. The seismic margins of the SSCs were determined on basis of the hazard curve (mean, free-field) of the 2020 PSHA with its reference value for the DBE with a PGA_H of 0.1059 g (Tables 1 to 4 in R-2). The adequacy of the seismic margins was evaluated by a seismic PSA level 1 and a full-scope PSA level 2. To assess the adequacy of the seismic margins to prevent accidents with large radioactivity releases the results of the full-scope PSA level 2 are important. The full-scope PSA level 2 resulted in a point value of $8.68*10^{-8}$ per year for the large release frequency (LRF) taken into account all operational states and all initiating events and all radioactive sources of the core and the spent fuel pool. The results demonstrate compliance with the risk-related numerical criteria specified in the Belarusian regulatory requirements: less than 10^{-7} per year. The LRF value of

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	into account the alternative seismotectonic model. Work on the construction of a seismotectonic model and refinement of the seismic hazard curves, taking into account the alternative seismotectonic model, is currently ongoing. Deadline for completion of the work: March 2020. The deadline for adjusting the PSA for seismic impacts, taking into account the revised seismic hazard curves, has been postponed until December 2020. Belarusian NPP developed a PSA in cooperation with the General Contractor: PSA-2018 Level 1 and PSA-2018 level 2 for Unit 1 of Belarusian NPP as part of the licensing package. The materials for PSA-2018 Level 1 and PSA-2018 Level 2 for Unit 1 of Belarusian NPP are reviewed by experts as part of a safety report with a view to obtaining a licence to operate Unit 1. The licensing procedure for that Unit is ongoing. As part of the commissioning works, ATOMTECHENERGO AO is assessing the seismic stability of safety-critical equipment using the ‘Programmes for determining the dynamic characteristics and seismic stability of safety-critical equipment’. The work is expected to be completed by 31 March 2020. As part of the adjustment to the seismic PSA (Point 1 of the National Plan), work on seismic stability analyses is in hand. The results will form the basis for a list of components, and the probabilistic parameters of their seismic damage to Unit 1 will be determined. (The work is being done by “TsKTI-VIBROSEYSM OOO” and “ATOMPROYEKT AO” and is	BelNPP meets also international expectations. In summary it can be stated that based on the hazard curve from the 2020 PSHA and the fragility evaluations the full-scope PSA level 2 shows that the seismic margins of all SSCs relevant to prevent damages with large radioactivity releases are adequate. Actions taken and implemented meet the intent of the 2018 PRT recommendation. This recommendation is considered closed. For more details, see R-2.

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	scheduled for completion by 31 May 2020.	
R-19, PRT p. 71 NAcP 4-12	**Recommendation:** Further consideration should be given to the prevention and the mitigation of severe accidents under open reactor conditions, when heat exchangers of the SG PHRS system are disabled and time margin to core damage is rather short. **Action:** Develop, for subsequent implementation, technical and organisational measures ensuring restoration of the water supply in time to prevent serious accidents occurring in an open reactor in the event of a total loss of external and emergency power supply to the power unit. **Status:** Belarusian NPP issued a call for technical and commercial proposals for implementation of the work. Proposals were received from JSC IC "ASE".	**Implementation:** The current situation as regards managing design extension conditions (beyond design basis accidents) with the potential transition to a severe accident in the open reactor has been described in the responses to PRT questions and in the subsequent discussion with BelNPP. According to full-scope PSA Level 1 (including all operating regimes, events in the spent fuel pool, internal and external hazards), initiating events with open reactor represent 6% of the total core damage frequency (9.77×10^{-7}/year). According to the Safety Analysis Report (SAR) the supply of coolant to the open reactor is not needed sooner than about 2 hours from the loss of cooling with the capacity of injection being 11 kg/s. The loss of coolant due to evaporation can be further compensated by coolant from the hydro accumulators (which is sufficient for about 7 hours) or in the long term by low-pressure pumps–(if power supply is recovered). The necessary actions are covered in the EOPs or SAMGs. The designer is intentionally not considering the use of any external source for injecting non-borated coolant to the reactor because of possible problems with recriticality of the degraded core. If all the above-mentioned actions to compensate the loss of cooling fail, the accident can evolve into a severe accident at low pressure in the RCS. If relocation of the core is not kept within the RPV, molten corium will penetrate the RPV and will be relocated to the core catcher. Afterwards, cooling of the corium will be ensured by the cooling system of the core catcher, with the heat being eventually removed to the environment through the C PHRS, thus ensuring containment function and integrity, and preventing large radioactive releases. The potentially dangerous situation of a severe accident in open reactor occurring in combination with open containment although not fully ruled out can be prevented, as the containment can be isolated within 30 minutes to 1 hour according to the SAMGs, which is less than the time of the potential transition into a severe accident. The

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		isolation includes evacuation of personnel, isolation of all pipes and valves penetrating the containment and closing the hatches and gates. With regard to the operation of the material hatch, the PRT was informed that only one of the two gates can be open at any moment. Power is needed to isolate the containment, but there are redundant power supplies for the necessary systems. Power supply and separate batteries exist for each safety system (e.g. ventilation valves isolation). **Evaluation:** In the case of shutdown regimes with an open reactor, the SG PHRS is disabled and the amount of coolant in the RPV is smaller, thus contributing to a higher vulnerability of a transition to a severe accident. On the other hand, in regimes with an open reactor, the residual power is smaller and thus the transition to a severe accident takes longer. The responses to the PRT's questions and the additional explanations received during discussions between the PRT and BelNPP as well as during the plant visits show that the implementation of the action is well advanced. During the plant visits it was demonstrated that in the event of a severe accident, the containment can be reliably isolated in a timely manner. Successful use of the measures described above would ensure that there would be no significant release of radioactive substances and no radiation risk to the public in the areas surrounding the plant. Actions taken and implemented meet the intent of the 2018 PRT recommendation. This recommendation is considered closed. Nevertheless, as further enhancement of the preventive part of accident management, the plant is encouraged in the long term to seek additional sources and means for injecting the borated coolant into the reactor in order to delay or avoid the fuel damage.
R-21, PRT p. 71 NAcP 4-19	**Recommendation:** Although habitability of control areas (main control room, emergency control room) during a severe accident in combination with station blackout has been assessed in the	**Implementation:** Responses provided to the PRT's questions described the current situation regarding habitability of control areas should an SBO occur. The implementation of technical measures aimed at ensuring habitability of control areas includes three different tasks:

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	SAR as satisfactory, it is still advised that this issue be further assessed and habitability enhanced. **Action:** Review the need to equip the management zones (MCR, ECR) with additional systems which ensure survivability and the habitability of the MCR/ECR. **Status:** Belarusian NPP issued a call for technical and commercial proposals for implementation of the work. Proposals were received from JSC IC “ASE”.	• implementing measures to ensure habitability of MCR/ECR/TSC if their surroundings should be contaminated by radioactive or toxic substances; • assessing the possibility of long-term occupation of control places if they become completely isolated from the external air supply; • developing additional measures to ensure long-term habitability of control places if they become completely isolated from the external supply of fresh air, and If necessary, provide personal protective means for occupants of the control places. Existing design measures ensure protection of the control places against external radiation and the effects of fires resulting from severe accidents. There are ventilation and air conditioning systems, operating either in direct mode (with double filtration) or in recirculation mode, providing adequate living conditions in the control places corresponding to the hygienic norms. If power supply is lost and the ventilation systems are thus not operable, control places are completely isolated from their surroundings. In this case, the temperature and the concentration of CO_2 will start increasing in the control places. For a fully isolated MCR/ECR, the time margin to reach the parameters that require the use of personal protective means was determined as appropriate in the MCR and ECR. In addition to habitability of the MCR/ECR, the habitability of the technical support centre (TSC) and the emergency centre was also discussed. It was stated and verified during the site visit that these facilities have suitable habitability conditions, equipped with an appropriately sized autonomous power supply and resistant against hazards. There are independent diesel generators, ventilation and filtration, food and drinking water, communication between the TSC, emergency centre and the control rooms, decontamination systems and other systems for ensuring habitability. There is also an independent (twin) emergency centre 20 km away, in the city. **Evaluation:** Suitable living and working conditions in the control places, in particular the MCR, ECR and TSC, are important for the operators to reliably carry out actions under emergency conditions, including for the operators’ psychological comfort owing to their personal

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		safety. Implementation of the recommended actions has progressed satisfactorily. Available design provisions ensure that control places in the plant, including in situations involving station blackout conditions, are habitable for a sufficiently long time, allowing actions to be carried out to shut and cool down the plant. In case of a fire in the MCR and the need for transit from MCR to ECR personal protective means are provided, including refillable breathing apparatus. Several types of communication means exist for on- and off-site communication (e.g. video, telephone, voice, radios, vcr, server for data exchange). Also access control is provided and video recording. Batteries and backups are available for situation with loss of power supply. Realistic estimation included in the report presented to the PRT during the plant visit demonstrates habitability of the control places for more than 3 days without any further action. This is in line with other relevant autonomy requirements applicable to the BelNPP. Actions taken and implemented meet the intent of the 2018 PRT recommendation. This recommendation is considered closed.
R-22, PRT p. 71 NAcP 4-20	**Recommendation:** In the event of NPP blackout the emergency ventilation system of the annulus is not available. Whether there is a need for the system to be in operation in the event of severe accident in combination with station blackout should be further investigated, and, if necessary, the emergency ventilation system of the containment annulus should be modified. **Action:** Review the expediency of ensuring operation of the	**Implementation:** In the responses related to the given issue and further discussions it was explained by the BelNPP that in the safety demonstration of the plant included in the Safety Analysis Report, the most conservative assumptions were used for analysis of radiological consequences of a reference severe accident with largest source term in the containment. It was explained that the reference accident is a large break loss of coolant accident (LBLOCA) (a break of the main circulation line in the primary circuit) which quickly develops into a severe accident, in combination with complete loss of power supply (SBO) lasting for 24 hours (it means without operation of the annulus ventilation system). The acceptance criterion used for the radiological analysis was no need to evacuate people within a radius of more than 800m from the reactor.

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	emergency ventilation system of the annulus (inter-containment space) in the event of a serious accident combined with a loss of external and emergency power supply to the power unit. **Status:** Belarusian NPP issued a call for technical and commercial proposals for implementation of the work. Proposals were received from JSC IC "ASE".	The calculation of the radioactive release to the environment and the public doses demonstrated compliance with the acceptance criterion and the relevant international recommendations on emergency planning, in particular confirming that there is no need for the urgent emergency countermeasures beyond 10 km from the plant. Based on the above mentioned facts, and taking into account very low probability of a severe accident (total value of CDF=9.79E-7/year), taking measures for ensuring operation of the ventilation system in case of a severe accident in combination with SBO was not considered as necessary. It is noted that in the cases when off-site power or emergency electric power (safety DGs) is available (including severe accidents due to common causes other than SBO), emergency ventilation of the annulus will be running. **Evaluation:** The basis for the recommendation was the expected positive effect of filtered ventilation of the containment annulus (KLC system) on the reduction of radioactive releases to the environment and thus on the reduction of doses to the public. The PRT recommendation was inspired by the fact that in the case of design basis accidents, when activity in the containment is relatively small and therefore releases to the annulus are smaller, the emergency ventilation system is in operation, which further reduces the radioactive releases. In contrast, in the case of a severe accident combined with SBO, when radioactivity in the containment is higher and operation of the emergency ventilations could have a stronger effect, the emergency ventilation of the annulus does not work because there is no power supply. On request of PRT, selected results of the radioactive releases to the environment for various severe accident conditions were submitted for the review (including comparison of releases with and without operation of the annulus ventilation system). Comparison of the cases demonstrated low values of the releases of radiologically significant isotopes also under previously described conservative assumptions. For example, even without ventilation of annulus, 3-day release of I-131 was 130 TBq, and release of Cs-137 was 6.5 TBq. Such values allow to conclude that the public doses even in the case of severe accidents will be acceptably low.

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		The comparison of releases under different conditions shows that implementation of the annulus ventilation for the severe accident combined with SBO would further reduce the radioactive releases. In addition, use of the annulus ventilation would convert the ground release to elevated release, contributing to further reduction of public doses. However, the PRT acknowledges that even without implementation of any additional actions the radioactive releases are already low and well below the acceptance limits. Having a possibility for annulus ventilation in case of severe accident combined with SBO would constitute as a further enhancement of safety. The PRT leaves it up to BelNPP and GAN to consider whether such an enhancement would be practicably reasonable. Actions taken and implemented meet the intent of the 2018 PRT recommendation. This recommendation is considered closed.
R-23, PRT p. 71 NAcP 4-21	**Recommendation:** Noting that symptom-based emergency procedures (EOPs and SAMGs) are required before a licence to operate is granted and the challenging timescales, it is recommended that there is a clear programme of work in place to develop the symptom-based emergency procedures; to verify and validate the procedures; and to train personnel before core load. **Action:** Prepare a work programme for the development and implementation of symptom-oriented emergency procedures. **Status:** Belarusian NPP prepared a "Work Programme for the Development and Implementation of Symptom-Oriented Emergency Procedures". The Programme activities are	**Implementation:** The responses to the PRT's questions and the following discussions highlighted that the recommendation had been successfully implemented before the commissioning of the plant. The system of procedures is composed of a combination of event and symptom-based procedures. The symptoms are available in the main and emergency control room as well as in the technical support centre, as needed. There is a special panel in the MCR for displaying the symptoms applicable for design extension conditions. Three sets of procedures are available: for design basis accidents (ILA), for BDBA (RUZA) (both event based and symptom based) and for severe accidents (RUTA). It was confirmed that the set of procedures is of the same type as that currently used in the majority of VVER 1000 reactors as well as in many PWRs in Europe (known as Westinghouse Owner Group type procedures). The procedures cover both power and shutdown operational regimes (including regimes with open reactor) and accidents that originate in the SFP. The EOPs and SAMGs have been developed using relevant analytical basis. The transition between different procedures is clearly defined. The consistency and transition between procedures is ensured by a special procedure. Transition from ILA to RUZA happens when critical safety functions start to be violated during ILA. Safety

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	currently being implemented, including: - development of a preliminary version of SOEP (AtomRED OOO); - preliminary editions of Belarusian NPP have been reviewed and have been agreed upon, taking into account the results of the preliminary review (Belarusian NPP); - preliminary editions of the SOEP have been verified with the issue of a verification report (Belarusian NPP); - an adjustment has been made to the preliminary edition of the SOEP based on the verification results (AtomRED OOO); - operational personnel have been trained to work with the corrected results of verification of the SOEP (Belarusian NPP); - a review has been carried out and there has been coordination of a preliminary version of the SOEP with the developers of the project AS and RU (NIC "Kurchatov Institute", OKB "Gidropress"); - calculation and analytical substantiation of the SOEP (Kurchatov Institute) is being developed, and preparations are under way for validation of the SOEP (Belarusian NPP has developed a draft programme for validation of the SOEP and a draft order for SOEP validation).	functions are similar to those used in Westinghouse type EOPs (subcriticality, core cooling, secondary heat removal, primary circuit integrity, containment integrity, primary circuit inventory). Transition from RUZA to RUTA is based on clear symptoms, including core outlet temperature > 650 °C, hot leg temperature and reactor coolant level. There are also different (specific) SAMGs transition parameters for spent fuel (mainly the coolant level). Experience from the development and implementation of the procedures in the reference plant (Leningrad-2) has been used. The procedures and guidelines were validated (in accordance with a special procedure for performing the validation) and the lessons learned from the validation have been introduced to the updated procedures. The operating staff have undergone training, which consisted of both theoretical and practical parts, including training on full-scope simulator with severe accident simulation capabilities. Other members of the emergency response organisation, e.g. firemen, were also trained. Severe accident management is an integral part of the plant emergency response. At country level, there is a national system of the responses to emergencies. Several external organisations are involved in emergencies, such as fire response and medical services. At the plant, the emergency response is managed by the emergency director, who in case of a need coordinates the activities with the external support teams. Emergency response plans are tested (drills) and updated regularly. Additional forces can be provided by the Ministry of Emergency and Civil Protection from nearby areas. Several exercises and drills have been made during the previous years (every year since 2015, including evacuation of a nearby town). **Evaluation:** In the information provided to the PRT, in the discussions and during the plant visit it was confirmed that the whole system of procedures and guidelines, including the symptom-based EOPs and SAMGs, have been developed, validated and implemented

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		before the plant commissioning in line with the recommendation. Adequate simulation tools including full-scope simulator with severe accident sequence and management simulation capabilities are used in the training. Actions taken and implemented meet the intent of the 2018 PRT recommendation. This recommendation is considered closed.
NAcP 4-15	**Action:** Examine and supplement the list of severe accident management strategies at the in-vessel stage with a control strategy that ensures the timely supply of water to the steam generator (SG) (in order to protect SG tubes from destruction and, if necessary, ensure heat removal via the secondary circuit). **Status:** Belarusian NPP issued a call for technical and commercial proposals for implementation of the work. Proposals were received from JSC IC “ASE”.	**Implementation:** According to the information provided in BelNPP’s responses and in the discussions that followed, the works on the given action have been carried out in cooperation with the plant and the general designer including: • analysis of the possible leakages between the primary and secondary side of the SG under conditions involving a severe accident associated with SG PHRS failure and/or loss of secondary coolant; • evaluation of possible measures for refilling the SG with coolant above the SG tubes in order to prevent damage to the tubes and to ensure the retention of radioactive fission products. The issue of a combination of a severe accident with steam generator tube rupture (leading to a containment by-pass accident) was included in 2018 PRT recommendations among the conditions to be practically eliminated. There are corresponding design means in support of practical elimination, including an automatic algorithm to manage accident caused by a steam generator tube rupture, and flooding of the secondary side of the steam generators. Flooding is covered by the implemented symptom based EOPs. The source of coolant for flooding are external tanks with demineralized water. The pump used for flooding with injecting capacity 40 kg/s is powered from channels 7 and channel of electric power supply, with delivery of coolant to the common emergency feedwater collector. It was verified by the analysis, that the capacity is sufficient for flooding secondary side of all steam generators with the objective to prevent tube ruptures due to their overheating.

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		Evaluation: Although there was no specific PRT recommendation on refilling SGs BelNPP decided – in line with the strategies considered by the applied generic procedures and guidelines to introduce into the severe accident strategies the flooding of the SG's secondary side. This measure would be effective in dealing with the unlikely accident caused by the combination of a severe accident and the failure of SG PHRS, or the combination of a severe accident and the loss of secondary coolant. The sources of coolant for flooding, the means to deliver the coolant are available and the associated actions are covered by the symptom based EOPs. Adequacy of the means for flooding was confirmed by safety analysis. A combination of a severe accident with steam generator tube rupture was included among the conditions to be practically eliminated. Actions taken and implemented meet the objective of the NAcP as an additional component contributing to the intent of the 2018 PRT recommendation on implementation of the symptom-based emergency procedures (EOPs and SAMGs) and the action is considered closed.
NAcP 4-16	**Action:** Qualify the available technical means of controlling the primary circuit protection function against overpressure under post-design conditions, including serious accidents. **Status:** Belarusian NPP issued a call for technical and commercial proposals for implementation of the work. Proposals were received from JSC IC "ASE".	**Implementation:** In the responses to the PRT's questions, it was confirmed that the means for reducing the pressure in the primary circuit (PRZ safety valves, including an additional control line and the emergency gas removal system) were developed in line with the relevant codes and standards. These include qualification of the relevant equipment for the environmental conditions (temperature, pressure) in the primary circuit, as well as in the containment corresponding to design extension conditions (including severe accidents). It is assumed (taking into account the experience of the reference NPP) that the post-accident conditions will be very close to the conditions considered in the design. **Evaluation:** This is a complementary action (not explicitly listed in the PRT's list of

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		recommendations) to Recommendation R-17, aimed at dedicated means for depressurising the RCS in the event of a severe accident. The implementation of the action seems satisfactory, and the attention devoted to ensuring qualification of the equipment is acknowledged. According to information provided by BelNPP, the plant in cooperation with the designer, continues the evaluation and, subject to the results, the decision could be made on whether the equipment will need to be additionally tested (for example, by the manufacturer). Actions taken and implemented the objective of the NAcP as an additional component contributing to the intent of the 2018 PRT recommendation on independent means of reactor coolant system depressurization in case of a severe accident and the action is considered closed.
NAcP 4-18	**Action:** Review the adequacy of technical measuring devices for the management of serious accidents and develop additional measures if necessary. **Status:** Belarusian NPP issued a call for technical and commercial proposals for implementation of the work. Proposals were received from JSC IC "ASE".	**Implementation:** In the responses to PRT's questions, it was explained that in the procedure '*Use of Measuring Instruments in Severe Accident Management*', all information is provided on the existing measuring instruments which are required as symptoms for the operator to carry out actions if severe accidents occur. Special severe accident instrumentation includes monitoring of: • integrity of the SG with backup (using sensors status insulation, hatch tightness sensors, radiation monitoring dosimeters within the containment, in containment annulus, and on-site); • level and temperature in the spent fuel pool; • pressure, temperature, hydrogen and oxygen concentration in the containment; • temperature in the molten core; • temperature and level in the system of passive heat-removal tanks; • parameters of operating conditions of different systems, etc. It was confirmed that measurements exist for all parameters needed for the transition from BDBA procedures (RUTA) to severe accident guidelines (RUZA) and for all actions included in the procedures and guidelines to be carried out. The measuring range of the

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		devices seems adequate for severe accidents. For example, there are the core outlet temperature monitoring sensors up to 1200°C, hydrogen concentration in the containment monitoring up to 25%, sensors of three discrete reactor coolant level positions. The MCR has a special control panel for BDBAs with controls to the equipment designed to manage the accidents, as well as displays that reflect the state of the parameters of the reactor facility under BDBA conditions. The presence of such a panel in the MCR and such equipment was considered to be '*good practice*' during the IAEA pre-OSART mission in 2019. **Evaluation:** Reliable measurements providing information to operators or the staff in the TSC to enable them to make decisions are necessary for accident management actions to be carried out in a reliable fashion. Based on information provided the PRT concluded that the implementation of the action is satisfactory. EOPs and SAMGs have been developed, taking into account the existing measuring instruments. All parameters needed for management of design extension conditions and severe accidents are available in a special control panel. Essential parts of the instrumentation for severe accident is independent from instrumentation for design basis accidents, Availability of a special control panel in the MCR and associated equipment for management of severe accidents was recognized to be 'good practice' by the IAEA pre-OSART mission in 2019. Actions taken and implemented meet the objective of the NAcP as an additional component contributing to the intent of the 2018 PRT recommendation on implementation of the symptom based procedures and guidelines and the action is considered closed.
PRT p. 70	**Recommendation:** In the NR no information was given regarding the evidence of the efficiency and reliability of the new passive safety	**Implementation:** Passive heat removal systems are important parts of design features of the plant. There are two passive systems: 10JNB (for heat removal from the steam generators) and

Action (Source[33]:)	PRT recommendation, action in NAcP and status in NAcP update of January 2020	Implementation and evaluation of action
	systems as the SG PHRS and C PHRS. During the discussion the PRT requested information based on experimental data and commissioning test in similar plants. No additional evidence was available during the review mission. Nevertheless, GOSATOMNADZOR stated, that comprehensive tests, proving the efficiency and functionality of new systems have to be carried out as a part of the commissioning procedure and were requested in the licensing procedure. **Action:** n/a **Status:** n/a	10JMP (for heat removal from the containment). The valves isolating passive heat exchangers from the steam generators and from the containment are closed when electric power is available. In case of loss of the electric power for more than 2 minutes the isolating valves will open passively in accordance with their fail-safe positions. In the written responses provided as well as in further discussion it was confirmed that in line with the program for commissioning of the plant, the systems were verified during the commissioning tests (in addition to the experiments performed in experimental facilities for demonstration of adequacy of the design). The main objectives of the tests were to demonstrate the reliable opening of all initiating valves (including verification of their opening time, which is few seconds) of the systems and to quantify thermal power removable by the systems (expressed in terms of thermal power removed, up to more than 50 MW), depending on the steam pressure on the secondary side of the steam generators (in the range from 0.1 to 7 MPa). All commissioning tests have confirmed design parameters of the passive heat removal systems. Materials proving the PHRS performance at the reference units and at the units of the Belarusian NPP have been provided to PRT in the follow-up interactions. The materials included summary of the quantitative results of the commissioning tests (both for 10JNB and 10JMP systems). **Evaluation:** Passive means for heat removal (SG PHRS and C PHRS) are innovative design features which according to IAEA Safety Requirements for design (SSR-2/1 (Rev.1)) '*shall also be adequately tested to the extent practicable before being brought into service, and shall be monitored in service to verify that the behaviour of the plant is as expected*'. It is essential that these innovative features function properly for both the preventive and mitigative part of accident management, and thus also very important for practical elimination of early or large releases, as covered by Recommendation R-16. These are the reasons why it is important that the tests are carried out and the results are made available. Based on the submitted information it is concluded that the actions taken and

Action (Source[33]:)	PRT recommendation, action in NAcP and status in NAcP update of January 2020	Implementation and evaluation of action
		implemented meet the intent of the 2018 PRT recommendation. This recommendation is considered closed.

• LIST OF ABBREVIATIONS

AC	Alternating current
BDBA	Beyond design basis accident
BelNPP	Belarusian nuclear power plant
CDF	Core damage frequency
C PHRS	Containment passive heat removal system
CPL	Cable power line
DBA	Design basis accident
DBE	Design basis earthquake
DEC	Design extension condition
DG	Diesel generator
DiD	Defence-in-depth
ECR	Emergency control room
EDG	Emergency diesel generator
ENSREG	European Nuclear Safety Regulators Group
EOP	Emergency operating procedure
EU	European Union
g	standard value of the gravitational acceleration (9.81 m/s^2)
GAN	Gosatomnadzor
GMPE	Ground motion prediction equation
HCLPF	High confidence in low probability of failure
HPME	High pressure melt ejection
HVAC	High voltage alternating current
I&C	Instrumentation and control
IAEA	International Atomic Energy Agency
ILA	Emergency operating procedure for design basis accidents (Russian acronym)
LB	Large break
LBLOCA	Large break LOCA
LCU	Makeup water system
LERF	Large or early radioactive releases
LOCA	Loss of coolant accident
LRF	Large release frequency
MCR	Main control room
Mmax	Maximum possible magnitude
MSK-64	Medvedev–Sponheuer–Karnik (seismic intensity scale)
NAcP	National Action Plan
NFDF	Nuclear fuel damage frequency
NPP	Nuclear power plant
NR	(Stress Test) National Report
OBE	Operating base earthquake
OSART	Operational Safety Assessment Review Team
PGA	Peak ground acceleration
PGA_H	Horizontal peak ground acceleration
PHRS	Passive heat removal system

PR	Peer review
PRT	Peer Review Team
PRZ	Pressuriser
PS	Power substation
PSA	Probabilistic safety assessment (also known as PRA)
PSHA	Probabilistic seismic hazard assessment
PWR	Pressurised water reactor
RCS	Reactor coolant system
RPV	Reactor pressure vessel
RUTA	Severe accident management guidelines (Russian acronym)
RUZA	Beyond design-basis accident management procedure (Russian acronym)
SAM	Serious accident management
SAMG	Severe accident management guideline
SAR	Safety Analysis Report
SBO	Station blackout
SFP	Spent fuel pool
SG	Steam generator
SG PHRS	Steam generator passive heat removal system
SMA	Seismic margin assessment
SOEP	Symptom-oriented emergency procedures
SSC	Structures, systems and components
SSE	Safe shutdown earthquake
SV	Safety valve
TSC	Technical support centre
UPS	Uninterruptible power supply
VVER	Russian pressurised water reactor
WENRA	Western European Nuclear Regulators Association
XLPE	Cross-linked polyethylene