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Title: **KNPS 3rd Periodic Safety Review Final Report (PSR Summary Report: Attachment 3)**

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1. Executive summary

Koeberg Nuclear Power Station (KNPS) conducted its third Periodic Safety Review (PSR) over the period 2019–2021 in fulfilment of its 10-yearly regulatory requirement. The objective of PSR is to ensure a high level of safety throughout the plant's operating life. This PSR also intends to support the KNPS application to extend the operating life, also called Long Term Operation (LTO) of KNPS for 20 years to 2045.

The PSR scope and methodology were conducted in accordance with National Nuclear Regulator (NNR) Regulatory Guide: RG-0028, 'Periodic Safety Review of Nuclear Power Plants' [7]. KNPS produced PSR methodology documents that provide guidance on the scope, and these have been accepted for use by the NNR. The PSR was performed by a multi-disciplinary team comprising Eskom experts, national nuclear experts, and international PSR experts.

The PSR scope was subdivided into a review of 14 safety factors (SFs), which included all important nuclear plant aspects relevant to determining suitability for continued operations, including the additional 20-year LTO period. Each SF was evaluated to identify any gaps (deviations) or strengths (a positive finding). The deviations were graded according to their impact on nuclear safety, utilising established nuclear risk assessment methods. The PSR included a global assessment (GA), which considered the SF outcomes, the cumulative effects of deviations, and the impact of strengths identified. In addition, proposed safety improvements (PSIs) to resolve the deviations were verified, screened, and ranked. This consolidated list of safety improvements was then included and scheduled in an Integrated Implementation Plan (IIP). The IIP was developed so that all safety improvements would be addressed before the start of the KNPS fourth PSR.

The International Atomic Energy Agency (IAEA) performed an independent technical and process review of all PSR documents as part of a technical support review (TSR) agreement with KNPS. The TSR identified, in general, good alignment of the reviewed documentation with the IAEA safety standards. There were areas identified in the KNPS PSR documentation that required further consideration in relation to the IAEA safety standards, and the TSR provided recommendations associated with the areas of consideration. All technical and process review comments, and recommendations from the IAEA TSR have been adequately addressed in the affected KNPS PSR documents.

Overall, it is viewed that the PSR SF reviews and outcomes are deemed to be comprehensive and provide sufficient data for use in the PSR GA process. The GA process provided a balanced view of the cumulative effect of the deviations on the overall level of safety and acceptability of continued plant operation. Although deviations were identified that need to be mitigated or resolved within a reasonable time (in some cases in the short term and before LTO), it was judged that the current risk is acceptable for continued safe operation. No deviations were identified that required an immediate justification for continued operation. In conclusion, the PSR has demonstrated that the plant is suitable for continued operations. The

PSR identified safety improvement actions (contained in the IIP) that are required to maintain risk within acceptable levels, ensure continuous improvement, and support safe operation over the next PSR period and into LTO.

2. Introduction

KNPS is the only commercial nuclear power plant on the African continent. It is located 30 km from Cape Town near Melkbosstrand on the west coast of South Africa. KNPS is owned and operated by Eskom. It consists of two three-loop pressurised water reactors (PWR), each rated to produce ~960 MW of electrical power, which are similar in design to many of the French utility Électricité de France (EDF's) plants. Construction of the plant commenced in 1976, with Unit 1 being synchronised to the grid in April 1984, followed by Unit 2 in July 1985. KNPS has been licensed to operate for 40 years. Following an engineering feasibility study, it was concluded that it is possible to extend the operating life of the KNPS units, and Eskom has applied to the NNR to change its operating licence to 60 years (an additional 20 years of operation). Similar activities have been or are currently being performed by nuclear operators worldwide for stations commissioned in the 1970s or 1980s.

In accordance with the KNPS Nuclear Installation Licence (NIL-01 (Variation 19) [5]), KNPS should conduct a PSR every 10 years. The first KNPS PSR commenced in 1995 and was completed in 1998, when the report was submitted to the NNR for acceptance. The second PSR commenced in 2008 and was submitted to the NNR in 2011. Following the 2011 accident at Fukushima Daiichi Nuclear Power Plant (NPP) in Japan, Eskom performed an extensive External Event Safety Reassessment (EE-SRA). This review was concluded and submitted to the NNR in 2014. These assessments have allowed KNPS to implement significant improvements and remain in line with international standards and regulatory requirements, as they have evolved with time because of technological developments, lessons learnt, and operational experience.

In August 2019, the NNR released the interim regulatory guide, RG-0028 [7], which is aligned with the IAEA Safety Standard Guide, SSG-25, 'Periodic Safety Review of Nuclear Power Plants' [3]. This regulatory guide provides guidance on how to conduct a PSR to meet the requirements stipulated in NIL-01 [5] and R.388 'Safety Standards and Regulatory Practices' (SSRP) [8].

The purpose of this report is to provide a brief overview of the KNPS third PSR and to summarise the key outcomes from the PSR.

3. References, definitions, and abbreviations

3.1 References

[1] IAEA GC(59)/14, The Fukushima Daiichi Accident, Report by the Director-General, 2015

[2] IAEA SF-1, Fundamental Safety Principles, 2006

[3] IAEA SSG-25, Periodic Safety Review for Nuclear Power Plants, 2013

[4] IAEA SSR-2/1, Safety of Nuclear Power Plants: Design, 2016

[5] NIL-01 (Variation 19), NNR Nuclear Installation Licence, 2019

[6] NNR RG-0027, Ageing Management and Long Term Operations of Nuclear Power Plants, Rev. 0, 2019

[7] NNR RG-0028, Periodic Safety Review of Nuclear Power Plants, Interim Regulatory Guide, Rev. 0, 2019

[8] Safety Standards and Regulatory Practices (SSRP) R388, Regulation in terms of Section 36 (read with National Nuclear Regulatory Act), 2014

[9] WENRA RHWG, WENRA Safety Reference Levels for Existing Reactors, 2014

3.2 Definitions

Term	Description
Defence in depth	Defence in depth is an overall safety philosophy that encompasses all safety activities, including the siting, design, manufacture, construction, commissioning, operating, and decommissioning of nuclear power plants.
Design basis accident	A postulated accident leading to accident conditions for which a facility is designed in accordance with established design criteria and conservative methodology and for which releases of radioactive material are kept within acceptable limits.
Deviation	A negative finding to either the national regulations, the KNPS licence or international requirements, or those codes, standards, processes, or practices that are adopted to meet any of those requirements.
Fundamental safety functions	The fundamental safety functions (FSF) to be ensured for a nuclear reactor are defined as: - Reactivity control; - Heat removal; and - Confinement of radioactivity. The FSF are provided by single or combinations of the safety functions.
Fundamental safety principles	A unified set of principles representing a common safety philosophy across all areas of application of the IAEA Safety Standards.
Global issue	A common higher level, cross-functional, underlying issue that results in multiple deviations, potentially in different SFs.
Long-term operation	The operation of a NPP beyond an established time frame set forth by, for example, the licence term, design, standards, licence, and/or regulations, which have been justified by the safety assessment, with consideration given to life-limiting processes and features of structures, systems, and components (SSCs).

Term	Description
Licensing basis	The collection of documents or technical criteria providing the basis upon which the regulator issues a licence to construct or operate a nuclear facility.
Operating experience	Information in various formats (personal knowledge and/or experience, event warning sheets, INPO operating experience, team briefs, etc.) that highlight previous human, technical, procedural, logistical, and/or process deficiencies that contributed to an event.
Periodic safety review	A systematic reassessment of the safety of an existing facility (or activity) carried out at regular intervals to deal with the cumulative effects of ageing, modifications, operating experience, technical developments and siting aspects, and aimed at ensuring a high level of safety throughout the service life of the facility (or activity).
Requirement	A nationally or internationally defined nuclear safety requirement that applies to the KNPS.
Safety factor	A review area defined in RG-0028 [7], assessed in a PSR.
Strengths	A positive finding where good practices are either thoroughly applied or current safety requirements are exceeded.

3.3 Abbreviations

Abbreviation	Description
AMP	Ageing Management Programme
CRDM	control rod drive mechanism
DSSR	Duynefontein Site Safety Report
EDF	Électricité de France
EERI	External Events Response Initiative
EE-SRA	External Events Safety Reassessment
EPRI	Electric Power Research Institute
FSF	fundamental safety function
FSP	fundamental safety principle
GA	global assessment
GI	global issue
IAEA	International Atomic Energy Agency
IIP	Integrated Implementation Plan
INPO	Institute of Nuclear Operations
KNPS	Koeberg Nuclear Power Station

Abbreviation	Description
LTO	long-term operation
NIL	Nuclear Installation Licence
NNR	National Nuclear Regulator
NSA	nuclear safety assurance
OE	operating experience
PSI	proposed safety improvement
PSR	periodic safety review
PTR	reactor cavity and spent fuel pit cooling system
PWR	pressurised water reactor
RPVH	reactor pressure vessel head
SALTO	Safety Aspects of Long Term Operation
SCC	stress corrosion cracking
SF	safety factor
SSC	structures, systems, and components
SSHAC	Senior Seismic Hazard Analysis Committee
WANO	World Association of Nuclear Operators
WENRA	Western European Nuclear Regulators Association

4. Description of performed PSR

4.1 Objectives of PSR

The objectives of the PSR, using a systematic and documented approach, are to determine:

a) The extent to which the licensing basis remains valid, now and for the period of LTO;

b) The extent to which KNPS conforms to modern codes, standards, and good practices, to ensure that the currently adopted codes, standards, and practices are not obsolete and do not pose a nuclear safety risk for KNPS;

c) The adequacy and effectiveness of the nuclear safety-related programmes and the SSCs important to safety to ensure plant nuclear safety until the end of the commercial operation; and

d) Safety improvements to be implemented to resolve any deviations identified in the PSR and provide suitable timelines for their implementation.

The PSR was performed by a multi-disciplinary delivery team that combined Eskom experts, national nuclear experts, and international PSR and safety analysis experts.

4.2 Scope

KNPS compiled procedures that provided the detailed scope and methodology of the third PSR and was accepted by the NNR. The review period for this PSR is from 2009 to 2020.

The scope of the assessment is to review the current nuclear safety status of the plant to determine its suitability for continued operation, including the additional 20-year LTO period. Because of this, the assessment looks beyond the 10-year period considered in a typical PSR into those areas that are required to support the justification of LTO.

The PSR scope is subdivided into a review of 14 SFs, as shown in Table 1. The general scope of the SF review involved assessing the extent to which KNPS complies with current national regulations, codes, and standards, as well as conforms to international codes, standards, and good practices. These regulations, codes and standards, methods, and good practices were detailed in the third PSR scope and method procedures. These documents served as the formal agreement between KNPS and the NNR for the third PSR scope and review methodologies. The PSR scope also included a GA, conducted through various safety analyses of SF identified deviations against current codes and standards, as well as the impact of the strengths on nuclear safety.

The scope of the PSR is restricted to:

- The facilities regulated under KNPS's Nuclear Installation Licence (NIL) [5].
- The SSCs within the scope of the PSR review encompassing the KNPS SSCs important to nuclear safety.
- The nuclear safety-related processes and programmes.
- The organisational and human resource requirements associated with nuclear safety-related aspects.

4.3 KNPS PSR process overview

The KNPS third PSR was conducted in four phases:

i. Preparation

Identifying the PSR scope and requirements (national licensing, international codes, standards, and good practices) and developing the review methodologies agreed with the NNR.

ii. Safety factor review

The PSR considers five subject areas of plant, safety analysis, station performance and use of operational experience, management, and environment. Each area is then subdivided into 14 areas, as listed in Table 1 and referred to as SFs. The SFs identified as focus areas to support LTO application, as required by RG-0027 [6] and RG-0028 [7], are indicated in the last column.

Table 1: PSR safety factors

Subject area	Safety factor		LTO focus
Plant	**SF-1**	Plant design	Yes
	SF-2	Actual condition of SSCs	Yes
	SF-3	Equipment qualification	Yes
	SF-4	Ageing	Yes
Safety analysis	**SF-5**	Deterministic safety analysis	Yes
	SF-6	Probabilistic safety assessment	
	SF-7	Hazard analysis	Yes
Performance and OE feedback	**SF-8**	Safety performance	
	SF-9	Use of experience from other plant and research findings	
Management	**SF-10**	Organisation, the management systems, and safety culture	Yes
	SF-11	Procedures	
	SF-12	Human factors	Yes
	SF-13	Emergency planning	Yes
Environment	**SF-14**	Radiological impact on the environment	

During the SF reviews, KNPS safety-related systems, processes, programmes, and procedures in the SF subject areas were thoroughly assessed against national regulatory and international requirements. Deviations and strengths were generated as a result of the assessment. Deviations were assessed for their impact on nuclear safety. Potential safety improvement recommendations were also identified based on the individual deviations. A strength is a positive finding where good practices are either thoroughly applied or where current safety requirements are exceeded.

iii. Global assessment (GA)

The GA phase determined the level of plant safety and documented the suitability of continued operation until the next PSR, specifically in this third PSR, including the LTO period. This was achieved by having an expert team cross-examine the impact of the deviations and strengths both in terms of an individual and a cumulative impact on plant safety. This was supported by safety assessments relating to FSFs (as outlined in IAEA SSR-2/1, Safety of Nuclear Power Plants: Design [4]), levels of defence in depth (also described in [4]), and IAEA Fundamental Safety Principles (as outlined in IAEA SF-1, Fundamental Safety Principles [2]).

Results from the assessment led to the formulation of global issues that were categorised in accordance with their impact on nuclear safety. A balanced approach was applied to the resolution of the deviations by considering strengths identified during the SF review phase. Other factors considered in developing the resolution included the nuclear safety significance of the deviations, the practicality and effectiveness of available solutions and the organisation's capability to implement a timeous solution. The outcomes of the balanced approach, which includes a ranking of the safety improvements, were then presented in an IIP by documenting each safety improvement and the associated implementation date, while the suitability for continued operations was assessed and documented for submission to the NNR.

iv. PSR final report

This report summarised the key PSR outcomes from the SF reviews and GA. It included the finalised IIP, which was approved and endorsed by relevant Eskom committees to ensure Eskom's commitment to the implementation of the safety improvements. In addition, the document incorporated an assessment of the safety for future plant operation over the period addressed in the PSR. The PSR is concluded when the finalised IIP is accepted by the NNR.

The PSR looks beyond the current and new national regulatory requirements and also identifies new or updated requirements in the latest applicable IAEA Safety Standards and WENRA (Western European Nuclear Regulators Association) document (as described in WENRA Safety Reference Levels for Existing Reactors, 2014 [9]). These are the benchmarking requirements sources used to identify the applicable requirements against which to perform the review.

4.4 KNPS PSR delivery team and logistics

The PSR scope and method procedures provided detailed information on the PSR team and their roles (e.g. PSR project manager, PSR technical lead, the 14 SF review teams, the deviation safety significance grading team, the GA team, etc.). The KNPS third PSR review team is comprised of the following groups:

- KNPS experts in various fields and disciplines
- Eskom-wide engineers
- National nuclear experts
- International nuclear and PSR experts
- Other external support and responsibilities included:
    - The IAEA TSR agreement with KNPS that was responsible for independently reviewing all PSR documentation, including all scoping and methodology documents, SF review reports, and the GA and IIP report.
    - NNR is responsible for the final review of all PSR documentation and its outcomes for acceptance/acknowledgement.

In addition, the PSR methodology specified the logistical arrangements for delivery (e.g. quality management, training, internal and NNR communications, etc.) and the PSR project schedule.

5. Summary of KNPS operation since the last PSR

The last (second) KNPS PSR was submitted to the NNR in 2011.

Over the KNPS third PSR period, the key external operating experience (OE) involved the Japanese Fukushima Daiichi NPP accident in 2011, which is documented in detail in a report by the IAEA Director-General on the accident (IAEA GC(59)/14, The Fukushima Daiichi Accident, Report by the Director-General, 2015 [1]). The reactor units at Fukushima experienced an external event well beyond its design basis, resulting in severe damage to four of the six units that led to a radioactive release into the environment. Following this event, Eskom performed an extensive EE-SRA, focusing specifically on external events. This review was concluded, and the report was submitted to the NNR in 2014. KNPS is currently addressing the deviations found during the EE-SRA (actions are linked to plant modifications and procedures), and significant progress has already been made. Additional mobile diesel generators have been purchased, and modifications have been completed to enable alternate sources of electrical power to supply safety systems. Additional sources of cooling water have also been made available in the event of an emergency.

With regard to internal OE over the PSR period, appropriate performance indicators are established at KNPS, which are based on World Association of Nuclear Operators (WANO) performance indicators, and are adequately utilised to monitor and report on safety performance. Trends of performance indicators have remained stable with isolated incidents, which were appropriately identified, investigated, corrected, and not considered to be of high safety significance. Risk-based indicators illustrate favourable nuclear safety performance over this PSR period.

Some internal OE over the PSR period has included potential risks caused by plant ageing, wear and tear, which in particular has involved the steam generators, containment buildings, certain water storage tanks, reactor pressure vessel heads (RPVH), and control rod drive mechanisms (CRDM). Additional spent fuel storage capacity is mainly required for 60 years of operation. Mitigations and upgrades to resolve these issues are discussed in Section 6.

Monitoring safety performance through self-assessments, quality audits, and surveillances, nuclear safety assurance (NSA) assessments, and external peer reviews is embedded at KNPS. With regard to external peer reviews and information-sharing platforms, participating organisations over the PSR period have included WANO, the Institute of Nuclear Operations (INPO), Électricité de France (EDF). and the Electric Power Research Institute (EPRI). No significant events were identified during this period that challenged KNPS's continued safe operations. The areas for improvement identified from such assessments are captured as corrective actions in the well-developed Corrective Action Programme OE platform and tracked through to completion.

During the PSR period, a number of new regulatory requirements, national, international, and industry safety standards, codes and methods, and operational good practices have been developed or updated. The PSR review identified that even though KNPS has made significant strides in implementing new requirements, there were a few instances where scheduling of the identified benchmark improvements was not prioritised accordingly. For example, the international requirements and expectations to make provisions for external hazards such as severe windstorms and severe earthquakes (more severe than what KNPS was originally designed for) have been enhanced. Historically, KNPS is not exposed to the same level of risk from external hazards because of its geographical location. However, the established international methodology should be used to identify, classify, justify, document, and provide prevention or mitigation measures for all external hazards. While some progress has been made to address external hazards, the remaining outstanding actions to bring KNPS in line with current international norms are included in the IIP.

6. Overview of safety upgrades implemented at KNPS since the last PSR

KNPS has continually improved the plant through upgrades to align it with the latest technological advancements and address issues such as plant degradation, ageing, and wear and tear. Improvements with regard to safety analysis and safety documentation are also periodically undertaken. Notable improvements that have been implemented, were ongoing or were in the project planning phase over the PSR period (2009 to 2020) are discussed below and include:

- The current KNPS steam generators that have been operating since the plant was commissioned. The steam generator tubes are manufactured from Inconel 600. This material is susceptible to stress corrosion cracking (SCC), which the steam generators are experiencing. Therefore, it is causing an increase in degradation, especially at elevated temperatures. The condition of the SG tubes is closely monitored through inspections every refuelling outage to confirm that they are fit for purpose. The steam generators are planned to be replaced in 2023 for both units.
- Installation of super-high-density storage racks in the spent fuel wet storage facility was undertaken to extend the storage capacity of the spent fuel pool for future KNPS operation. Dry storage fuel casks are to be used for the safe removal, transport, and storage of spent fuel older than 10 years. Preparations are being made to increase the number of storage casks and to store these for a longer period in the cask storage building.
- Replacement of the refuelling water storage tanks (PTR tanks) in 2018 for Unit 2 and in 2019 for Unit 1 to address ageing effects in the tank shell.
- Replacement of the Unit 1 RPVH to address ageing effects before the PSR period in 2008. The replacement of the Unit 2 reactor head with the associated control rod drive mechanism is scheduled for 2022.
- Embarking on a significant maintenance and refurbishment of the containment buildings in 2014 by repairing areas of corrosion and delamination on both units. It is also intended to implement an impressed current cathodic protection system into the concrete of the containment buildings to delay the effects of the ocean's chlorine-induced corrosion, which will extend the lifespan of the structures for the foreseeable future.

- Implementation of several mitigating actions to improve the habitability of the control room and to ensure that the risk of unfiltered in-leakage is minimised in the event of an accident with a radiological release. Further modifications and repair work is planned and scheduled for 2022 and 2023.
- Rewinding of the generator stator for Unit 1 in 2012, with the generator stator for Unit 2 rewound before the PSR period in 2008. After years of operation, the main electrical generators developed stator winding problems, such as elevated vibration, build-up of copper oxide and water box leakage.
- Replacing the main turbine control and protection system of both units between 2007 and 2010. The original system had been operating since the plant was commissioned, and KNPS wanted to improve the reliability and maintainability of the system. These systems have a role in nuclear safety by ensuring that the secondary plant responds to the demands of the nuclear plant; for example, by ensuring that the steam is evacuated correctly when required to do so.
- Replacing the plant computer system, which provides continuously visible safety monitoring features to operators, in 2010 and 2011 on both units.
- Commissioning a second full-scale plant operator training simulator, enabling a higher number of engineers and operators to be trained on the design and operations of KNPS to improve competence levels.
- Pressure testing the reactor containment buildings to confirm that they meet design requirements and are leak-tight. The tests are conducted periodically to meet regulatory requirements and were last conducted in 2015 for Units 1 and 2. They both successfully passed the pressure test and the pre- and post-pressure test inspections and were deemed fit for purpose.
- Conducting the KNPS Safety Aspects of Long Term Operation (SALTO) review, conducted in conjunction with IAEA LTO experts. This has been a major ongoing programme of work since the last PSR. This review considers the safety assessment of the ageing management aspects performed at KNPS to achieve the regulatory ageing management requirements and provide assurance for safe LTO. The scope of this review includes both SSCs important to safety and human resources. The programme of work also identified those ageing management-related items of plant to be improved to support LTO.
- Initiated an external events review initiative (EERI) project to implement mitigation strategies to address the deviations from the EE-SRA. This includes providing additional equipment for plant enhancement and hardware modifications to mitigate the impact of accidents that may be caused by severe external events, such as windstorms and earthquakes. Significant progress has already been made, and these modifications are included in the PSR IIP.

- Carrying out significant work over the PSR period to produce an updated site safety report entitled the Duynefontein Site Safety Report (DSSR). The DSSR provides an updated assessment of all aspects of the site characteristics, including external hazards, to extend the original design basis. The outstanding Senior Seismic Hazard Assessment Committee (SSHAC) study for seismic analysis is expected to be completed and incorporated into the DSSR before July 2024. The DSSR will then be submitted to the NNR for approval.

7. Summary of KNPS third PSR outcomes on overall level of safety and acceptability of continued plant operation

The SF reviews assessed all aspects important to nuclear safety against the NNR regulatory requirements and standards and IAEA and WENRA safety standards. SFs classified as important for LTO and managing external hazards were considered focus areas (refer to Table 1). Each SF was evaluated to identify deviations and strengths against the defined criteria or requirements. PSIs were identified to resolve all deviations. Based on all these outcomes, conclusions were drawn on the overall nuclear safety in relation to the scope of the specific SF.

The identified deviations were assessed for their impact on nuclear safety and categorised accordingly. No deviations were identified during the SF reviews that required an immediate justification for continued operation. Most deviations were graded as having low or negligible nuclear safety significance.

The deviation with the highest priority for resolution relates to measures to prevent unfiltered in-leakage to the control room envelope in the unlikely event of a nuclear accident. In gaining a better understanding of the issue, it was determined, during testing, that the rate of unfiltered air into the control room was in excess of allowable limits. The issue was identified in recent years, before the start of this PSR, communicated to the NNR, and several mitigations have already been implemented and further plant modification work planned.

The other deviations considered as priorities for safety improvement implementation are mainly related to the documentation and provision of prevention or mitigation measures for extreme external hazards. These issues were identified in the assessment of recommendations that arose from the global nuclear industry-wide learning that stemmed from the understanding of events at Fukushima Daiichi NPP, and PSIs to address the issues were identified as appropriate.

The remaining deviations were of lesser safety significance and have safety improvements identified to address them but have lower priority.

While deviations were identified that need to be mitigated or resolved within a reasonable time (in some cases in the short term and before LTO), all the SF reviews concluded that the current risk is acceptable for continued safe operation, including the SFs that were focus areas for LTO.

The identified strengths recorded and evaluated across the SF review process related to aspects in plant design, the DSA, probabilistic safety assessment (PSA) and in the use of external OE. No conflicts between the strengths and deviations were identified across the various SFs.

A GA was conducted to determine KNPS's suitability for continued operation until the next PSR and into the period of LTO based on a balanced view of the strengths and deviations, as well as the associated PSIs, identified in the SF reviews. This was achieved by conducting complex and rigorous safety analysis of SF review results and the cumulative effects of deviations and strengths, with due consideration of ongoing work activities at the station.

The safety analyses conducted as part of the GA included the assessment of the impact of the deviations on the key NPP safety features such as defence in depth (D-i-D) [4], fundamental safety functions (FSF) [4], and fundamental safety principles (FSP) [2]. A causal analysis of all the deviations was also conducted. The safety significance of the deviations was verified against the outcomes of the GA safety analyses. Cross-functional themes were grouped into global issues (GIs), with the main theme being the implementation of new international recommendations or requirements from relevant codes, standards, or good practice that were not prioritised accordingly. The GIs were also assessed for their impact on nuclear safety and categorised accordingly.

The PSIs for each of the deviations and GIs were verified, screened, and ranked according to their impact on nuclear safety and prioritised in accordance with the GA analysis results. This consolidated list of safety improvements, where each safety improvement consists of one or more safety improvement actions, was then included and scheduled in the PSR IIP to resolve all deviations and GIs.

A significant portion of safety improvements relates to undertaking further analytical studies and to improving programmes, procedures, and/or processes in readiness for LTO. The safety improvements were confirmed to be reasonably practicable, taking into account all other ongoing safety improvement actions (before completion of the PSR process). KNPS regards safety improvements as necessary to ensure that undue risk to the safety and health of the public and the environment is avoided or mitigated and thus aims to implement the safety improvement actions in a timely manner, commensurate with the safety significance of the deviations.

The IIP was approved by KNPS senior management and submitted to the NNR. The implementation of the actions will be monitored on an ongoing basis.

The safety improvement actions are ranked in the IIP, taking into consideration primarily the safety significance of the deviation and importance for LTO, with high-ranking improvement actions being prioritised. All the deviations have implementable safety improvements, and all safety improvements are scheduled in the IIP to be completed before the start of the next PSR, in accordance with RG-0028 [7].

In addition, the GA draws conclusions with regard to the suitability of continued operation, providing assurance for safe operation over the forthcoming 10 years and into the period of LTO. Inputs for the suitability for continued operation review were derived from the SF review outcomes and the results of the analyses undertaken as part of the GA. Overall, it was assessed that the outcome of the PSR supports the continued safe operation, and LTO is feasible with the implementation of the safety improvements in the IIP.

The PSR scoping, methodology, and review reports were reviewed and verified by the IAEA TSR, which identified good alignment with the IAEA safety standards. The TSR concluded that the scope of review of KNPS PSR documentation was comprehensive and generally followed the recommendations provided in IAEA SSG-25 [3]. There were areas identified in the KNPS PSR documentation that required further consideration in relation to the IAEA safety standards, and the TSR provided recommendations associated with those areas of consideration. All technical and process review comments, and recommendations from the IAEA TSR, have been adequately addressed in the affected KNPS PSR documents.

8. Conclusion

The PSR was performed in compliance with RG-0028 [7] and the NIL-01 [5], utilising the latest national and international standards. The review was performed by a multi-disciplinary team comprised of Eskom experts, national nuclear experts, and international PSR experts.

From the 14 SF reviews, a number of strengths and deviations were identified across several SFs, and during the SF review process, these were assessed to remove duplication and ensure the findings aligned to the PSR requirements. The PSR SF reviews and outcomes are deemed to be comprehensive and provided sufficient data for use in the PSR GA process. The GA process provided a balanced view of the cumulative effect of the deviations on the overall level of safety and suitability of continued plant operation.

Further assessment of the consolidated strengths and deviations as part of the GA process led to identifying a few GIs. Safety improvements were proposed for all deviations and GIs. These safety improvements were verified, screened, and ranked according to the nuclear safety significance of the associated deviation/GI. This consolidated list of safety improvements, where each safety improvement consists of one or more safety improvement actions, was then included and scheduled in the IIP to resolve all deviations and GIs. No deviations were identified that required an immediate justification for continued operation. The IIP was developed so that all safety improvements would be addressed before the start of the KNPS fourth PSR. The safety improvements implementation spans the window from 2022 until before the start of the fourth PSR in 2029. A few of these safety improvements have been scheduled to be implemented in the short term and before entry into LTO.

The PSR methodology and review reports were reviewed and verified by the IAEA TSR, which identified good alignment with the IAEA safety standards.

Based on the systematic and rigorous analyses in the SFs reviews and GA, coupled with detailed technical and process reviews, the outcome of this third KNPS PSR concludes that the continued safe operation of KNPS, including LTO, is supported by the implementation of the safety improvements in accordance with the IIP.