

Steam Generator Replacement Performance Review Report (October 2022)

1. Introduction

Generation initiated the Steam Generator Replacement (SGR) Project together with the approval of the Long-Term Asset Strategy for Koeberg by Board IFC on 31 August 2010. The SGR Project ERA was approved by Board IFC on 11 February 2011. The execution contract for this project was placed with AREVA NP on 05 September 2014, three and a half years later. Group Capital Division was tasked in March 2015 to take this project over from the Generation Division.

The contract value for the placed contract was ZAR 456 025 080 and EUR 269 810 000 with an exchange rate of EUR 1 = ZAR 10.1070 at the time of placing the contract. The form of contract is NEC Option A (Activity Schedule).

The scope of work for this contract is as follows:

- Lot 1 – Design, manufacture, and delivery of six Steam Generators (SGs).
- Lot 2 – Installation design, installation, and commissioning of six SGs.
- Lot 3 – Safety studies and engineering analysis for SG replacement and Thermal Power Uprate (TPU).

The complete interface management between Lot 1, Lot 2, and Lot 3 and within the Lots resides with the contractor.

The planned and contracted installation was contracted for during the outages in March and September 2018, i.e. outages 123 and 223 respectively.

The need for the steam generator replacement stems from the age at concept release approval (CRA) stage (30 years) of the steam generators and the known degradation mechanisms associated with the material (Inconel 600Mill Annealed) used for the manufacture of the heat exchange tubes. Although the condition of the existing steam generators at Koeberg are in good condition for 30 years of operation (0.5% tube plugging), these steam generators form part of a handful of steam generators remaining in operation worldwide with Inconel 600Mill Annealed heat exchanger tubes. This reduced Eskom's access to operating experience of these steam generators beyond 30 years.

With regards to the steam generator replacement project, AREVA NP have experienced forging defects during the forging activities in the Creusot Forge (France) facilities which has resulted in a projected 21-month delay in the delivery of the first set of SG's for unit 1.

The consequence of these delays means that the replacement of the steam generators was no longer possible in March and September 2018 (outages 123 and 223 respectively) and AREVA NP in turn incurred the full delay damages as stated in the contract i.e. 20% of the contract value estimated at R989M (@ €1=ZAR16.8591) at the exchange rate at the time.

The SGR Project was then planned for outages 125 (January 2021) and 225 (January 2022). Unfortunately, the SGs were not replaced during these outages.

The project endured numerous delays since the initiation and approval of ERA Rev.0 in September 2010. The first implementation date was scheduled for outages X21 in FY2015/2016. The following challenges were concluded:

- Significant delays in PFMA approval resulted in delays in the commercial process.
- Metallurgy quality concerns emerged from the SG forging analysis, which required rework on most of the forgings manufactured at Creusot Forge.
- Design deficiencies on the SGs, resulted in the abandonment of the anti-stratification device and the nozzle forgings to be scrapped.
- Poor quality of the overall installation design resulted in the Contractor (Framatome) being unprepared for outage 125.
- Additionally, Eskom's inability to provide supporting facilities during outage 225 would have prolonged the outage. This would have imposed additional risk to an already constraint power grid and therefore increased the risk of load shedding. This ultimately resulted in deferring implementation to outages 126 (December 2022) and 226 (September 2023).

The challenges encountered, resulted in net cost increases and time deferrals to beyond the currently approved ERA costs and timelines. A cost and time revision were therefore required.

2. Executive Summary

Strategic context: The Long-Term Asset Management Strategy to extend the life of Koeberg Power Station (KPS) to 60 years was approved in August 2010 by the Board Investment and Finance committee. The SGR Project is the main enabler in extending the life of KPS. Several decisions were taken along the way which had major impacts and caused significant delays to the project.

Justification: The SG tubes are the most vulnerable part of the SG and are affected by inter-granular stress corrosion cracking. Tube failures provide a direct path of radioactive material releases to the environment. By not replacing the SGs, the tube plugging limits will be reached in 2024 for unit 1 and 2025 for unit 2, the initial 40-year life of Koeberg resulting in shutting down the power station. However, plugging activities have increased recently during outages indicating the need for these replacements.

Scope: To replace six steam generators; three per unit. The scope further involves the provision of supporting facilities to house new and old SGs, as well as other modifications of existing plant components interfacing with the new increased capacity SGs.

Schedule: Implementation of the SGs for unit 1 is currently planned for outage 126, commencing in December 2022. Implementation of the SGs for unit 2 is planned for outage 226, commencing in September 2023. Sufficient time was added in the schedule to allow for defect repairs in the following outages 127 (early 2023) and 227 (late 2024, early 2024).

Financial implications:

- The net cost increase on ERA revision three (3) for the project is R3 594 M (excl. IDC of R1 782 M) and is driven by both cost reductions (-R1 200 M) as well as cost increases (+R4 794 M).
- Contingency is the largest cost driver, and accounts for R3 497 M (73%) of the total cost increases, caused by disputes and claims due to project deferrals and a higher exchange rate. Other increases are due to owner's cost (R535 M) and moving scope not performed by the main contractor to other packages (R735 M).
- The mentioned net cost increase and time extension brings the total project cost to completion to R13 135 M (excl. IDC of R3 978 M and incl. contingency of R5 749 M).

Risks: Readiness of implementing the SGs in outage 126 and 226 due to outage preparation work being delayed. A proper integrated schedule is developed to ensure commitment dates are properly monitored, tracked, and delays mitigated. It will further be used to defend claims and disputes to reduce costs. The owner's team will be sufficiently staffed to oversee implementation and to properly assess disputes and claims.

3. Background History

3.1. Inception to October 2022

The need for the steam generator replacement stems from the age at concept release approval (CRA) stage (30 years) of the steam generators and the known degradation mechanisms associated with the material (Inconel 600Mill Annealed) used for the manufacture of the heat exchange tubes. Although the condition of the existing steam generators at Koeberg are still in a relative good condition after 36 years of operation (0.5% tube plugging), these steam generators form part of a handful of steam generators remaining in operation worldwide with Inconel 600Mill Annealed heat exchanger tubes. This reduced Eskom's access to operating experience of these steam generators beyond 36 years.

Generation initiated this project with the approval of the Long-Term Asset Strategy for Koeberg by Board IFC on 31 August 2010. The Steam Generator Replacement Project ERA was approved by Board IFC on 11 February 2011. The execution contract for this project was placed with AREVA NP on 05 September 2014, three and a half years later.

The contract value for the placed contract was ZAR 456 025 080 and EUR 269 810 000 with an exchange rate of EUR 1 = ZAR 10.1070 at the time of placing the contract. The form of contract is NEC Option A (Activity Schedule).

3.2. Pre-contract: Enquiry leading up to contract formation and signing

On 03 June 2012, the tender process was initiated with the issuance of Expressions of Interest ("EOI") to pre-qualify and establish a short-list of suppliers, who were then invited to submit bids for the steam generator replacement ("SGR") project.

Only two bidders had been found to have met the minimum criteria for the three lots: AREVA NP and Westinghouse.

The ultimate decision maker in respect of the tender was the Eskom Board Tender Committee ("The BTC"), a committee of Eskom's board of directors. At its meeting on 06 February 2013, the BTC determined that it did not have the necessary expertise to deliberate meaningfully on which bid was superior. In March 2013, a Swiss company, AF Consult, was appointed to assist the BTC. It furnished a report to the BTC in August 2013.

On 02 June 2014, the BTC formally approved the composite approach and gave the evaluation team the mandate to negotiate, but not to conclude, a contract with Westinghouse or AREVA NP.

On 12 August 2014, after receiving inputs from, inter alia, Eskom's executive procurement sub-committee ("EXCOPS") and senior management on the outcome of the negotiation process, the BTC decided to award the tender to AREVA NP.

Westinghouse challenged the award and the final judgment was eventually made in the Supreme Court of Appeal. The Supreme Court of Appeal of South Africa judgement was:

"[80] 1 The appeal is upheld, and the cross-appeal is dismissed, in each instance with the costs of three counsel.

2 The order of the court a quo is set aside and replaced with the following:

(a) The application to review and set aside the decision of the Bid Tender Committee of 12 August 2014 succeeds with the costs of three counsel.

(b) The matter is remitted to Eskom Holdings (Soc) Ltd for reconsideration in terms of s8(1)(c)(i) of the Promotion of Administrative Justice Act 3 of 2000."

Cited: *Westinghouse v Eskom Holdings (476/2015) [2015] ZASCA 208 (9 December 2015).*"

3.3. AREVA NP and Framatome

French company NEW NP, the subsidiary of the AREVA NP subsidiary responsible for the AREVA Group's nuclear reactor operations, has been renamed Framatome following its sale to Electricite de France (EDF), Mitsubishi Heavy Industries (MHI) and Assystem. Framatome is the name of the reactor vendor from which AREVA was initially created. Under the agreements, EDF acquired 75.5% of the shares.

The transaction was completed on 31 December 2017. AREVA NP announced on 04 January that NEW NP had been renamed Framatome.

3.4. Programme: Contractor's disregard for the contract programme and planning requirements

To date Framatome has refused to provide Eskom with a programme that meets the basic requirements of the contract i.e. a resource loaded, time and costs measurable schedule. This has resulted in Eskom being unable to quantify the true project performance, or to identify and proactively mitigate risks (evidenced by the monthly schedules received and Eskom responses to the monthly schedules. The last approved Framatome schedule was Rev 32.1 (28 June 2017, Letter reference 4600055123 EC 5015).

Recovery plans are a contractual responsibility when delays are indicated on schedules, as per 32.1 of the NEC contract, however Framatome would not provide these. (example: Letter 4600055123EC 10145_LOT 0_ECC CORE CLAUSE 32.1 - REVISED PROGRAMME - RATE OF PROGRESS noting delays with no recovery observed in subsequent schedules.)

Framatome have not provided a Baseline schedule as requested by Eskom, to be able to compare to the Current schedule submissions. They then do not provide variance explanations and they do not provide recovery plans on variances.

Framatome changes activities and activity identifiers, and in that way the integrity of the schedule is lost (example - the monthly Document Comment Resolution Forms (DCRFs) generated and submitted to Framatome).

The Framatome schedule does not reflect the full scope of work as per the contract. Framatome includes the site work packages and other documentation necessary for final NNR approval. The fact that this is missing from the schedule illustrates that Framatome choose to exclude an item key to measuring installation readiness.

Framatome have continually requested the re-baselining of the programme, to stop the application of the contractual Delay Damages. The Eskom review concluded that there was no basis for the re-baselining of the contract key dates.

Independent reviews confirm Eskom's challenges with the Framatome programme.

SGR Team accepted two of their programmes under pressure from Eskom Corporate but (in the view of the SGR contracts manager) contractually not one of their programmes were acceptable.

As the programmes were never formally accepted by ESKOM, this created confusion when issues were taken for arbitration – the programme could only be used as loose reference but would show the Eskom delays – upon which adjudicators would base decisions, leaving Eskom at a disadvantage.

SGR team efforts to force the contractor to produce a working schedule have failed. This appears to be a long-standing issue within the project, for which a definitive explanation has not been provided.

3.5. Design

Steam Generators (SG) are heat exchangers that enable heat transfer from the primary moderator (reactor coolant system) to the secondary water system to produce steam that drives the turbine-generators to produce electricity. The steam generators are positioned between the primary and secondary coolant loops and are housed within the reactor containment building. Each reactor unit contains three steam generators. The primary water, flowing through the reactor core, flows under pressure through inverted U-tubes in the steam generators, while the secondary water flows over the steam generator tubes to turn into steam. The steam generators form part of the primary pressure boundary as the second barrier against the release of radioactive products. The containment serves as the third barrier.

The SG tubes are the most vulnerable part and are affected by primary water stress corrosion cracking (PWSCC), which is a characteristic flaw of the material used in the tubes' manufacturing; Inconel 600 that was Mill Annealed (MA) compared to thermally treated (TT). Five of Koeberg's SGs are Inconel 600 MA and one SG is TT. Thermally treated tubes are significantly less susceptible to PWSCC than MA tubes and this has been confirmed by Koeberg and International experience. In addition to being affected by PWSCC (initiated from the primary side of the SG), Inconel 600 SGs are also prone to attack of the tube material due to the chemical conditions on the secondary side's feedwater leading to inter-granular stress corrosion cracking (IGSCC). IGSCC has overtaken PWSCC as the dominant degradation mechanism leading to early SG replacement or unit decommissioning. Other degradation issues such as high-cycle fatigue and partition-plate cracking have also been experienced by EDF.

Of all the major accidents analysed, steam generator tube failures are the most frequent. With the degradation of the SG tubes, the nuclear industry has implemented many programs to reduce the incidence of tube failures. Nevertheless, a steam generator tube failure may remain one of the more likely accidents. Such accidents provide a direct release path for radioactive contaminated primary coolant to the environment via the secondary side relief valves. The integrity of the SG's is a Critical Safety Related Function requirement, that will ensure safe reactor operations and satisfy the integrity of the reactor core.

Increased leaks will result in increased plugging, increased maintenance, prolonged radiation exposure and longer outage durations. If the leak rate exceeds the Operating Technical Specification (OTS) threshold, the reactor will be shutdown to Maintenance Cold Shutdown. Direct boratation will be initiated to ensure sufficient shutdown reactivity and stable conditions prior to the isolation of the leaking SG. A study performed by Koeberg in conjunction with the Original Equipment Manufacturer (OEM) revealed that Koeberg will reach its plugging limit by a 40-year life, which is imminent.

3.6. Outage readiness

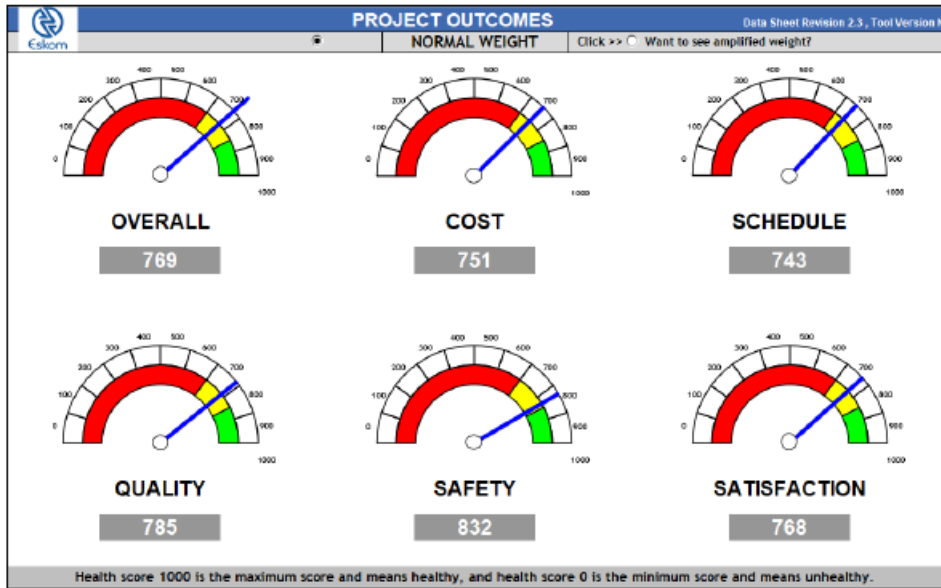
The Chief Nuclear Officer (CNO) received weekly project updates from Nuclear Project Manager (NPM), including SGR in the form of weekly CNO reports. A review of these reports showed that the ongoing issues (CAF design / OSGISF construction / daughter mod designs / National Nuclear Regulator (NNR) approvals / tube sheet buttering) were presented. A number of these items were repeated on the weekly feedback reports, week after week, with no progress. A few cite requires for executive assistance, although it is not clear what form this assistance was expected to take.

The CNO Weekly Report from first week December 2021 show the issues that were still unresolved and brought to the CNO's attention a few weeks before the start date of outage.

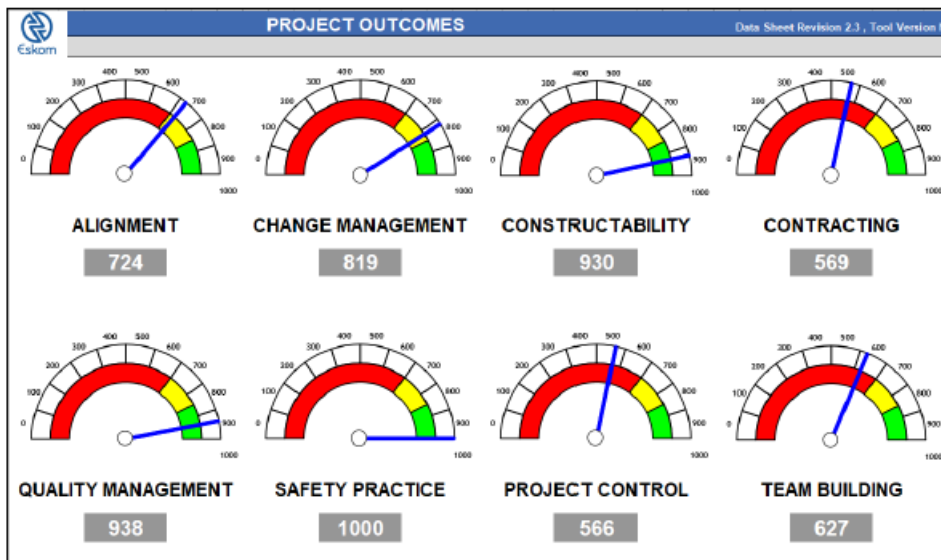
Project Control Systems and Team Building, Contract Administration and Contracting scored below the requirement for the Project Key Health Indicator (PKHI) Tool Report.

This is extremely poor as the project has been in execution for years and 80% of the cost was spent already.

Project Outcomes



Project Practices



3.7. Contractor’s deviation from the standard execution methodology of an ECC3, Engineering & Construction contract

The impasses that resulted from the Contractor’s deviation from the main contractual approach within an NEC3 Engineering and Construction Contract between the Contractor and the Employer’s functions were significant. This included the neglect of the Programme and the circumvention clause 10.1 – “*The Employer, the Contractor, the Project Manager and the Supervisor shall act as stated in this contract and in a spirit of mutual trust and co-operation*”.

The Contractor realised that they will not achieve the contractual dates for outages 123 and 223, it was inevitable that the 20% delay damages would be due to the Employer.

This turned the contract into a loss for the Contractor and their main focus turned to mitigating the financial loss. Initial negotiations failed between the parties to find a compromise.

The Contractor then decided to deploy a strategy to recover funds through Compensation Events.

3.8. Suspension of the three project team members

The decision was taken by CNO in consultation with the Nuclear Engineering Manager (NEM) and the NPM to suspend three project team members.

The basis as stated in the original notification letters (attached) signed by the CNO was as follows:

2. Having regards to:

2.1. The serious nature of the concerns raised around the SGR project.

2.2. The possibility that your presence at work as a senior leader on the project may jeopardize the ongoing investigations.

3. In the circumstances and considering the above and the serious nature of the concerns raised at the Generation Board, Eskom believes it is appropriate to place you on immediate temporary suspension with pay.

The response to one of the team member's reasons why he should not be suspended (part of the Eskom process) contained the following also signed by the CNO:

✓ "I refer to my previous letter dated 06 June 2022 relating to our intention to preliminarily suspend you from your work duties, due to an investigation which needs to be undertaken by Eskom. I have reviewed and taken all your submissions on the reasons why you should not be suspended into account. This letter therefore serves to confirm you that I have taken the decision to finalise of your suspension.

This decision is taken in line with Paragraph 3.2.4 (c) of Eskom's Disciplinary Procedure, EPC 32-1113, Rev 1 and please note that this suspension with pay is not a disciplinary measure, nor an interruption of your service with Eskom."

This stresses the point that the suspension was not a disciplinary measure. The CNO at the time stressed this point when he briefed NEXCO. He felt that some of the previous investigations may have been influenced by the overpowering presence of the three individuals on the SGR team. This is consistent with the reason stated in the suspension letters.

The Public Finance Management Act 1 of 1999 states in Section 51 "...prevent irregular expenditure, fruitless and wasteful expenditure, losses from criminal conduct and expenditure **not complying with the operational policies of the public entity** (subsection 51(1)(b)(ii))".

Eskom's Procurement and Supply Chain Management Procedure (32-1034) set out the defined procedures and guidance on placing and managing contracts. This Procedure

applies uniformly throughout Eskom, its Divisions, wholly owned subsidiaries, and entities wherein Eskom has a controlling interest, which are subject to the provisions of the PFMA.

32-1034 states in 16.1.4.6 Monitor Supplier Performance that “This includes requesting performance evaluation inputs from the CFT the supplier is part of. **Scorecards are generated from performance evaluation inputs and provide insight into various aspects of the suppliers' performance. Meetings are held with suppliers to discuss their performance and action plans for improvement of performance are developed if required.**”

32-1034 Guideline G: Maintaining an Audit Trail states; “The Eskom Agent or Contract Manager must keep a separate contract file containing all relevant documentation, including concurrent notes or minutes of meetings affecting the contract, compensation events and non-conformance reports.” This file and required registers were not available during the CMO contract review.

The process to follow in the case of a modification or increase in contingency value and time is as follows: During the execution phase of the contract, the Contract Manager / Eskom Agent monitors and controls the money spent and time used in accordance with the approvals given by the DAA. a) Once the Contract Manager realises that the contract value and time and / or contingency value and time is near depletion and more contract value and / or time is required or where there is a compensation event / variation order that will deplete the allocated contingency value and / or time, he / she approaches the Procurement Practitioner with a request for a modification to the contract.” Without the monitoring and reporting by the Contracts Manager, this requirement was difficult to be met. This resulted in very short notice for a high value payment.

Many items were not ready and managed by the Project team. The SGR project entered the 225 outage with too many items in contingency space, and ongoing (not yet completed). These included the lead blankets, CAF design and construction, OSGISF construction, HWS design and construction but to mention a few.

Due to the above it results in a misconduct issue rather than a mere poor performance issue. If the Project Manager was responsible for ensuring, as example, the procurement of the lead blankets, was or should have been reasonably aware of the importance/urgency of their timeous procurement and the potential consequences of failing to do so (even without the alleged reminders sent to him), he could be confronted with misconduct charges (most appropriate being either 2.28 – negligence and/or 2.29 – act or omission detrimental to Eskom of attached)

Based on other information in the reports, as well as various other documents, the following misconducts could be considered, however, this decision will only be made upon careful studying of the Generation Board external investigation report currently in the process of finalisation:

- ✓ 2.1 Contravenes or fails to comply with Eskom Conditions of Service, procedures, directives, and applicable statutory requirements.
- ✓ 2.2 Disregards or wilfully fails to carry out a lawful order (instruction) given to him/her by a person authorised to do so.

- ✓ 2.28 Is negligent in the performance of his/her duties.
- ✓ 2.29 Commits an act or omission detrimental to Eskom.
- ✓ 2.30 Makes any false statement or representation that relates to or ensues from his/her duties.