

Periodic Safety Review as a Key Element in the Process for Lifetime Extension and Relicence of Unit 5 at Kozloduy NPP

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Abstract. The article presents the methods used for the Periodic Safety Review (PSR) of unit 5 at Kozloduy NPP. It is based on the Bulgarian Nuclear Regulatory Agency (BgNRA) requirements and the IAEA Specific Safety Guide SSG-25 - Periodic Safety Review for NPPs (2013). The role, requirements, objectives, scope, approach, stages and activities, and resources for the PSR are briefly described. The key points are that (1) the PSR should assess future safety at the nuclear power unit/plant at least until the next PSR and, where appropriate, up to the end of planned operation; (2) the PSR is complementary to the routine and specific safety reviews and does not replaced them; (3) the level of compliance with current safety requirements towards higher conservatism are point out; (4) all safety aspects (fourteen Safety Factors – SF) of NPP operation and all equipment (SSCs) on site are covered; (5) four stages with the main activities for the PSR are defined and performed. It is point out that the success of the PSR is based on the NPP staff team work, the cooperation and approval of PSR activities by the Bulgarian Regulator (BgNRA), and cooperation with external organizations in some areas with proved experience.

Keywords: Periodic Safety Review (PSR), Safety Factor (SF), NPP lifetime extension, NPP licence renewal.

1 Introduction

The regular reviews of the operation of the Nuclear Power Unit (NPU) are already proved means as one of the key elements to ensure the NPU safety. They include all aspects of the NPU operation, such as the assessment of all hardware modifications of the equipment (Structures, Systems and Components – SSCs), important to safety, and their configuration, changes in the operating and maintenance documents, changes in the organizational structure, management system and safety culture, the competence of the personnel, operating experience and significant events, during the covered period. Another very important aspect of the PSR is the assessment of the cumulative effects of equipment ageing and modifications [1–3].

2 Role of the Periodic Safety Review (PSR)

The PSR in a systematic way reassesses the compliance of the NPU current design, configuration and operation with the current safety standards and operating practices. The PSR results are used as evidence for the level of safety throughout the NPU's operating lifetime. The PSR is complementary to the routine and specific safety reviews conducted at Nuclear Power Plants (NPPs) and does not replace them [1–3].

The internationally accepted reasonable period, covered by the PSR, is considered of no more than ten year intervals – from the start to the end of NPU operation. The interval of maximum of ten years for the PSR is accepted to be an appropriate, because within such a period can be taken into account: [1–3]

- Changes in national and international safety standards, operating practices, technology, scientific knowledge and analytical techniques;

- The cumulative effects of plant modifications to adversely affect safety or the accessibility and usability of the safety documentation;
- Significant ageing effects or trends;
- Accumulation of relevant operating experience;
- Changes in the NPP operation and procedures;
- Changes in the natural, industrial or demographic environment in the vicinity of the plant;
- Changes in the staff experience and levels;
- Changes in the NPP management structures and administrative procedures.

The PSR provides means for: [1–3]

- Regulation of safety of NPP operation in a long term;
- Addressing requests by licensees for authorization to continue NPP operation beyond an established licensed term or for a further period established by a safety evaluation;
- Reassurance that the licensing basis continues to be valid, taking account ageing, current safety requirements and operating practices, etc.;
- Determine reasonable modifications to ensure safety or improve safety to an appropriate high level (identification of any SSCs lifetime limiting features);
- An effective way to obtain an overall view of actual NPP safety and the quality of the safety documents.

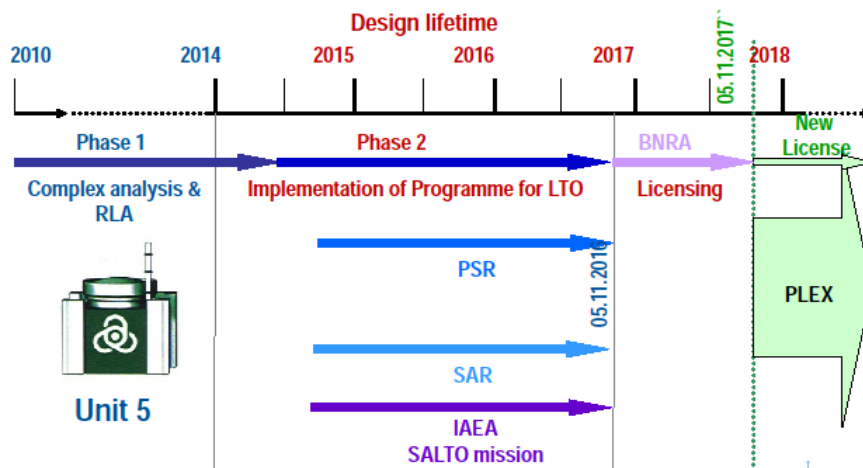


Figure 1. The role of the PSR among the other projects needed for the extension of the lifetime operation and the licence renewal for unit 5 at Kozloduy NPP

It must be stated that the PSR should determine the status of all aspect of the unit/plant operation (safety factors) at the time of the PSR and should assess future safety at the nuclear power unit/plant at least until the next PSR and, where appropriate, up to the end of planned operation. This should include a review of the capability of the operating organization to identify potential failures and either prevent them or mitigate their consequences before they could lead to a radiological incident. Ageing related degradation mechanisms that could lead to failures of SSCs important to safety that could potentially limit the plant's operating lifetime should be identified to the extent possible [1–3].

The role of the PSR among the other projects needed for the extension of the lifetime operation and the renewal of the licence of unit 5 at Kozloduy NPP is shown in Figure 1.

The process started in 2010. It included two phases:

- Phase 1: (2010-2014), Complex analysis and rest lifetime analysis (RLA) of the equipment (Structures, Systems and Components – SSCs). Two lists of SSCs were prepared; one for SSCs which continue to be in operation and the second – with SSCs which must be replaced;
- Phase 2: (2014-2017), Implementation of measures for Long Term Operation (LTO) of unit 5, based on the results of the Phase 1. Phase 2 includes also IAEA SALTO mission (2016), and updates of the Final Safety Analysis Report (AFSAR) and PSR.

All the documents have to be prepared and submit to the BgNRA before 05 November 2016* (the BgNRA requirement is the complete package for licence renewal has to be submitted to the BgNRA at least 12 months before the valid expire date of the current licence of the unit).

*05 Nov 2017 – date of expire of the licence of operation of unit 5 (series E, N°03000/02.10.2009)

06 Nov 2017 – 06 Nov 2027 – period of the new licence of operation of unit 5 (series E, N°5303/03.11.2017)

02 Oct 2019 - date of expire of the licence of operation of unit 6 (series E, N°03001/02.10.2009)

3 Requirements for PSR of Unit 5 at Kozloduy NPP

The requirements for PSR applied for unit 5 are described in the BgNRA Regulation for nuclear safety (published in 2004, last update in 2010). It is superseded with the new one, published in Sept 2016. “Art. 22. (1) Existing plant design and operations shall be periodically reviewed in the light of the operating experience and the new safety significant information to identify deviations from current requirements and international recognized operational experience...”

In the IAEA Safety of NPPs: Commission and Operation, Specific Safety Requirements SSR-2/2 (2011), (this document was updated with SSR-2/2 in 2016) the Requirement 12 is: “Systematic safety assessment of the plant, in accordance with the regulatory requirements, shall be performed by the operating organization throughout the plant's operational lifetime, with due account taken of operating experience and significant new safety related information from all relevant sources.”

4 Objectives of PSR of Unit 5 at Kozloduy NPP

Objective of the PSR is to define [1–3, 9, 10]:

- The level of compliance with the current safety requirements (national, international, and good practices);
- The level of validity of licensing basis;
- The appropriate measures to ensure safety throughout the next PSR or to the end of the NPP lifetime;
- All factors and contributors causing degradation of the lifetime of the equipment (SSCs);
- Measures to resolve the defined deviations from the safety requirements.

5 Scope and Period of PSR of Unit 5 at Kozloduy NPP

The scope of PSR of unit 5 includes [1–3, 9, 10]:

- All aspects of the safety of unit 5 (as it is required by the BgNRA and the IAEA requirements);
- The whole equipment (Structures, Systems and Components - SSCs) on NPP site, included in the operating licence, full scope simulator, operating organization and staff);
- The aspect of the security protection are not in the scope of the PSR;
- PSR is performed for each nuclear unit separately;
- declared operating term of next 10 years (until 2027);
- 01 July 2014 as the cut-off date, beyond which updates to standards and new information will not be considered during the PSR (standards issued after this date were subjected under special discussion with BgNRA);
- Reference basis at the time of initiating the PSR;
- Defined priority of the documents for PSR.

The PSR of unit 5 at Kozloduy NPP was planned and accomplished in the period of 2014–2016.

6 Approach for PSR of Unit 5 at Kozloduy NPP

To accomplish the defined objective and scope of the PSR, the requirements of the IAEA SSG-25 were applied, based on the agreement with the BgNRA [1–3, 9–13].

The PSR must be complete, systematic and thorough.

- All aspects of operation of unit 5 were analyzed to insure the PSR completeness;
- The stages, their tasks and consistency were clearly defined to insure the systematic and thoroughness of the PSR.

The following results were used, to accomplish the objectives of the PSR:

- The results of the last PSR, performed in 2007-2008 for units 5 and 6 of Kozloduy NPP;
- The results of the stress-tests for the site of Kozloduy NPP (2011-2013);
- The result of the complex assessment of rest lifetime of equipment (SSCs) of unit 5;
- The results of assessment of the Kozloduy site in the framework of the project for possibility to construct a new nuclear unit at Kozloduy site.

6.1 Reference level for PSR for unit 5 at Kozloduy NPP

The reference basis at the time of the performance the PSR is defined as a complete set of national and international documents with the safety requirements [1–3, 9, 10].

The importance of the documents which are included in the list (reference basis) to assess each safety factor is based on the BgNRA requirement (Licensee of operation of unit 5, series E, № 03000/02.10.2009) and IAEA recommendation in SSG-25.

The licensee basis of unit 5 is included in the reference basis for the PRS of unit 5. The date of 01 July 2014 was defined by BgNRA as the cut-off date, beyond which updates to standards and new information will not be considered during the PSR (standards issued after this date were subjected under discussion with BgNRA).

The same date of 01 July 2014 was used as a cut-off-date to assess the condition of the equipment (SSCs).

This reference basis was used as input data to identify the deviations and deficiencies that were considered significant for unit/plant safety. These deviations and deficiencies were designated as “safety issues” or “issues” in short.

In accordance with requirements of the BgNRA and recommendation in the IAEA guidance SSG-25, the priority of the safety requirements were towards higher conservatism. Three levels of importance for the documents in PSR:

- First level of priority:

Bulgarian documents with safety requirements;

- Second level of priority:

IAEA documents (in cases when the Bulgarian documents do not contain specific methodological or technical requirements. At that level the document of WENRA are included too;

- Third level of priority:

Documents of manufactures and suppliers of the equipment (SSCs) (they are applied when the higher conservatism is required):

The reference basis for each SF was defined.

The complete reference basis for the PSR was established based on the reference basis of each SF.

6.2 Areas and Safety Factors (SFs)

Each important aspect of the safety in NPP operation which is in the scope of PSR is defined as Safety Factor (SF). One or several SFs are combined as area.

Four areas and fourteen SFs are defined for the PSR of Unit 5 at Kozloduy NPP, based on the BgNRA requirements, BgNRA position and IAEA guidance SSG-25 for PSR of NPPs [1–3, 9–13].

BgNRA, para (2), art. 22 of Regulation for nuclear safety (not any more in power, superseded by a new one in Sept 2016) defines 9 areas, equivalent to safety factors.

Table 1. Areas and Safety Factors (SFs)

AREA	FACTOR	
	BgNRA requirements	IAEA requirements (SSG-25)
Plant	(1) Site characteristics considered in the design	SF01: Plant design
	(2) Plant design as built and actual condition of SSCs taking into account implemented modifications, ageing and other aspects that impact safety and plant lifetime	SF02: Actual condition of SSCs important to safety
		SF03: Equipment qualification
		SF04: Ageing
Safety analysis	(3) Current safety analysis methods and applicable new safety requirements	SF05: Deterministic safety analysis
		SF06: Probabilistic safety assessment
		SF07: Hazard analysis
Performance and feedback of experience	(6) Safety performance indicators and effectiveness of safety and quality management	SF08: Safety performance
	(4) Operating experience during the review period and effectiveness of the systems used for experience feedback	SF09: Use of experience from other plants and research findings
Management	(5) Organizational arrangements for operation	SF10: Organization, the management system and safety culture
	(7) Staff number, levels of training and qualification	SF11: Procedures
		SF12: Human factors
		SF13: Emergency planning
Environment	(8) Emergency preparedness	
	(9) Radiological impact on the environment	SF14: Radiological impact on the environment

The IAEA guidance SSG-25 (2013) defines 14 safety factors, grouped in 4 areas. Based on the position of the BgNRA, IAEA guidance SSG-25 was used as a basis for the PSR of unit 5 [3].

The SFs grouped in areas and their correspondence, based on the BgNRA requirements (para (2), art. 22 of Regulation for nuclear safety) and the IAEA SSG-25 are presented in Table 1 [9].

6.3 Elements and criteria for SF

The elements and the criteria (requirements) for assessment of the given Safety Factor (SF) reflect the key features of that SF. The definition of the elements and the criteria are defined based on:

- Regulation on ensuring the safety of nuclear power plants (2004, last update in 2010, superseded in Sept 2016);
- Elements and criteria from the previous PSR for unit 5 and 6 (2007-2008);
- Annex: Typical inputs, outputs and relevant publications for the review of safety factors, of IAEA SSG-25 guidance;
- WENRA Safety Reference Levels for Existing Reactors: Update in relation to lessons learned from TEPCO Fukushima Dai-chi accident (Sept 2014);
- WENRA Safety of new NPP designs (March 2013);

- Documents of manufactures and suppliers of the equipment (SSCs).

The used approach insures the sufficiency and the comprehensiveness of the definition of elements and criteria.

The name, the code of the reference basis and the text of each element and criteria (requirement) are described in the method of assessment, developed for each safety factor. All this process was subject to agreement with the BgNRA.

7 Stages and activities in the framework of PSR of unit 5 of Kozloduy NPP

7.1 Features of PSR for unit 5 at Kozloduy NPP

The following features are important for the accomplishment of the PSR of unit 5 [9, 10]:

- Last PSR was carried out in the period of June 2007 – March 2008;
- The PSR covers the last ten-years period of operation of unit 5 (and unit 6 also) in their designed lifetime of 30 years;
- The PSR report is part of the set of documents which will be submitted to the BgNRA for continuation of the lifetime of unit 5 (also for unit 6);
- The PSR is joined together with the updating of Final Safety Analysis Report (UFSAR);

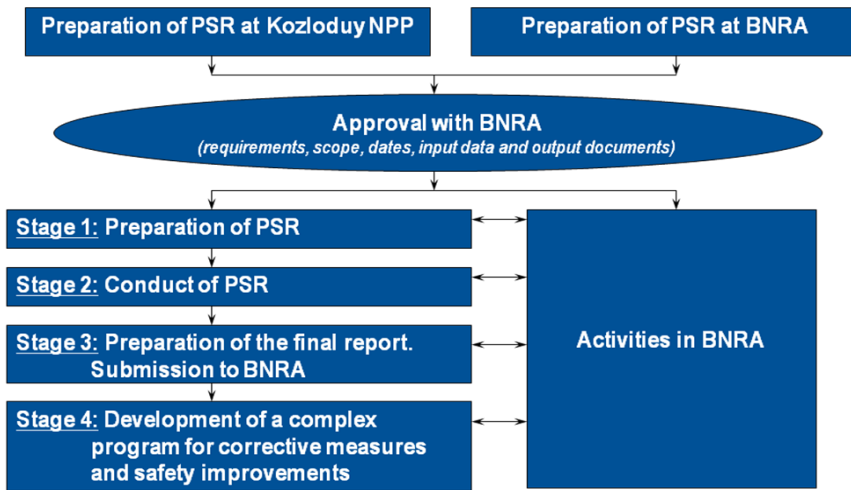


Figure 2. Stages of PSR for unit 5 at Kozloduy NPP.

- Accomplishment and results of the stress-test for Kozloduy NPP;
- Accomplishment and results of a project for complex assessment of actual conditions of equipment (SSCs) of unit 5 and 6, 2012-2013 (it covers SF2 – current condition of SSCs and SF4 - Ageing);
- Applicability of the results of existing analyses (e.g. results from last PSR – 2007-2008).
- Preparation;
- Conduction;
- Preparation of the final report. Submission to the BgNRA;
- Development of a complex program for corrective measures and safety improvement.

7.2 The stages of PSR for unit 5 at Kozloduy NPP

Four stages for PSR of unit 5 at Kozloduy were defined, based on the BgNRA requirements and the IAEA guidance SSF-25 for PSR [1–3, 9]:

The stages for PSR of unit 5 at Kozloduy are presented in Figure 2.

The hierarchy of the documents developed in the framework of PSR for unit 5 at Kozloduy NPP, based on the PSR stages, is presented in Figure 3.

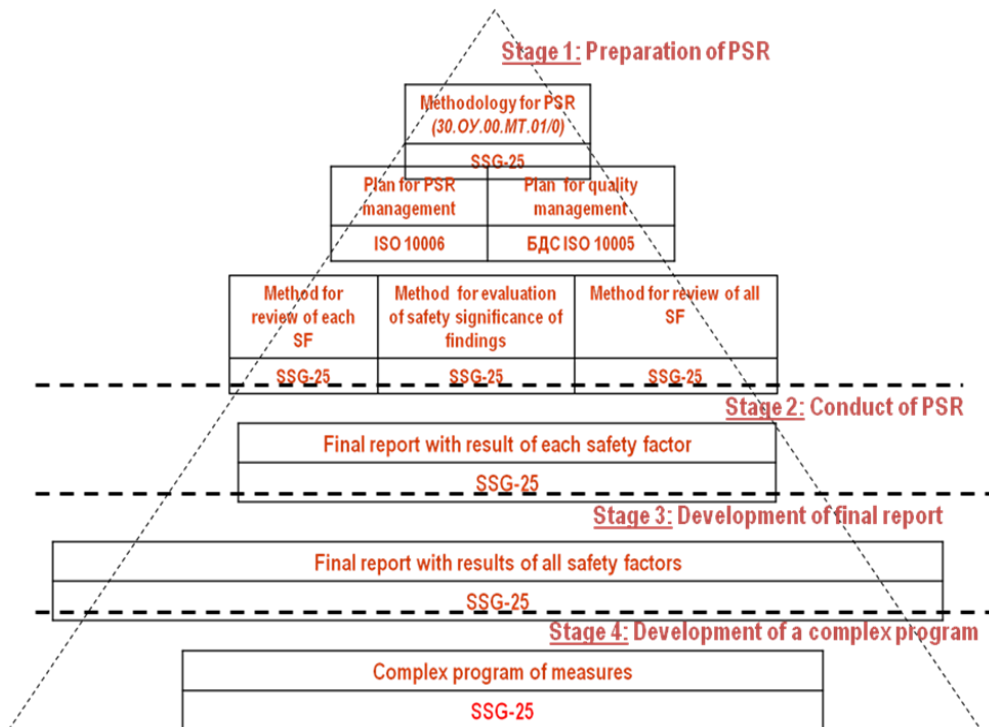


Figure 3. The hierarchy of the documents developed in the framework of PSR for unit 5 at Kozloduy NPP, based on the PSR stages.

8 Resources for PSR of Unit 5 at Kozloduy NPP

The specialists of Kozloduy NPP accomplished the PSR of unit 5. They have knowledge and experienced in:

- Design basis of the unit/plant;
- Operation and maintenance of the unit/plant;
- Project of last PSR in 2008;
- Project of the stress-tests (2011-2013);
- Project of assessment of the current condition of equipment (SSCs) (RLT/LTO);
- WANO and IAEA mission (e.g. OSART and WANO missions).

Training covering all features and complexity of the PSR was performed. The specific areas were covered too as:

- Non routing activities;
- Participation of many specialists in deferent areas;
- Participation and coordination between many specialists (from Kozloduy NPP and external companies and organization;
- Insurance of team work and cooperation with representatives on the Bulgarian NRA;
- Simultaneous work and coordination of several teams.
- Cooperation with external companies and organizations will be used in areas where they have proved experience.

Based on agreement with BgNRA, the assessment of one safety factor (SF12: Human factors) was contracted with external company, to insure the independence of the assessment.

9 Summary

The Periodic Safety Review (PSR) of unit 5 at Kozloduy NPP was accomplished in the period of 2014–2016. It is based on the Bulgarian Nuclear Regulatory Agency (BgNRA) requirements and the IAEA Specific Safety Guide SSG-25 - Periodic Safety Review for NPPs (2013). The role, requirements, objectives, scope, approach, stages and activities, and resources for the PSR are briefly described. The key points are that (1) the PSR should assess future safety at the nuclear power unit/plant at least until the next PSR and, where appropriate, up to the end of planned operation; (2) the PSR is complementary to the routine and specific safety reviews and does not replaced them;

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