

Kozloduy NPP Units 5&6 Modernization and Plant Life Extension (PLEX) Programs

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Abstract. In the present material main steps and procedures for the modernization and plant lifetime extension of Kozloduy NPP Units 5&6 are discuss. The paper traces the various stages in the period 1998–2019 important for plant life extension.

Keywords: Ageing, Ageing Management Program (AMP), Plant Life Extension (PLEX), Scoping & screening, Long Term Operation (LTO).

List of abbreviations

SSCs — Structure Systems and Components
 AMP — Ageing Management Program
 PLEX — Plant Life Extension
 LTO — Long Term Operation
 MCP — Main Coolant Pump
 SAR — Safety Analyses Report
 I&C — Instrumentation and Control
 PSR — Periodic Safety Review
 BNRA — Bulgarian Nuclear Regulatory Agency
 IAEA — International Agency of Atomic Energy

1 Introduction

Kozloduy NPP is the first nuclear power plant in the south-eastern Europe. The most important dates in the operational history of the units 5&6 are presented in Table 1.

Table 1. Operational History of Kozloduy NPP plc

	Unit 5	Unit 6
Commisioning	1987	1991
Licensed until	03.11.2027	02.10.2019
Fuel company	25	24

Each of Units 5&6, in operation, has the installed a WWER-1000/B-320 reactor installation located in a hermetic steel concrete protective structure (containment), a turbine generator unit with K-1000/6015002 type turbine, and an electrical generator TBB-1000-4UZ.

For the period 2012-2019, the “Units 5&6 the plant life extension project” and its successful completion within the deadline set is determined as a strategic priority for the plant development.

2 Plant Programmes Relevant to Long Term Operation (LTO)

The design lifetime of Units 5 at Kozloduy NPP has expired in 2017. The operational license for Unit 5 of Kozloduy NPP PLC was renewed in 3 November 2017 by the Nuclear Reg-

ulatory Agency in compliance with the Act on the Safe Use of Nuclear Energy and the Regulation on the proceeding to issued licences and permissions for nuclear energy use for a period of up to 10 years. Kozloduy NPP PLC has fulfilled actions for extending the operational lifetime of Units 5&6 as follow.

2.1 Modernization programme relevant to LTO

In the period 1998 to 2008, a large-scale modernization programme was implemented, thus implementing all the necessary improvements in order to put the units in compliance with the international recommendations in terms of safety and reliability. The programme is based on the IAEA document on the safety issues and their ranking for WWER-1000 Model 320 Nuclear Power Plants (Safety Issues and Their Ranking for WWER-1000 Model 320 Nuclear Power Plants IAEA-EBP-WWER-05, 1996). The programme included 212 measures to enhance safety, operation and reliability of the units. The implemented measures are included in the following groups:

- Replacement of mechanical equipment;
- Modernization of electrical equipment;
- Replacement of the I&C systems with modern digital control systems;
- Improvement of fire protection and level of seismic resistance;
- Optimization of the conditions for equipment performance.
- Studies and analyses applying the conservative assumptions, contemporary methods and computers codes in compliance with the accepted requirements were carried out.

The equipment capability of performing the design functions was verified. The analysis spectra were extended in

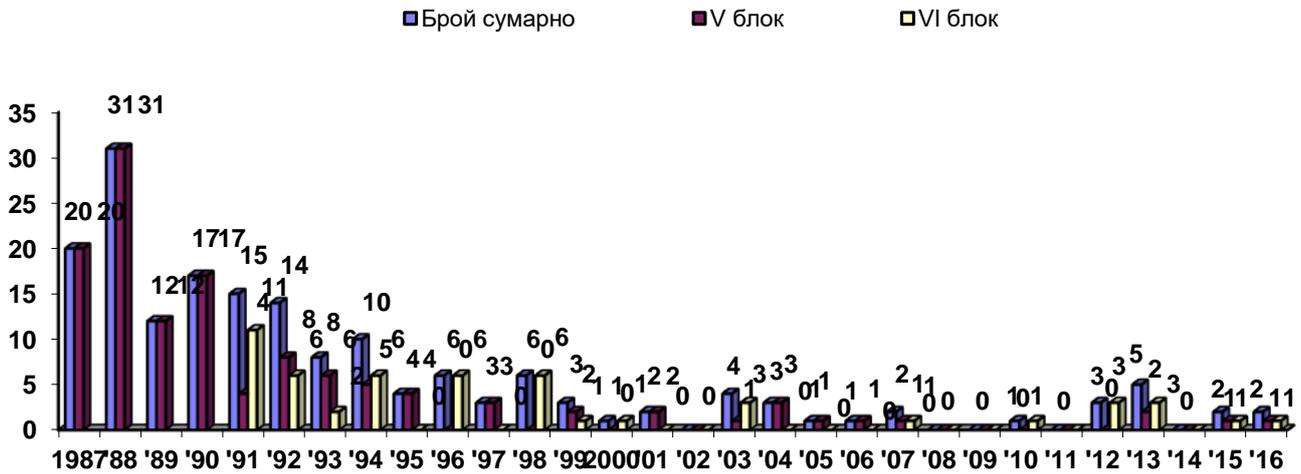


Figure 1. Number of unplanned scrams at Kozloduy NPP Units 5&6 in the period 1992-2015 years.

order to identify the capabilities of the units for management of design and beyond design accidents. The equipment was classified in terms of safety, seismic and quality. Completely new systems were installed such as:

- containment on-line monitoring and hydrogen recombination system for design accidents;
- reactor pressure vessel measurement and level control
- system required for transient management (small LOCA, primary to secondary leaks and cool down without operating MCPs);
- automatic reactor pressure vessel cold over pressurization system;
- filter ventilation system to prevent the containment from integrity loss and minimization of the radioactive releases to the environment in case of beyond design accident;
- on-line isolation monitoring of 6 kV motors in stand-by mode.

The Units 5&6 Modernization Project of the Bulgarian nuclear power plant is the first and the only programme in the world which applies the full scope of the prescriptions

for improvements of the WWER-1000 /320 units identified in the Safety Issue Book (IAEA-EBP-WWER-05). The completion of the Modernization Programme is a very important stage of the lifetime of Units 5&6 and provides for the compliance of the plant design with contemporary requirements to safety. Number of unplanned scrams at Kozloduy NPP Units 5&6 in the period 1992-2015 decreased significantly, as it is shown in Figure 1.

After modernization completion, Kozloduy NPP proceeded to the implementation of the Unit 5&6 Investment Programme. The main programme priorities are plant lifetime management and plant lifetime extension, maintain and enhance safety of operation and spent fuel storage (SFS) as well as increase the reliability of open switchyard. The investment programme include measures for safe management and storage of radioactive and non-radioactive waste generated during the plant operation, environmental radiation monitoring, physical protection, fire safety. In the period from 2008 to 2012, the safety control systems used for establishing a cold condition of reactor system were replaced with new. The optimization of the maintenance is achieved through:

- long-term planning of maintenance and repairs,
- optimization and planning some of the maintenance activities for their implementation during normal operation (without shutdown) of the units,

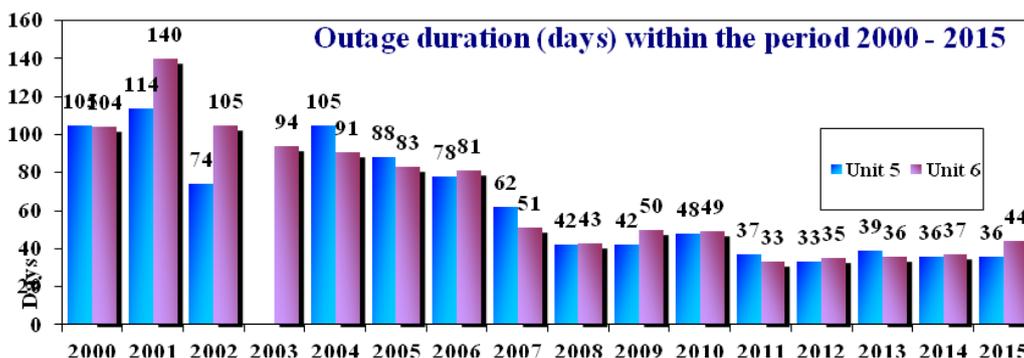


Figure 2. Outage duration of Kozloduy NPP Units 5&6 (2000-2015).

- preliminary detailed planning during the preparation of schedules for maintenance and repairs,
- use of condition monitoring systems;
- use of developed documentation for specific types of equipment.

This provides for shorter outage duration and improves the plant load factors and it is shown in Figure 2.

The benefit can be demonstrated and it is shown in Figure 3 by change of CDF as a result of the safety enhancement measures (by PIE's). After the end of Modernization Programme CDF was decreased more than 10 times.

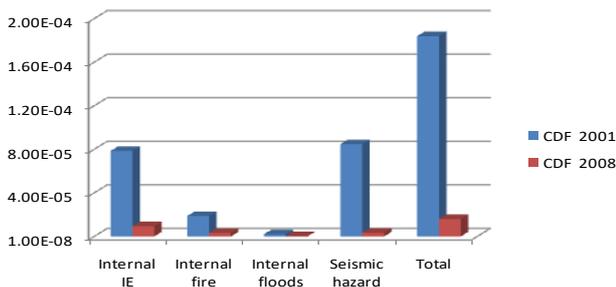


Figure 3. Change of CDF as a result of the safety enhancement measures (by PIE's).

2.2 Ageing management relevant to LTO

The Kozloduy NPP concept on Units 5&6 ageing management and the planned activities on ensuring the units' lifetime extension are specified in the "Kozloduy NPP Units 5&6 ageing management programme. In relation to the activities on Unit 5 lifetime extension and operating license renewal, an update of the ageing management programme is forthcoming that shall introduce the results from the 2015-2016 periodic safety review (PSR) at Unit 5, and following the design analyses reports, the time limited ageing analyses for Unit 5 (concerning the second stage of the Unit 5 LTO project). In 2012, Kozloduy NPP initiated a project for the lifetime extension of Unit 5&6, contracted by Consortium, consisted from Rosatom Service, Rosenergoatom OAO, Riskengineering PLC and the Electricity de France. The project goals were completed after receiving the license of Unit 5 in 2017 (for Unit 6 in 2019). The project includes two stages:

2.2.1 First stage

Ageing Management Review (AMR) of Unit 5&6 of Kozloduy NPP AMR was performed in compliance with the requirements of Methodology for performance of a comprehensive assessment of the residual lifetime of the equipment and facilities at Units 5&6 of Kozloduy NPP. The objective of the Procedure is assess the actual condition and residual lifetime of the equipment and facilities (the abbreviation SSCs for structure, systems and components will be used further in the test, as adopted in the international practice) of Unit 5 to identify the capacity and conditions for long term operation (LTO) and development of

programmes for preparation of Unit 5 for extended operation. After the completion of AMR, A Summarized Report for Comprehensive assessment of Actual Condition and Residual Lifetime of SSCs of Unit 5 of Kozloduy was developed, which summarized the results from the work reports for comprehensive assessment of SSCs considering the results from the assessment of the technical condition, lifetime of SSCs and recommendation for the possibility for lifetime extension of the assessed SSCs. The current report also contains the measures performed by the personnel of Kozloduy within the lifetime extension of Unit 5.

As a result of the performed AMR, Lifetime Extension Preparation Programme of Unit 5 at Kozloduy NPP PLEXDQA- KNPP-0003-02 was developed and coordinated with the Nuclear Regulatory Agency.

2.2.2 Second stage

Implementation of the Units 5&6 Lifetime Extension Preparation Programme

The technical and organizational measures to provide for the operational lifetime of the SSCs were implemented in the period from 2014 to 2017 for Unit 5 include:

- Replacement of the components that have worked out their operational lifetime;
- Additional analyses and justification of the residual lifetime of non-replaceable components;
- Change in the procedures for maintenance, repair and operation of the components in terms of their long-term operation.

There were 245 measures to be implemented by the end of the license period, which are split into five areas, planned for Unit 5:

- Unit 5 mechanical equipment;
- Unit 5 Electrical equipment and I&C systems;
- Unit 5 civil structures and BoP equipment;
- Measures resulting from the comprehensive study and assessment of the residual lifetime of SSCs at Unit 5 for urgent implementation;
- Measures resulting from the comprehensive study and assessment of the residual lifetime of SSCs at Unit 5 for periodic implementation.

For Unit 6 the activities are similar and ongoing in the period from 2016 to 2019(about 220 measures).

2.3 Safety analysis reports

The results from the Unit 5&6 Lifetime Extension Project at Kozloduy NP were used for development of Upgraded Safety Analysis Reports confirming the capability of the plant for extended operation, which were submitted to the Bulgarian NRA as a part of the required documents for license renewal.

3 Conclusion

The term of the license for operation of Unit 5 of NPP “Kozloduy” was renewed in November 2017 (expectations are October 2019 for Unit 6). Originally the Licensee were authorized to operate the Unit 5&6 for another 10 years. All activities and measures of the unit 5 were completed. The

International Atomic Energy Agency has checked and evaluated within several missions the activities to extend the life of the units.

The recent modernization and measures taken to increase safety of the unit provide the duration of the life of the units to be extended to 2047 (2051).