NERSA EVALUATION REPORT FOR ESKOM NORTH WEST OPERATING UNIT – DISTRIBUTION NETWORK PLANNING FOR COMPLIANCE WITH THE GRID CODE REQUIREMENTS

FINANCIAL YEAR 2016/17

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LIST OF ABBREVIATIONS AND ACRONYMS

Capex	Capital Expenditure
CIC	Customer Interruption Cost
COUE	Cost of Unserved Energy
CRA	Concept Release Approval
DPA	Development Planning Approval
DRA	Design Release Approval
FRA	Finalisation Release Approval
GC	Grid Code
HOA	Hand Over Approval
HV	High Voltage
IDC	Interest During Construction
IDP	Integrated Development Plan
IRP	Integrated Resource Plan
km	Kilometre
kV	Kilovolt
kWh	Kilowatt hour
LCC	Life Cycle Cost
LV	Low Voltage
LLCC	Least Life Cycle Cost
LILO	Loop-in Loop-out
MTS	Main Transmission Station
MV	Medium Voltage
MVA	Mega Volt Ampere
NDP	Network Development Plan
NRS	National Rationalised Specification
NERSA	National Energy Regulator of South Africa
NMD	Notified Maximum Demand
NDP	Network Development Plan
NMP	Network Master Plan
NPV	Net Present Value
NW	North West
ODC	Owners Development Cost
OU	Operating Unit
O&M	Operational & Maintenance
Opex	Operating Expenditure
PEM	Project Evaluation Model
PRF	Planning Review Forum
PPI	Producer Price Index
SAIDI	System Average Interruption Duration Index
SAIFI	System Average Interruption Frequency Index

1. OBJECTIVES

The objectives of the audit are to perform an evaluation of the distribution network development of Eskom North West (NW) Operating Unit (OU) with the network development requirements of section 7 of the Distribution Network Code, version 6, applicable for the audit period.

2. BACKGROUND

The National Energy Regulator of South Africa (NERSA) is a regulatory authority established as a juristic person in terms of Section 3 of the National Energy Regulator Act, 2004 (Act No. 40 of 2004) with the mandate to regulate the electricity, piped-gas and petroleum pipeline industries in terms of the Electricity Regulation Act, 2006 (Act No. 4 of 2006), Gas Act, 2001 (Act No. 48 of 2001) and Petroleum Pipelines Act, 2003 (Act No. 60 of 2003).

NERSA is the administrative authority for the South African Grid Code ('the Grid Code') in terms of sections 35(1) and 14(t) of the Electricity Regulation Act, 2006 (Act No.4 of 2006). In accordance with the Act, NERSA shall ensure that the Grid Code is developed, implemented and complied with for the benefit of the industry. The South African Distribution Grid Code applicable at the time of the evaluation was version 6 of 2014.

This financial year, the NERSA Audit Team decided to carry out an evaluation for Eskom NW OU. Therefore, this report covers the resulting findings for Eskom NW OU consistent with the approved NERSA Framework for Distribution Planning Audits.

3. GRID CODE EXEMPTIONS GRANTED TO ESKOM NW OU AND ITS IMPLICATIONS ON THE AUDIT

No exemptions were granted to Eskom Distribution (i.e. Eskom NW OU) by the Energy Regulator with regard to Section 7 of the Distribution Network Code, version 6. No exemptions were applicable to Eskom NW OU during the 2016/17 audit period with regard to Section 7 of the Distribution Network Code from the Network Development Plan where the list of projects were selected for detailed evaluation.

4. AUDIT APPROACH

The audit was conducted in line with the NERSA Framework for Distribution Network Planning Audits approved in 2013. In terms of the framework, the audit is divided into two categories, namely the evaluation of Eskom NW OU's Planning Process documentation and the detailed evaluation of selected projects.

Section 7, the Network Code of the Distribution Grid Code, was used to evaluate the planning and development process for compliance, as prescribed by the approved Framework for Distribution Network Planning Audits.

The audit process was initiated by a request from NERSA for a list of all distribution planning projects developed by Eskom NW OU for the financial year 2016/17. Thereafter, Eskom NW OU submitted to the Energy Regulator a list of all documents that were used in the planning process. These include:

a) Distribution Voltage Regulation and Apportionment Limits;
b) Eskom Methodology for Network Master Plans and Network Development Plans;
c) Geo-based Load Forecasting;
d) Network Planning Guideline for Transformers;
e) Network Planning Guideline for MV Shunt Capacitors;
f) Network Planning Guideline for MV step-voltage regulators;
g) Network Planning Guideline for Electrification Plans;
h) Network Planning Guidelines for Lines and Cables;
i) Network Planning Usage Standard for Tips;
j) Network Planning Reliability Guideline;
k) Network Planning Standard for Electric Motors;
l) Network and Grid Planning Standard for Generation Grid Connection – Generators Technology Overview and Effects on Networks;
m) Project Evaluation Model;
n) Wires Business Project Life Cycle Governance Guideline;
o) Network and Grid Planning Standard for Generation Grid Connection – Examples on Planning Studies;
p) Methodology for identifying MV Constraint Networks;
q) Methodology for Town and Regional Planning; and
r) Planning Guideline for Medium Voltage Underground Cable Systems.

The above planning documents were received together with two NDPs from which a list of projects were selected for detailed evaluation. Two NDPs were received, namely for Mmabatho Zeerust and Marang.

5. ESKOM NW OU'S FRAMEWORK FOR DISTRIBUTION NETWORK PLANNING AND DEVELOPMENT

This section discusses the key components of Eskom NW OU's framework for distribution network planning and development processes. These include (1) the methodology used by Eskom NW OU to compile and analyse projects within its NDPs, (2) the network planning process for project approval, (3) the project phases and approval gates, and (4) the Project Evaluation Model (PEM) used by Eskom NW OU as a tool for project selection on a LCC approach.

5.1 Methodology used by Eskom NW OU to compile and analyse projects within its Network Development Plans (NDPs)

Eskom's Methodology for Network Master Plans (NMPs) and Network Development Plans (NDPs) prescribes the following steps to be followed in the evaluation of each and every project within the NDPs, as shown in Table 1.

Table 1: Steps that are involved in evaluating projects within the NDP, source: Eskom Planning Methodology for NMPs and NDPs, page 18

Step	Activity	Notes
1	Identify problem (includes gathering & analysis data)	Explicitly identify the range of application and its limits. Try to see the problem in terms of the goals and write it down.
2	Determine the goals	This tells you where you are aiming to go. What goals are to be achieved?
3	Identify the alternatives	What alternative solutions are available? This is a critical step. Never assume that one man can see all the alternatives.
4	Evaluate the alternatives	Evaluate all the alternatives on a sound basis.
5	Select the best alternative	Select the best alternative that best satisfies the goals with respect to the problem.

This process is in line with the Least Life Cycle Cost (LLCC) approach that emanates from Section 7.2.1(4) of the Distribution Network Code ('the Grid Code') which specifically states that the investment choice must be justified by considering technical alternatives on a LLCC approach. LLCC is the discounted least cost option over the lifetime of the equipment, taking into account the technical alternatives for investment, operating expenses and maintenance.

Eskom NW OU uses this methodology for the development of its NMPs and NDPs. This methodology describes the process to be followed when compiling and analysing the projects within NDPs and NMPs.

The NDPs are aimed at providing a uniform approach to the development of the High Voltage (HV) and Medium Voltage (MV) distribution networks within Eskom NW OU. It provides a more detailed plan for the supply area under study. It is driven by the load growth, equipment and refurbishment needs, and reliability of supply requirements to achieve compliance with NRS048. It also provides the technical requirements for network extensions in response to load growth or network refurbishment requirements, and to comply with the requirements of the South African Grid Code.

The NMP includes the 20-year load forecasts and details the future state of the network given a wide range of possibilities and alternatives. It is therefore a fluid assessment based on assumptions that are available at that time to indicate the long-term development needs.

5.2 Eskom NW OU's network planning process for project approval within the NDP

Eskom NW OU's network planning process for project approval comprises of seven steps used to conduct a detailed network planning. It is a holistic approach and addresses all aspects of Eskom distribution network infrastructure planning, including the bulk supplies to support the national electrification drive. Figure 1 illustrates a high-level planning processes involved in order to make sure that adequate network capacity is available to supply the anticipated load demand.

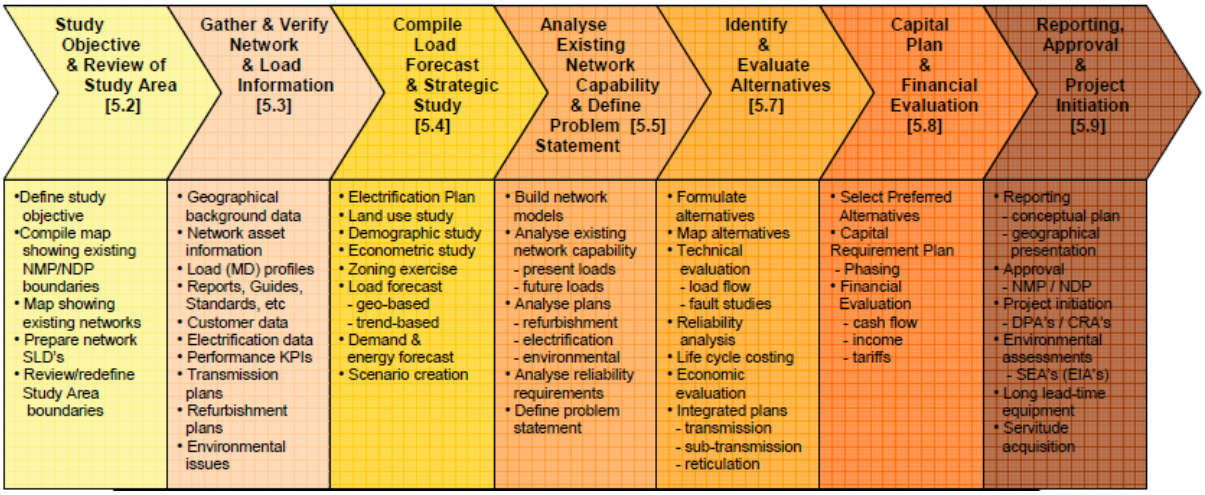

Figure 1: Eskom NW OU planning process for project approval, source: Eskom Planning Methodology for NMPs and NDPs, page 28

Figure 1 outlines the requirements for approval of NMPs and NDPs through the process called Development Planning Approval (DPA), including project initiation for the release of projects into Eskom's business through the process called Concept Release Approval (CRA). Figure 1 also outlines the identification of long lead-time equipment, environmental assessments and servitude acquisition.

5.3 Project phases and approval gates up until the project is commissioned

Projects undergo different life cycles until they are commissioned and finalised. This project life cycle has four phases, which include:

a) Concept phase;
b) Definition phase;
c) Execution phase; and
d) Finalisation phase.

Each of these phases have gate-keeping approval processes that are applicable to the Eskom NW OU's governance and divisional management structures authorised to allocate additional resources, approve additional financial investment, and take on additional risk for projects. The following are the five gates of the project life cycle:

i. Concept Release Approval (CRA);
ii. Design Release Approval (DRA);
iii. Execution Release Approval (ERA);
iv. Handover Approval (HOA); and
v. Finalisation Release Approval (FRA).

Figure 2 summarises the project life cycle and the different high-level deliverables per phase.

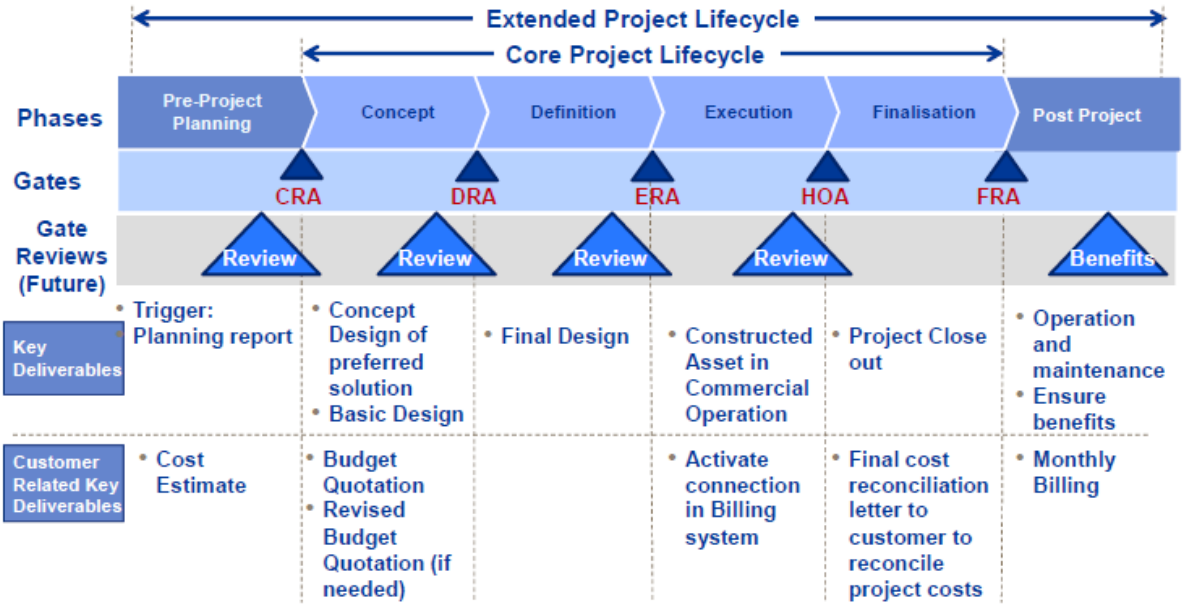

Figure 2: Project life cycle and the different high-level deliverables per phase, source: Eskom Wires Business Project Life Cycle Governance Guideline, page 14

The gate review process ensures that the various elements and work packages, of which deliverables for a specific phase consist, are reviewed and signed off as a prerequisite for investment approval, in a formal manner.

However, the NDP is regarded to be at a pre-project planning stage. Meaning that all of its projects haven't undergone gate-review processes, as they are still under the DPA. The DPA is actual a summarised process on a DPA form that is presented to the Planning Review Forum (PRF) for the identified projects to be approved. The outcome of the DPA form results in the development plan (for Eskom-related projects) or a planning report (customer-related or emergency projects).

In conclusion, the production of NDPs is a complex process of obtaining information, analysing it, and ultimately using it to make capital investment decisions. The process of compiling a detailed NDP is different from the process of compiling a summary planning report (essentially an 'expanded' Executive Summary), which is solely compiled for management to make sound capital investment decisions (i.e. mainly for the Engineering Manager, Network Services Manager, Capital Programme Manager, Electricity Delivery Manager and Field Services Manager).

5.4 Project Evaluation Model (PEM) used as a tool used by Eskom NW OU to select projects on a LCC approach

Section 7.2.2(1) of the Grid Code requires a Licensee to make prudent investment decisions using a LLCC approach. Eskom has developed a Project Evaluation Model (PEM) as its tool to provide comparative life cycle costs of multiple project alternatives.

PEM provides the comparative Life Cycle Costs (LCCs) of multiple project alternatives. The calculation of LCC includes the following key elements, namely the acquisition costs, technical losses, operation & maintenance costs, and disposal costs. Table 2 provides a snapshot of the result's section on the PEM.

Table 2: Snapshot of the result's section on the PEM

	Alternative 1	Alternative 2			Do Nothing
NPC Acquisition	R 0	R 0			-
NPC Losses	R 0	R 0			R 0
NPC O&M Scheduled (exc Energy)	R 0	R 0			R 0
NPC O&M Unscheduled	R 0	R 0			R 0
NP Disposal Cost / Value	R 0	R 0			R 0
Life-Cycle Cost to Eskom	**R 0**	**R 0**			**R 0**
NP Customer Interruption cost	R 0	R 0			R 0
Life-Cycle Cost to Eskom & Customers	**R 0**	**R 0**			**R 0**

Table 2 shows the different project alternatives that the PEM compares, including the 'do nothing' option. These options are compared in terms of an LCC approach and the best alternative is chosen for project implementation.

6. EVALUATION OF ESKOM NW OU'S FRAMEWORK FOR DISTRIBUTION NETWORK PLANNING AND DEVELOPMENT

The previous section of this report highlighted the planning processes that Eskom NW OU uses to identify the need to invest, which is firstly decided on technical grounds and thereafter justified on an LCC approach.

The NERSA Audit Team conducted an evaluation of Eskom NW OU's planning processes to check if Eskom NW OU follows its own processes and to identify gaps for improvement.

The framework for distribution network planning and development processes was evaluated by the NERSA Audit Team. They identified the following key components for improvement: (1) NDPs, (2) Process for project approval, and (3) PEM as a tool used to select best project alternative.

6.1 Evaluation of NDPs

Audit Findings:

Eskom NW OU does not produce detailed NDPs as prescribed by its methodology for the development of NDPs and NMPs. It actually produces an Executive Summary of NDPs that are meant for Eskom NW OU management (i.e. mainly for Engineering Manager, Network Services Manager, Capital Programme Manager, Electricity Delivery Manager and Field Services Manager) in order for them to make sound capital investment decisions.

These executive summaries do not promote a clear understanding of the network issues, alternatives considered and the motivation as to why those projects that were selected as solutions within the NDP. Even in literature, a detailed report is produced before an article or a journal is produced, which is then regarded as the executive summary of the actual report.

The Executive Summary of NDPs also posed many challenges to the NERSA Audit Team and may also pose similar challenges in terms of understanding when they are requested by customers. According to Section 7.1(4) & Section 7.1(5) of the Grid Code, the NDPs shall be made available to customers and to NERSA on request.

6.2 Recommendations on the NDPs

The NDPs should be clear and be easy to understand. Each project within the NDP should have identified problems, determined goals, identified alternatives, evaluated alternatives, and the best selected alternative. This process should be concluded before another project commences.

6.3 Eskom NW OU Management's response on audit findings

The response by Eskom NW OU Management is summarised in Table 3.

Table 3: Eskom NW OU Management response

Finding	Management response on the finding
• Eskom NW OU should improve the way it writes its NDPs. The NDPs should be detailed enough to allow someone reading the report for the first time to have a clear understanding of the subject matter.	• Finding is accepted. Management has already resolved to replace NDP summary documents with full NDP documents.
Management Action Plan to correct the findings	• Full NDP document procedure implemented.
Responsible Person	Mduduzi Msibi
Action Date	Completed

6.4 Evaluation of the process for project approval

Audit Findings:

The audit found that Eskom NW OU has in place the approved processes and procedures required for effective distribution network planning to ensure compliance with the provisions specified in the Grid Code.

However, these processes and procedures are not followed extensively as Eskom NW OU excludes all refurbishment projects from the planning process as depicted in Figure 1. More precisely, there is a thin line between choosing a refurbishment project and a strengthening project. A refurbishment project may recommend the replacement of a transformer with one of the same size, but if the planning processes have been followed, it might recommend that the old transformer be replaced with the one of a larger size as the load forecast of the area predicts growth in the area. This then becomes an oversight on Eskom NW OU's side as all of its refurbishment projects miss this opportunity to make informed technical and prudent investment decisions.

6.5 Recommendations

Eskom NW OU should improve on the correct implementation of its approved processes and procedures required for effective distribution network planning to ensure compliance with the provisions specified in the Grid Code. More

specifically, the refurbishment projects should consider the future load forecast of the study area to determine whether a project should be initiated as a refurbishment project or as a strengthening project.

6.6 Eskom NW OU Management's response on audit findings

The response by Eskom NW OU Management is summarised in Table 4.

Table 4: Eskom NW OU Management response

Finding	Management response on the finding
• Eskom NW OU should use the same process to evaluate its projects, including refurbishment projects, which at this stage are being excluded from following the same process as defined by the methodology for NMPs and NDPs.	• Refurbishment projects are identified by the Plant Department after evaluating the condition of the plant in question. • The refurbishment plan for the area under the planning review is then integrated into the NDP process for assessment. Should any strengthening and / or reliability conditions be identified during this process, then the categorisation of the "refurbishment project" may change, depending on the pre-eminent need identified during this process. Should no additional needs be identified, then the project will continue to be handled as a refurbishment project. Refurbishment projects are considered as part of the NDP process and are thus integrated as per the defined methodology for the creation of NMP's and NDP's. These projects don't follow the same process as strengthening projects due to the fact that it's replacement of like with like.
Management Action Plan to correct the findings	• Existing process and procedures for project identifications will be followed.
Responsible Person	Mduduzi Msibi
Action Date	Continuous

6.7 Evaluation of PEM used as a tool for selecting the best project alternative

Audit Findings:

Eskom's PEM is inconsistent with Section 7.2.1(4) of the Grid Code in that the Grid Code requires a Licensee to make prudent investment decisions using the LLCC approach, where Eskom's PEM uses LCC approach.

The LLCC is different from LCC in that the LLCC is the discounted least cost option over the lifetime of the equipment, taking into account the technical alternatives for investment, operating expenses and maintenance, whereas the LCC is used to evaluate differences in costs and the timing of costs between alternative projects. LCC is not recommended for economic evaluation to decide whether to accept or reject an investment because it provides no frame of reference for what are acceptable and unacceptable costs. Basically the LCC approach does not include all relevant costs to execute project alternatives.

This conflicting definition of what is a least cost in terms of ranking projects for Eskom NW OU actually emanates from page 23 of Eskom's Planning Methodology for NMPs and NDPs. The definition in the Eskom's methodology creates a scenario in which alternatives cannot be quantified using costs. This deviates from the notion of the LLCC, which promotes least cost and the inclusion of all relevant costs involved in a project.

Therefore PEM in its current form excludes most of the relevant Capital Expenditure (Capex) and Operational Expenditure (Opex). More specifically, the LCC approach does not indicate all the relevant costs involved to execute either of the evaluated alternatives. Reason being that it excludes land and rights costs, engineering costs, commissioning costs. Interest During Construction (IDC) is one of the biggest costs that is used to determine the prudency and efficiency of this project planning exercise. Therefore if PEM was able to indicate what will be the duration for constructing both alternatives and the associated IDC costs for both alternatives, then that can give a clear indication in terms of taking a prudent investment decision as Eskom NW OU still needs to service the debt while assets are being constructed.

Further to that, it is correct to exclude Overheads and IDC under Capex, but these costs should not be excluded completely in the PEM as they form part

of decision-making in order to choose the best alternative on the basis of the LLCC.

6.8 Recommendations on PEM

It is recommended that PEM should include the following additional costs:

a) **Owners Development Cost (ODC)/Overheads:** ODC refers to the internal Eskom NW OU resource costs that are allocated to the project i.e. project management, engineering, quality assurance and so forth. It also includes cost directly related to the commissioning of a substation or a line.
b) **Interest During Construction:** Interest during construction refers to allocation of interest/borrowing cost to a project during the construction phase.
c) **Escalation cost:** This is a cost normally catered for fluctuations on the long lead material like transformers. Long lead material is normally affected by fluctuations in the Producer Price Index (PPI) as it is copper intensive material.
d) **Any other relevant costs:** This may include the cost to secure servitudes, wayleave, and land & rights.

6.9 Eskom NW OU Management's response on audit findings

The response by Eskom NW OU Management is summarised in Table 5.

Table 5: Eskom NW OU Management response

Finding	Management response on the finding
• Eskom NW OU should improve its PEM to include other relevant Capex and Opex costs.	• The PEM implementation by Eskom was based on the understanding that its methodology as presented to NERSA was accepted. Management is willing to improve the PEM and consider other factors to be evaluated, after consultation with NERSA and other stakeholders.
Management Action Plan to correct the findings	• Meeting will be arranged between Eskom and NERSA to further improve the PEM applicability, and other components that might be included on PEM tool to improve the selection of options.
Responsible Person	Kurt Dedekind/Mduduzi Msibi/Barend van der Merwe/Ahilan Kaisalinathan
Action Date	December 2018

7. DETAILED AUDIT SCOPE

This section presents the detailed inner workings of the projects that were evaluated in terms of compliance with Section 7 of the Distribution Network Code, version 6.

The evaluation process was initiated by a request from NERSA for a list of all Eskom NW OU's distribution projects approved in the 2016/17 financial year, from which five projects were selected as representative for a detailed evaluation. Subsequent to that, the evaluation process took the form of a 'desktop evaluation' followed by a series of interactions with Eskom NW OU Distribution Planners for discussion and clarification.

The selected projects for detailed evaluation include:

7.1 **Gopane-Dinokana 22kV Feeder Split Project** – this is a strengthening project which is aimed at improving the reliability of supply by providing back-feeding should the Gopane-Dinokana 22kV breaker trip. The estimated total project cost is R1.9 million.

7.2 **Mafikeng main 88/33/11kV Substation Refurbishment Project** – this is a refurbishment project which is aimed at replacing old substation equipment due to unsafe operating conditions, outdated equipment, and spares no longer being available. The estimated total project cost is R16.5 million.

7.3 **Marang-Matte Smelters 88kV Line Project** – this is a strengthening and reliability project which is aimed at solving overloading problems under n – 1 conditions. The estimated total project cost is R46.5 million.

7.4 **Straatsdrift Switching Station Project** – this is a strengthening and reliability project aimed at solving the voltage and loading problems of the Zeerust 88kV network. The estimated total project cost is R25 million.

7.5 **Vryburg Road Substation Strengthening Project** – this is a reliability and refurbishment project which is aimed at solving the reliability and ageing equipment for the Vryburg Road 33/22/11kV substation. The estimated total project cost is R43.4 million.

The evaluation matrix was used as a background document as well as a yard stick in the assessment of the level of compliance of Eskom NW OU with the Grid Code.

8. DETAILED EVALUATION FOR THE FIVE SELECTED PROJECTS

In addition to the detailed evaluation covered in this section, the evaluation matrix as per the approved Framework for Distribution Network Panning Audits was used to check the level of compliance.

The evaluated projects are presented in the following order:

- Gopane-Dinokana 22kV Feeder Split Project;
- Mafikeng main 88/33/11kV Substation Refurbishment Project;
- Marang-Matte Smelter 88kV Line Project;
- Straatsdrift Switching Station Project; and
- Vryburg Road Substation Strengthening Project.

9. EVALUATED PROJECT NO.1 – GOPANA-DINOKANA 22KV FEEDER SPLIT PROJECT

9.1 Project description

The Gopane-Dinokana 22kV feeder emanates from Gopani Mine 2x20MVA, 88/22kV substation, which has four feeders namely Gopane-Dinokana 22kV feeder, Gopane-Khunotswana 22kV feeder, Gopane-Radikhudu 22kV feeder, and Gopane-Motswedi 22kV feeder. The Gopani Mine substation is currently loaded at 10.2MVA and its customer base is dominated by electrification projects.

Gopane-Dinokana 22kV feeder supplies 5 846 customers on its 22kV network that is 87km long. This 22kV feeder does not have a back-feeding network that can be used to supply these customers in case of an outage. Also, the length and the high number of customers connected to this feeder is affecting the system average interruption duration index (SAIDI) and system average interruption frequency index (SAIFI) performance targets as the customer numbers are higher than allowed as per the Eskom Reliability Guideline.

The solution to this problem will be to reduce the number of customers at the Gopane-Dinokana 22kV feeder as the electrification customers are anticipated to grow to over 6 000. This will be achieved by splitting the Gopane-Dinokana 22kV feeder, creating interconnectors in some parts of the network and creating normally-open points in some other parts of the network.

Figure 3 shows the existing geographic network around the Gopane-Dinokana 22kV feeder and the proposed solution.

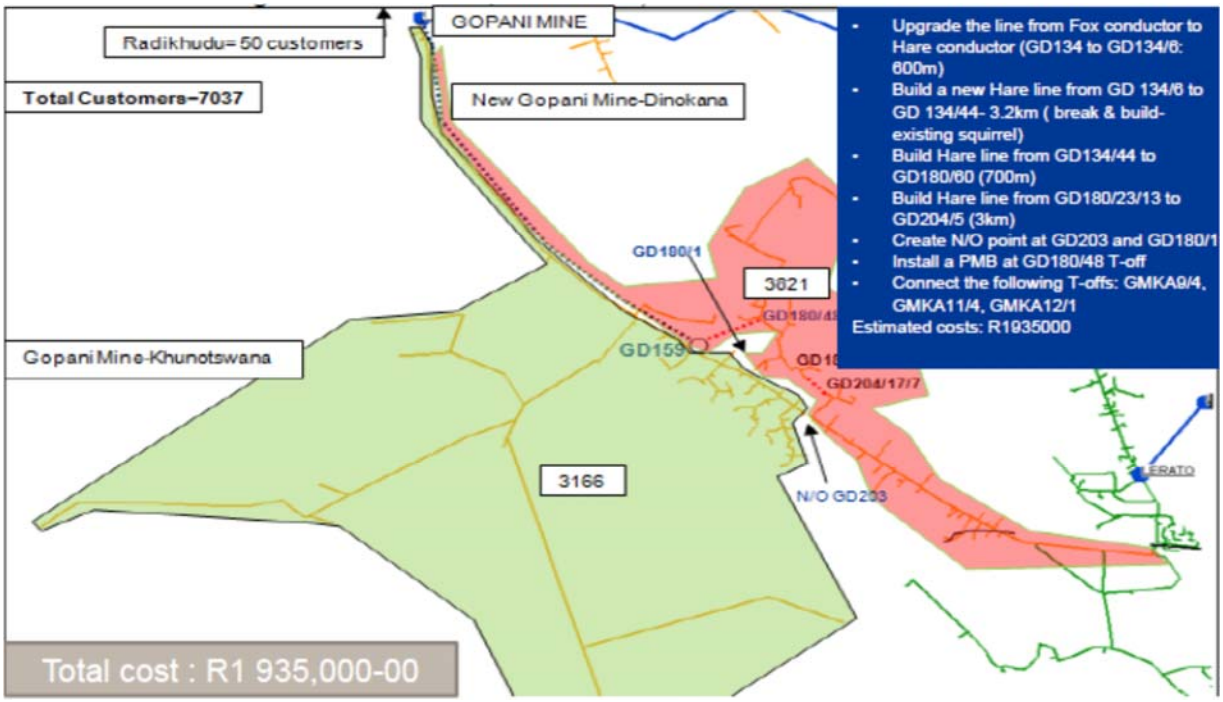

Figure 3: The existing geographic network around the Gopane-Dinokana area of study

This project is classified as a shared network investment in terms of section 7.2.3 of the Grid Code and the following sections of the Grid Code were not applicable for this project:

- Section 7.2.4;
- Section 7.2.5;
- Section 7.2.6;
- Section 7.2.7; and
- Section 7.3.

9.2 Alternatives considered

Audit Findings:

The following technical options were considered as options to solve the back-feeding problem, long line length, SAIDI and a high number of customers on the Gopane-Dinokana 22kV feeder:

- Option 1: The first option entails splitting the Gopane-Dinokana 22kV feeder by creating a normally-open point at pole number GD202, creating an interconnector from pole number GMKA137 to pole number GD134, and building a new 1.8km overhead line from pole number GD134 to pole number GD202. This option will have a total project capital cost of R1.5 million.

- Option 2: The second option involves splitting the Gopane-Dinokana 22kV feeder by creating T-offs at pole numbers GMKA9/4; GMKA11/4; and GMKA12/1, creating line interconnections, upgrading specific sections of the network from Fox conductor to Hare conductor and installing a pole-mounted breaker. This option will have a total project capital cost of R1.9 million.

Option 2 is the preferred option because it reduces the over-reliance of most customers on the Gopane-Dinokana 22kV feeder, it puts the SAIDI targets within the acceptable limits, and it reduces line losses on the network.

However NERSA's analysis based on the information provided by Eskom NW OU shows that option 2 is not the best option because of its higher capital cost, as well as higher scheduled and unscheduled O&M.

9.3 Cost/benefit analysis of the preferred option

Audit findings:

The estimated total project cost for the preferred option is R1.9 million compared to the other option of R1.5 million. The cost benefits of the preferred options are that it is more efficient as it results in lower line losses over the life of the network.

However the above reasoning by Eskom NW OU is misleading in that option 1, which was not chosen as the best alternative, has a lower capital cost as well as less scheduled and unscheduled operating and maintenance (O&M). This is also based on the fact that the preferred option omitted the inclusion of the labour and material cost for the following T-offs GMKA9/4, GMKA11/4 and GMKA12/1.

9.4 Technical evaluation of the preferred option

Audit findings:

The preferred option will resolve the problem of the high number of customers, which are currently sitting at 5 846 on the Gopane-Dinokana 22kV feeder, which is 87.1km long. The line losses will also be reduced from a calculated value of R8.6 million to R3.3 million.

However the PEM have provided controversial results by arriving at the same Customer Interruption Cost (CIC) of R3.5 million on both options, while the preferred option has higher scheduled and unscheduled O&M costs.

NERSA's analysis shows that option 1 should have been chosen as the preferred option because of its lower capital cost, and lower scheduled and unscheduled O&M costs. It is contradictory for option 2 to have lower line losses while it will experience higher scheduled and unscheduled O&M. Also, creating an interconnector from pole number GMKA137 to pole number GD134 provides the same back-feeding as the preferred option 2. This will then reduce the line losses as this feeder will have a parallel connection (i.e capable of back-feeding) and result in a lower LCC when compared to option 2.

9.5 Evaluation of the Least Life-Cycle cost

Audit findings:

All technically viable options were evaluated on the basis of the LCC approach.

According to the PEM, the preferred alternative resulted in an LCC of R8.8 million whereas the alternative resulted in an LCC of R10.4 million. Both assumed a project life expectancy of 25 years.

The costs used to arrive at an LCC for both options include the acquisition costs/Capex, technical losses, O&M costs (O&M after the plant is commissioned) and CIC.

However this LCC approach does not indicate all the relevant costs to execute either of the evaluated alternatives. It excludes land and rights costs, engineering costs, and commissioning costs. IDC is also one of the biggest cost that is used to determine prudency and efficiency of this project planning

exercise. More precisely, if PEM was able to provide what the duration for constructing both alternatives would be and the associated IDC costs for both alternatives, it would give a clear indication in terms of taking a prudent investment decision as Eskom NW OU still need to service the debt while assets are being constructed.

It is correct to exclude Overheads and IDC under Capex, but these costs should not be excluded completely in the PEM as they form part of the decision-making in order to choose the best alternative on the basis of the LLCC.

In conclusion, PEM in its current form does not indicate all the relevant cost involved to execute the evaluated alternatives in order to make a prudent investment decision and prove that the preferred option is the least cost planning option.

9.6 Evaluation of Economic and Financial Parameters

Audit findings:

Eskom NW OU used the approved discount rate of 7.8 per cent, but it did not use approved values of the Cost of Unserved Energy (COUE) which are either R77.30/kWh for Total COUE or the Direct Economic COUE of R21.63/kWh. These are the COUE values that were approved by the Energy Regulator on 29 October 2015, which were supposed to be used by Eskom NW OU when it approved its planning proposal on 30 November 2016.

The R77.30/kWh is a value used at a country level as a critical parameter in determining the optimum supply system adequacy for the purposes of power system planning (generation expansion or IRP, transmission and distribution) but not for individual project planning.

Eskom NW OU used the COUE value of R3.13/kWh instead of using the approved value of R21.63/kWh, which is a value used for distribution system planning where there are no major impacts. For example, if a planner checks the impact of a rural feeder or an informal settlement.

It is not clear why Eskom NW OU deviated from the approved values that Eskom submits annually to the Energy Regulator for approval and used its own unapproved values as shown in Table 6.

Table 6: Unapproved COUE values used by Eskom NW OU for Gopane-Dinokana Project

Customer Type	R/kWh
Industrial/Mining	27,58
Commercial	21,48
Agricultural/Rural	6,31
Residential	3,13
Traction	1,69

In conclusion, Eskom NW OU is compliant with Section 7.2.1(6)(a) of the Grid Code but did not comply with Section 7.2.1(6)(b) of the Grid Code.

9.7 Summary of audit findings: Gopane-Dinokana 22kV Feeder Split Project

The compliance with the relevant sections are illustrated in Figure 4 below.

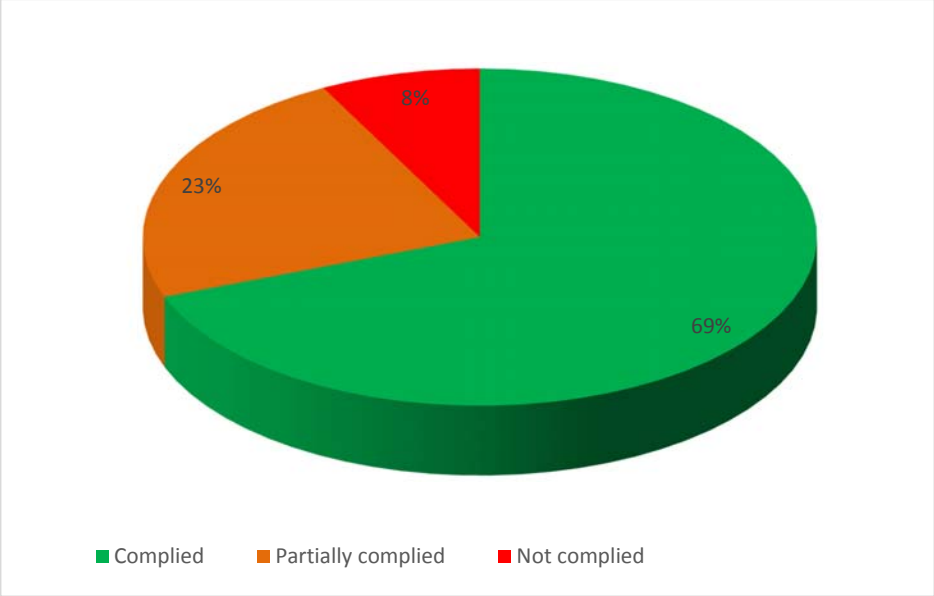

Figure 4: Summary of audit findings for Gopane-Dinokana 22kV Feeder Split Project

The section of the Grid Code requirements that Eskom NW OU did not comply with on this project are as follows:

- **Section 7.2.1(6) of the Grid Code:** The following key economic and financial parameters shall be determined by a NERSA approved process: cost of unserved energy (COUE).

Furthermore, Eskom NW OU complied partially with the following sections of the Grid Code requirements in this project:

- **Section 7.2.1(2) of the Grid Code:** The Distributor shall invest in the Distribution System when the required development meets the technical and investment criteria.
- **Section 7.2.1(4) of the Grid Code:** The investment choice must be justified by considering technical alternatives on a least life-cycle cost approach.
- **Section 7.2.2(1) of the Grid Code:** Investments should be prudent (that is justified) as a least life-cycle cost solution.

9.8 Recommendations

- Eskom NW OU should use the NERSA-approved values for the COUE.
- PEM should be improved in order to estimate all the relevant costs involved to execute the evaluated alternatives after those alternatives have met the technical requirements. PEM in its current state omits many relevant costs in order to be sure that the preferred option is the least cost alternative as the Grid Code promotes the least cost planning.
- Eskom NW OU should improve the content of its NDPs as it is too summarised to enable someone who is not involved in the daily planning of Eskom NW OU's network to understand the network problems and the solutions thereto. The executive summary of NDPs as presented by Eskom NW OU to the NERSA Audit Team are only meant for Eskom NW OU's management (i.e. mainly for Engineering Manager, Network Services Manager, Capital Programme Manager, Electricity Delivery Manager and Field Services Manager) to make sound capital investment decisions as detailed in Eskom Planning Methodology for NMPs and NDPs.

9.9 Eskom NW OU Management's response on audit findings

The response by Eskom NW OU Management is summarised in Table 7.

Table 7: Eskom NW OU Management response

Finding	Management response on the finding
• Eskom NW OU did not use the approved values of the COUE by the Energy Regulator.	• Finding accepted. Care will be taken in future to ensure that the COUE values as approved by NERSA are updated on PEM timeously.

• Eskom NW OU did not include some of the costs related to the build of the following T-offs: GMKA9/4, GMKA11/4 and GMKA12/1. • Eskom NW OU did not include IDCs, and Overheads/Owners Development Costs in the calculation of the LLCC. • Eskom NW OU did not demonstrate how the high unscheduled O&M will result in lower CIC as this is not possible in the calculation of the LLCC.	• Management accept the finding that 240m of T-offs for road crossings were omitted on the costing. The total costs of this work including labour amounts to R150k which does not change the outcome of PEM significantly and option 2 is still preferred. • The PEM implementation by Eskom was based on the understanding that its methodology as presented to NERSA was accepted. Management is willing to improve the PEM and consider other factors to be evaluated, after consultation with NERSA and other stakeholders. • A process to ensure that PEM results are checked by an investment specialist or Network Planning Manager is in place.
Management Action Plan to correct the findings	• Management will strive to use latest approved values by NERSA at all times. • A process to ensure that PEM results are checked by an investment specialist or Network Planning Manager is in place. • Meeting will be arranged with NERSA to further improve the PEM applicability and other components that might be included on the PEM tool to improve the selection of options.
Responsible Person	Kurt Dedekind/ Mduduzi Msibi/ Barend van der Merwe / Ahilan Kailasanathan.
Action Date	December 2018

10. EVALUATED PROJECT NO.2 – MAFIKENG MAIN 88/33/11KV SUBSTATION REFURBISHMENT PROJECT

10.1 Project Description

Mafikeng main 88/33/11kV refurbishment substation project has 2x20MVA, 88/11kV transformers and 1x20MVA, 88/33kV transformer. The substation has an installed capacity of 60MVA and only has a 20MVA firm capacity on the 88/11kV transformer and a capability of back-feeding through the Mmabatho Main 88/33/11kV substation.

The main problem facing the Mafikeng Main 88/33/11kV substation is that it has ageing equipment. Its transformers were manufactured in 1986 and its 11kV breakers are old with an outdated equipment, which makes it very difficult to operate as the spares required to perform repairs are no longer available.

The incident report also indicated that one of the indoor 11kV breakers had exploded, putting the lives of the technicians at risk. Therefore a need was identified to implement a refurbishment project in order to replace the dilapidated equipment.

Figure 5 shows the existing network configuration for Mafikeng Main 88/33/11kV substation study area.

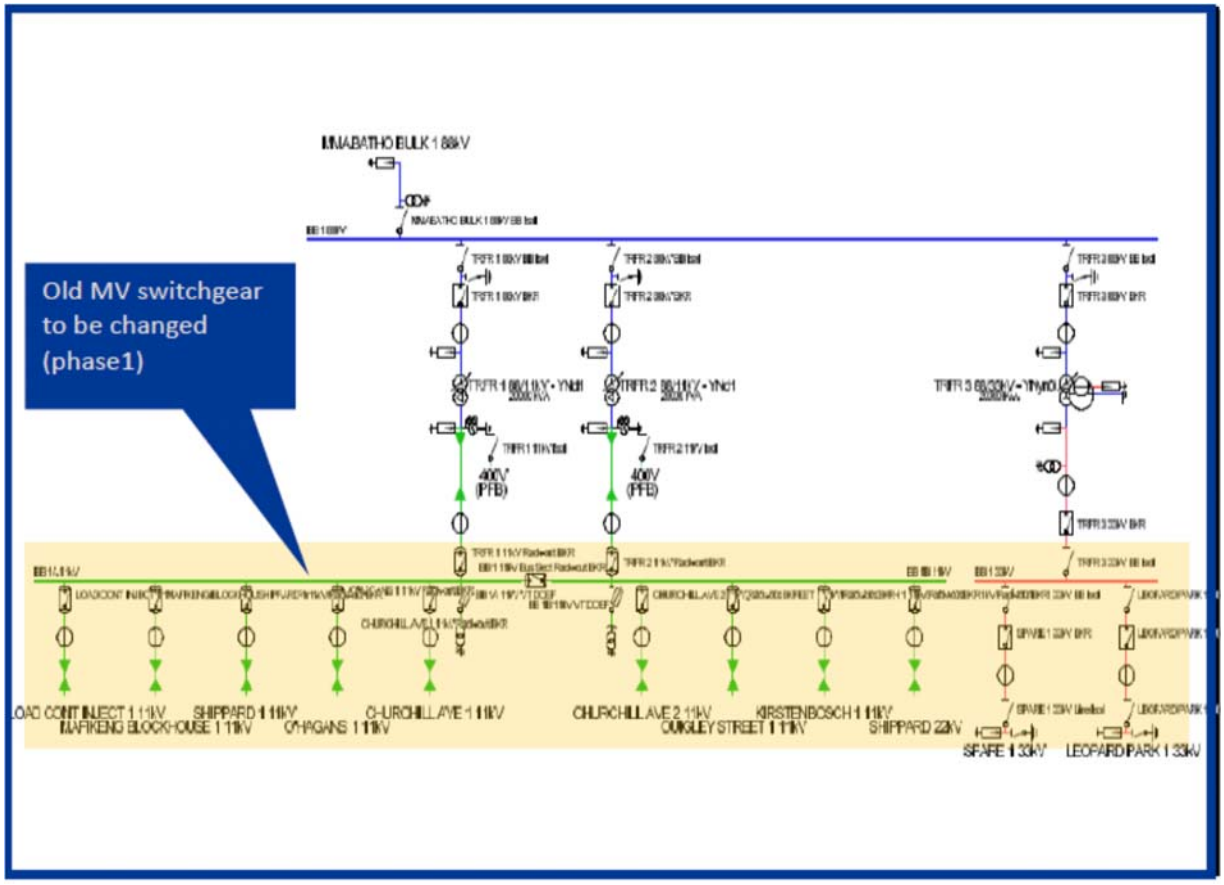

Figure 5: Existing network configurations for Mafikeng Main 88/33/11kV substation study area

This substation has eleven feeders that mainly supply residential customers and commercial loads, which mainly include recreation facilities, and the Churchill and Shippard 11kV switching stations.
The installed capacity is sufficient on the MV side for the next seven years, but the load forecast shows that the 11kV side will run out of firm capacity before the end of 2019.

This project is classified as a shared network investment in terms of section 7.2.3 of the Grid Code and the following sections of the Grid Code were not applicable for this project:

- Section 7.2.4;
- Section 7.2.5;
- Section 7.2.6;
- Section 7.2.7; and
- Section 7.3.

10.2 Alternatives considered

Audit Findings:

The following technical alternatives were considered as options to solve the problem of the ageing network and the overloading of transformers under n - 1 conditions:

- Option 1: The first option is the 'do nothing' option. This option will worsen the situation at the Mafikeng Main 88/33/11kV substation as it will put the lives of technicians that operate the 11kV circuit breakers in danger, increase unscheduled maintenance and increase the risk of collapsing the whole network in the Mafikeng area.
- Option 2: The second option entails refurbishing all the old substation equipment that were identified in the refurbishment report of Eskom NW OU. This will include building a new control room and equipping it with all necessary 11kV indoor switchgear together with the control plant equipment. This option will have an estimated total project cost of R16.5 million.

Option 2 is the preferred option because it will improve reliability of supply, improve safety levels for technicians and also resolve unscheduled maintenance issues.

10.3 Cost/benefit analysis of the preferred option

Audit Findings:

The cost/benefits of choosing option 2 at a total project cost of R16.5 million are that it will reduce unscheduled maintenance and address the safety issues that are experienced by technicians when operating the breakers as one of the breakers has already exploded.

10.4 Technical evaluation of the preferred option

Audit Findings:

The preferred option of refurbishing all the old substation equipment will reduce the failure rate of the 11kV indoor switchgear equipment. This option will also ensure uninterrupted power supply and also cater for future load growth in the Mafikeng area of supply.

10.5 Least Life-Cycle cost evaluation

Audit Findings:

Eskom NW OU uses PEM to evaluate alternatives on the basis of the LCC approach. PEM selects the best alternative on the basis of the prudent investment decision on the LCC approach.

The preferred option of replacing old substation equipment resulted in an LCC of R16.3 million while the 'do-thing' option resulted in an LCC of R3.5 million. The preferred alternative assumed a life expectancy of 25 years.

However Eskom NW OU's LCC approach does not indicate all the relevant costs involved to execute the evaluated alternatives. It excludes land and rights costs, engineering costs, and commissioning costs. IDC is also one of the biggest costs that is used to determine prudency and efficiency of this project planning exercise. More precisely, if PEM was able to determine the duration for constructing the preferred alternative and associate its IDC cost, then that could give a clear indication in terms of making a prudent investment decision as Eskom NW OU still needs to service the debt while assets are being constructed.

It is correct to exclude Overheads and IDC under Capex, but these costs should not be excluded completely in the PEM as they form part of decision-making in order to choose the best alternative on the basis of the LLCC.

10.6 Evaluation of Economic and Financial Parameters

Audit Findings:

Eskom NW OU used the approved discount rate of 7.8 per cent, but it did not use the NERSA-approved COUE values, which are either of R77.30/kWh for Total COUE or the Direct Economic COUE of R21.63/kWh. These are the COUE values that were approved by the Energy Regulator on 29 October 2015, which were supposed to be used by Eskom NW OU when it approved its project on 14 November 2016.

The R77.30/kWh is a value used at a country level as a critical parameter in determining the optimum supply system adequacy for the purposes of power system planning (generation expansion or IRP, transmission and distribution) but not for individual project planning.

Eskom NW OU used R3.13/kWh instead of using the approved value of R21.63/kWh, which is a valued used for distribution system planning where there are no major impacts, for example, if a planner checks the impact of a rural feeder or an informal settlement.

In conclusion, Eskom NW OU is compliant with Section 7.2.1(6)(a) of the Grid Code, but did not comply with Section 7.2.1(6)(b) of the Grid Code.

10.7 Summary of audit findings: Mafikeng Main 88/33/11kV substation refurbishment project

The compliance with the relevant sections is illustrated in Figure 6 below.

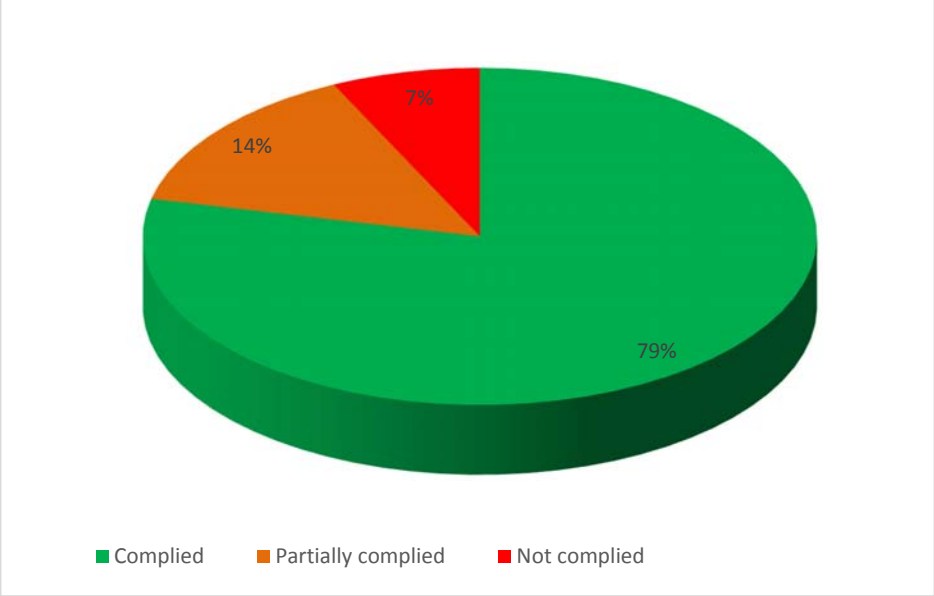

Figure 6: Summary of audit findings for Mafikeng Main 88/33/11kV Substation Refurbishment Project

The section of the Grid Code requirements that Eskom NW OU did not comply with are as follows:

- **Section 7.2.1(6) of the Grid Code:** The following key economic and financial parameters shall be determined by a NERSA approved process: the COUE and other parameters.

Furthermore, Eskom NW OU partially complied with the following sections of the Grid Code requirements in this project:

- **Section 7.2.1(4) of the Grid Code:** The investment choice must be justified by considering technical alternatives on a least-life cycle cost approach.

- **Section 7.2.2(2) of the Grid Code:** General (shared) shall be evaluated on the least life-cycle economic cost.

10.8 Recommendations

- Eskom NW OU should use the NERSA-approved values for the COUE.
- PEM should be improved in order to estimate all the relevant costs involved to execute the evaluated alternatives after those alternatives have met the technical requirements. PEM in its current state omits many relevant costs in order to be sure that the preferred option is the least cost alternative as the Grid Code promotes the least cost planning.
- Eskom NW OU should improve the content of its NDPs as it is too summarised to enable someone who is not involved on a daily planning of Eskom NW OU's network to understand the network problems and the solutions thereto. The executive summary of NDPs as presented by Eskom NW OU to the NERSA Audit Team are only meant for Eskom NW OU's management (i.e. mainly for Engineering Manager, Network Services Manager, Capital Programme Manager, Electricity Delivery Manager and Field Services Manager) to make sound capital investment decisions as detailed in Eskom Planning Methodology for NMPs and NDPs.

10.9 Eskom NW OU Management's response on audit findings

The response by Eskom NW OU Management is summarised in Table 8.

Table 8: Eskom NW OU Management response

Finding	Management response on the finding
• Eskom NW OU did not use the approved values of the COUE by the Energy Regulator.	• Finding accepted. Care will be taken in future to ensure that the COUE values as approved by NERSA are updated on PEM timeously.
• Eskom NW OU's LCC approach does not indicate all the relevant costs involved to execute the evaluated alternatives. It excludes land and rights costs, engineering costs, and commissioning costs. Also, IDC is one of the biggest costs that is used to	• The PEM improvements will be implemented after consultation with NERSA and other stakeholders.

determine prudency and efficiency of this project planning exercise.	
Management Action Plan to correct the findings	• Management will strive to use latest approved values by NERSA at all times. • Meeting will be arranged with NERSA to further improve the PEM applicability and other components that might be included on the PEM tool to better improve the selection of options.
Responsible Person	Kurt Dedekind / Mduduzi Msibi / Barend van der Merwe / Ahilan Kailasanathan.
Action Date	December 2018

11. EVALUATED PROJECT NO.3 – MARANG-MATTE SMELTER 88kV LINE PROJECT

11.1 Project description

The Marang-Matte Smelter 88kV line is a strengthening project that is aimed at providing an alternative source of supply to the Marang network that experiences overloading problems and the loss of supply under n - 1 conditions.

The Marang-Matte Smelter 88kV line is fed by the Marang 4X135MVA, 400/88kV Main Transmission Station (MTS) that also supplies a number of substations through its 88kV network. The Marang-Matte Smelter substation is fed by Rustenburg Furnace and Rustenburg Compressor 88kV lines and this is a scenario that happens under healthy-system conditions. However under worst system conditions when Matte Smelter-Rustenburg Furnace 88kV line is out of service, then the Marang-Rustenburg Compressor 88kv line becomes overloaded by 136%. This then leads to line trips in all the substations in the Marang 88kV network. This implies that the load will need to be load shared in order for this line to be restored.

This network problem would be solved by adding 15km of 88kV line from the Marang-Matte 400/88kV MTS to Matte-Smelter 4x20MVA, 88/6.6kV substation as shown in Figure 7.

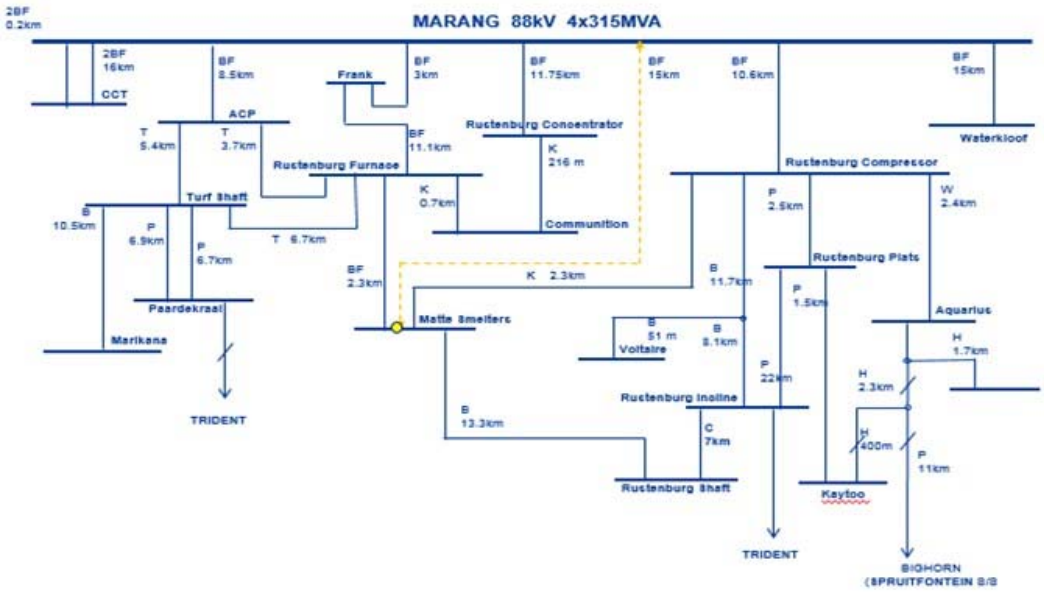

Figure 7: Marang-Matte area of study

The network investment criteria applicable to this section is section 7.2.3.

The Marang-Matte 88kV line project is a shared network investment project and will be evaluated in terms of Section 7.1 to Section 7.2.3 of the Grid Code in order to access the level of compliance.

The following sections of the Grid Code were not applicable:

- Section 7.2.4;
- Section 7.2.5;
- Section 7.2.7; and
- Section 7.3.

11.2 Alternatives considered

Audit Findings:

The audit found that Eskom NW OU considered the following alternatives in order to alleviate the overloading problems and hence maintain the quality of supply under n – 1 conditions:

- Option 1: The first option involves building a new 88kV, 15km overhead line from Marang 400/88kV MTS to Matte-Smelter 4x20MVA, 88/6.6kV substation. This option will solve the n – 1 conditions that emanate from Matte-Smelter – Rustenburg-Furnace 88kV line being out of service, which results in the Marang-Rustenburg 88kV line being overloaded by

136%, placing the load of 39MVA at risk. This option will have an estimated total project cost of R37 million.

- Option 2: The second option entails building a new 88kV, 25km overhead line from Trident MTS to Matte-Smelter 4x20MVA, 88/6.6kV substation. This option will solve the n – 1 problems and improve the quality of supply in the Marang area of supply. However obtaining a servitude for 25km of line may pose challenges and it will have an estimated total project cost of R71.5 million.

Option 1 is the preferred option because it will solve the overloading problem in the Marang area and solve the loss of supply under n – 1 conditions at an estimated total project cost of R37 million.

11.3 Cost/benefit analysis of the preferred option

Audit Findings:

The estimated total project cost for the preferred option is R37 million compared to the other option of R71.5 million.

The preferred option entails building 15km of line and a feeder bay of which the benefits are that it results in lower network losses, lower acquisition cost, and an easily obtainable servitude.

11.4 Technical evaluation of the preferred option

Audit Findings:

The load at risk is 39MVA, which is caused by the loss of Marang Matte Smelter – Rustenburg Furnace 88kV line with a customer base of 100% industrial load.

The preferred option of building 15km line from Marang 400/88kV MTS to Matte-Smelter 4x20MVA, 88/6.6kV substation will alleviate the overloading problem and possible loss of network supply. The load flow studies indicate that this network will be loaded at 81% after the 15km of line is commissioned which will then meet the reliability requirements under n – 1 contingencies.

11.5 Least Life-Cycle cost evaluation

Audit Findings:

Eskom NW OU uses PEM to evaluate alternatives on the basis of the LCC approach. PEM selects the best alternative on the basis of the prudent investment decision on the LCC approach.

The preferred option of building 15km of line resulted in an LCC of R33.8 million. The other option of building 25km of line resulted in an LCC of R52.4 million. Both alternatives assumed a project life expectancy of 25 years.

The costs used to arrive at an LCC for both alternatives include the acquisition costs/Capex, technical losses, and O&M costs (O&M after the plant is commissioned).

However, this LCC approach does not indicate all the relevant costs to execute either of the evaluated alternatives. It excludes land and rights costs, engineering costs, commissioning costs. Also, IDC is one of the biggest cost that can is used to determine prudency and efficiency of this project planning exercise. More precisely, if PEM was able to determine the duration for constructing both alternatives and associate IDC costs for both alternatives, then that can give a clear indication in terms of taking a prudent investment decision as Eskom NW OU still need to service the debt while assets are being constructed.

It is correct to exclude Overheads and IDC under Capex, but these costs should not be excluded completely in the PEM as they have to form part of decision-making in order to choose the best alternative on the basis of the LLCC.

In conclusion, PEM in its current form does not provide all the relevant costs involved to execute the evaluated alternatives in order to make a prudent investment decision in terms of whether the preferred option is the least cost planning option.

11.6 Evaluation of Economic and Financial Parameters

Audit Findings:

Eskom NW OU used the approved discount rate of 7.8 per cent, but it did not use NERSA-approved values of the COUE, which are either of R77.30/kWh for Total COUE or the Direct Economic COUE of R21.63/kWh. These are the COUE values that were approved by the Energy Regulator on 29 October 2015 which were supposed to be used by Eskom NW OU when it approved its project on 8 November 2016.

The R77.30/kWh is a value used at a country level as a critical parameter in determining the optimum supply system adequacy for the purposes of power system planning (generation expansion or IRP, transmission and distribution) but not for individual project planning.

Eskom NW OU used the COUE value of R3.13/kWh instead of using the approved value of R21.63/kWh, which is a value used for distribution system planning where there are no major impacts. For example, if a planner checks the impact of a rural feeder or an informal settlement.

It is not clear why Eskom NW OU deviated from the approved values of which Eskom submits annually to the Energy Regulator for approval and used its own unapproved COUE values as shown in Table 9.

Table 9: Unapproved COUE values used by Eskom NW OU for Marang-Matte Smelter 88kV line Project

Customer Type	R/kWh
Industrial/Mining	27,58
Commercial	21,48
Agricultural/Rural	6,31
Residential	3,13
Traction	1,69

Eskom NW OU also did not calculate the CIC for both alternatives on this project. Therefore Eskom NW OU is compliant with Section 7.2.1(6)(a) of the Grid Code, but did not comply with Section 7.2.1(6)(b) of the Grid Code.

11.7 Summary of audit findings: Marang-Matte Smelters 88kV line Project

The compliance with the relevant sections is illustrated in Figure 8 below.

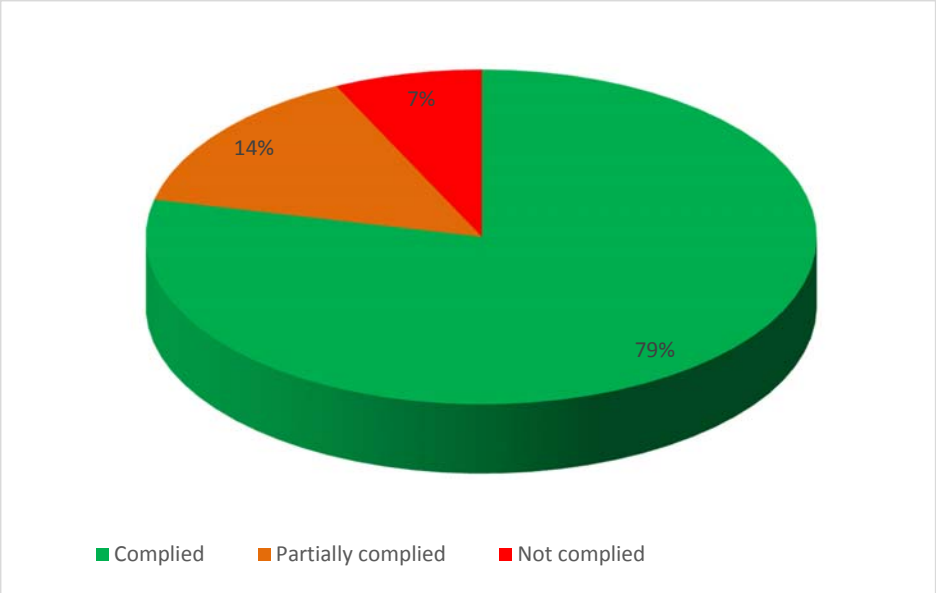

Figure 8: Summary of audit findings for Oakland City Main Substation Project

The details of the Grid Code requirement that Eskom NW OU did not comply with are as follows:

- **Section 7.2.1(6) of the Grid Code:** The following key economic and financial parameters shall be determined by a NERSA approved process: the COUE.

Furthermore, Eskom NW OU partially complied with the following sections of the Grid Code requirements on this project:

- **Section 7.2.1(4) of the Grid Code:** The investment choice must be justified by considering technical alternatives on a least life-cycle cost approach.
- **Section 7.2.2(2) of the Grid Code:** General (shared) shall be evaluated on the least life-cycle economic cost.

11.8 Recommendations

- Eskom NW OU should use the NERSA-approved values for the COUE.
- PEM should be improved in order to estimate all the relevant costs involved to execute the evaluated alternatives after those alternatives

have met the technical requirements. PEM in its current state omits many relevant costs in order to be sure that the preferred option is the least cost alternative as the Grid Code promotes the least cost planning.

- Eskom NW OU should improve the content of its NDPs as it is too summarised to enable someone who is not involved on a daily planning of Eskom NW OU's network to understand the network problems and solutions. The executive summary of NDPs as presented by Eskom NW OU to the NERSA Audit Team are only meant for Eskom NW OU's management (i.e. mainly for Engineering Manager, Network Services Manager, Capital Programme Manager, Electricity Delivery Manager and Field Services Manager) to make sound capital investment decisions as detailed in Eskom Planning Methodology for NMPs and NDPs.

11.9 Eskom NW OU Management's response on audit findings

The response by Eskom NW OU Management is summarised in Table 10.

Table 10: Eskom NW OU Management response

Finding	**Management response on the finding**
• Eskom NW OU did not use the approved values of the COUE by the Energy Regulator. • Eskom NW OU's LCC approach does not indicate all the relevant costs involved to execute the evaluated alternatives. It excludes land and rights costs, engineering costs, and commissioning costs. IDC is also one of the biggest costs that is used to determine prudency and efficiency of this project planning exercise.	• Finding accepted. Care will be taken in future to ensure that the COUE values as approved by NERSA are updated on PEM timeously. • The PEM improvements will be implemented after consultation with NERSA and other stakeholders.
Management Action Plan to correct the findings	• Management will strive to use latest approved values by NERSA at all times. • Meeting will be arranged with NERSA to further improve the PEM applicability and other components that might be included on the PEM tool to better improve the selection of options.
Responsible Person	Kurt Dedekind / Mduduzi Msibi / Barend van der Merwe / Ahilan Kailasanathan
Action Date	December 2018

12. EVALUATED PROJECT NO.4 – STRAATSDRIFT SWITCHING STATION PROJECT

12.1 Project description

The Straatsdrift Madikwe and Straatsdrift Pella 22kV lines are currently fed from Straatsdrift 1x10MVA, 88/22kV substation. These two 22kV lines experience low voltage problems due to their feeders having a customer base of about 4100 customers per feeder, which is far above the recommended limit as per the Eskom Reliability Guideline. The performance indicators also confirm that the MV networks in the area are not performing well in terms of SAIDI and SAIFI. This then compromises the reliability of this network as a fault in any part of the Zeerust-Zeerust Chrome substation trips the breaker at Zeerust Switching Station, which will result in the entire Zeerust area being without power supply.

Currently any fault happening on any part of the 88kV line will trip the 88kV breaker at Zeerust switching station, thus affecting supply to more than 40 000 customers that are dependent on this network. This reliability problem will be solved by establishing an 88kV switching station that will have three feeder bays as shown in Figure 9. This solution will make sure that any fault happening on the 88kV line supplying Straatsdrift substation will trip a breaker at the Straatsdrift Switching Station.

Figure 9 shows the Straatsdrift area of study.

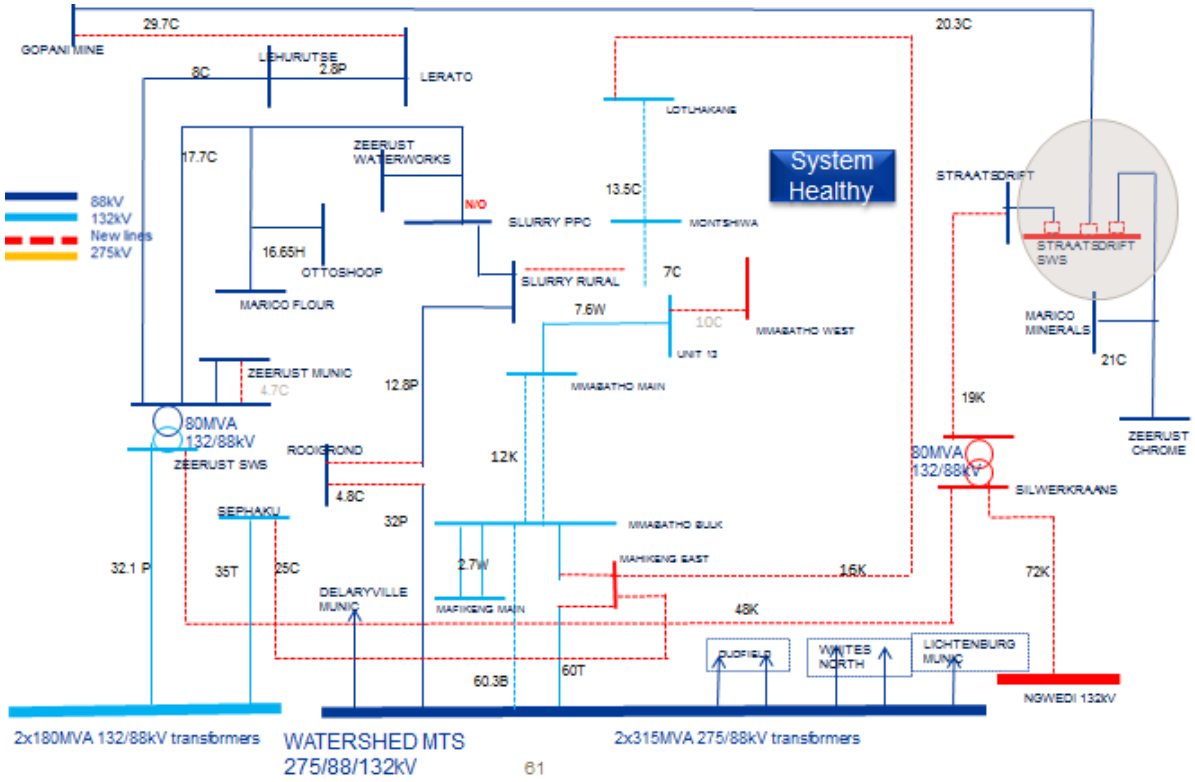

Figure 9: Straatsdrift area of study

This project is classified as a shared network investment in terms of section 7.2.3 of the Grid Code and the following sections of the Grid Code were not applicable for this project:

- Section 7.2.4;
- Section 7.2.5;
- Section 7.2.6;
- Section 7.2.7; and
- Section 7.3.

12.2 Alternatives considered

Audit Findings:

The following technical options were considered as options to solve the reliability problem:

- Option 1: The first option is to build an 88kV switching station next to Straatsdrift T-off pole number AB26 that will have three feeder bays. This option will have an estimated total project cost of R25 million.

- Option 2: The second option is to create loop-ins and loop-outs (LILOs) in all the substations in the area of study (i.e. Gopane, Straatsdrift, Lerato and Marico Minerals substations). This option will have an estimated total project cost of R109 million.

Option 1 is the preferred option because it will minimise the impact of faults should the Zeerust-Zeerust substation breaker trip, which puts about 4100 customers at risk of losing power supply.

12.3 Cost/benefit analysis of the preferred option

Audit findings:

This project will improve the reliability of supply to its customers and also reduce the SAIDI and SAIFI targets for Zeerust network. According to PEM, the customer interruption costs are estimated to be R38.6 million for the preferred solution. These Customer Interruption Costs become a benefit not only to Eskom NW OU, but also to its customers, as they are lower than those of the other option.

12.4 Technical evaluation of the preferred option

Audit findings:

The preferred option of building an 88kV switching station with three feeders will minimise the impact of line faults and introduce adequate protection on the Zeerust-Zeerust Chrome 88kV line.

12.5 Evaluation of the Least Life-Cycle cost

Audit findings:

Eskom NW OU uses PEM to evaluate alternatives on the basis of the LCC approach. PEM selects the best alternative on the basis of the prudent investment decision on the LCC approach.

The first option of building a switching station resulted in an LCC of R64 million and the second option of building LILOs resulted in an LCC of R172 million. Both alternatives assumed a project life expectancy of 25 years.

The costs used to arrive at an LCC for both alternatives include the acquisition costs/Capex, technical losses, and O&M costs (O&M after the plant is commissioned).

However this LCC approach does not indicate all the relevant costs involved to execute either of the evaluated alternatives. It excludes land and rights costs, engineering costs, and commissioning costs. IDC is also one of the biggest costs that can be used to determine prudency and efficiency of this project planning exercise. More precisely, if PEM was able to determine the duration for constructing both alternatives and associate IDC costs for both alternatives, then it would give a clear indication in terms of making a prudent investment decision as Eskom NW OU still needs to service the debt while assets are being constructed. More pointedly, the Straatsdrift Switching Station Planning Proposal evaluated two alternatives. These two alternatives would not have resulted in the same construction period. Therefore, they should have been included and compared in terms of costs so it can be determined which option has the least cost.

It is correct to exclude Overheads and IDC under Capex, but these costs should not be excluded completely in the PEM as they have to form part of decision-making in order to choose the best alternative on the basis of the LLCC.

In conclusion, PEM in its current form does not indicate all the relevant costs to execute the evaluated alternatives in order to make a prudent investment decision to say the preferred option is the least cost planning option.

12.6 Evaluation of Economic and Financial Parameters

Audit findings:

Eskom NW OU used the approved discount rate of 7.8 per cent, but it did not use the NERSA-approved values of the COUE, which are either of R77.30/kWh for Total COUE or the Direct Economic COUE of R21.63/kWh. These are the COUE values that were approved by the Energy Regulator on 29 October 2015 of which were supposed to be used by Eskom NW OU when it approved its planning proposal on 13 February 2017.

The R77.30/kWh is a value used at a country level as a critical parameter in determining the optimum supply system adequacy for the purposes of power system planning (generation expansion or IRP, transmission and distribution) but not for individual project planning.

Eskom NW OU used the COUE value of R3.13/kWh instead of using the approved value of R21.63/kWh, which is a value used for distribution system planning where there are no major impacts, for example, if a planner checks the impact of a rural feeder or an informal settlement.

It is not clear why Eskom NW OU deviated from the approved values which Eskom submits annually to the Energy Regulator for approval and used its own unapproved values as shown in Table 11.

Customer Type	R/kWh
Industrial/Mining	27,58
Commercial	21,48
Agricultural/Rural	6,31
Residential	3,13
Traction	1,69

Table 11: Unapproved COUE values used by Eskom NW OU for Straatsdrift Switching Station Project

In conclusion, Eskom NW OU is compliant with Section 7.2.1(6)(a) of the Grid Code but did not comply with Section 7.2.1(6)(b) of the Grid Code.

12.7 Summary of audit findings: Straatsdrift Switching Station Project

The compliance with the relevant sections are illustrated in Figure 10 below.

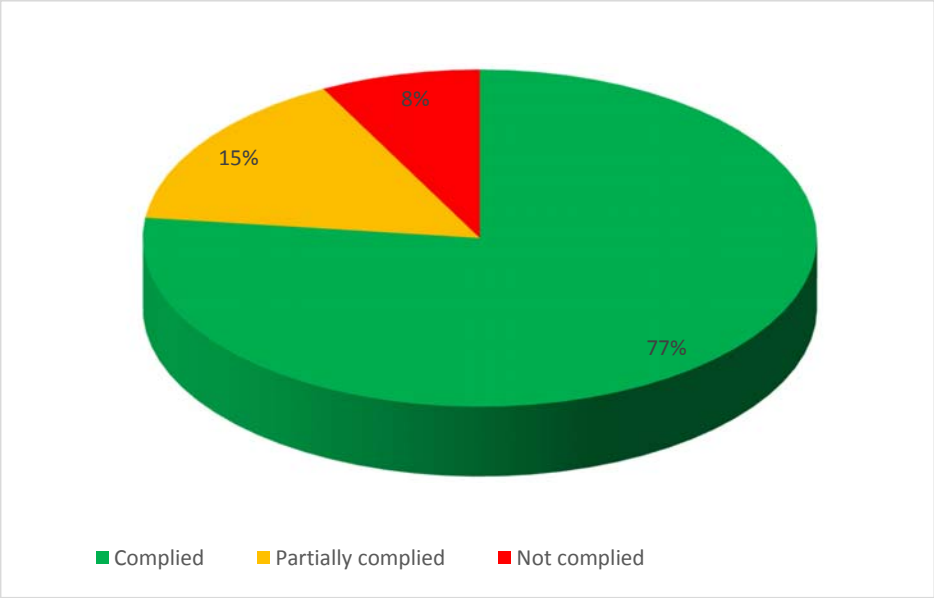

Figure 10: Summary of audit findings for Straatsdrift Switching Station Project

The section of the Grid Code requirements that Eskom NW OU did not comply with is as follows:

- **Section 7.2.1(6) of the Grid Code:** The following key economic and financial parameters shall be determined by a NERSA approved process: the COUE and other parameters.

Furthermore, Eskom NW OU partially complied with the following sections of the Grid Code requirements on this project:

- **Section 7.2.1(4) of the Grid Code:** The investment choice must be justified by considering technical alternatives on a least life-cycle cost approach.
- **Section 7.2.2(1) of the Grid Code:** Investments should be prudent (that is justified) as a least life-cycle cost solution.

12.8 Recommendations

- Eskom NW OU should use the NERSA-approved values for the COUE.
- PEM should be improved in order to estimate all the relevant costs involved to execute the evaluated alternatives after those alternatives have met the technical requirements. PEM in its current form omits many relevant costs in order to ensure that the preferred option is the least cost alternative as the Grid Code promotes the least cost planning.
- Eskom NW OU should improve the content of its NDPs as it is too summarised to enable someone who is not involved on a daily planning of Eskom NW OU's network to understand the network problems and solutions. The executive summary of NDPs as presented by Eskom NW OU to the NERSA Audit Team are only meant for Eskom NW OU's management (i.e. mainly for Engineering Manager, Network Services Manager, Capital Programme Manager, Electricity Delivery Manager and Field Services Manager) to make sound capital investment decisions as detailed in Eskom's Planning Methodology for NMPs and NDPs.

12.9 Eskom NW OU Management's response on audit findings

The response by Eskom NW OU Management is summarised in Table 11.

Table 11: Eskom NW OU Management response

Finding	**Management response on the finding**
• Eskom NW OU did not use the approved values of the COUE by the Energy Regulator. • Eskom NW OU's LCC approach does not indicate all the relevant costs involved to execute the evaluated alternatives. Reason being that it excludes land and rights costs, engineering costs, and commissioning costs. Also, IDC is one of the biggest costs that is used to determine prudency and efficiency of this project planning exercise.	• Finding accepted. Care will be taken in future to ensure that the COUE values as approved by NERSA are updated on PEM timeously. • The PEM improvements will be implemented after consultation with NERSA and other stakeholders.
Management Action Plan to correct the findings	• Management will strive to use latest approved values by NERSA at all times. • Meeting will be arranged with NERSA to further improve the PEM applicability and other components that might be included on the PEM tool to better improve the selection of options.
Responsible Person	Kurt Dedekind / Mduduzi Msibi / Barend van der Merwe / Ahilan Kailasanathan
Action Date	December 2018

13. EVALUATED PROJECT NO.5 – VRYBURG ROAD SUBSTATION STRENGTHENING AND REFURBISHMENT PROJECT

13.1 Project description

Vryburg Road Substation strengthening and refurbishment project was initiated to resolve the transformer overloading problems as well as refurbishments needs that are as a result of indoor circuit breaker failures due to ageing.

Vryburg Road is a 33/22/11kV Substation that is equipped with 1x5MVA, 33/22kV transformer and a 1X30MVA, 33/11kV transformer. This substation is currently peaking at 13.5MVA on the 30MVA, 33/11kV transformer side and 4.5MVA on a 1x5MVA, 33/22kV transformer side.

This substation is fed from the Mmabatho Main 88/33kV, 2x30MVA substation by a Hare overhead conductor that is 6.7km long.

Figure 11 shows the existing single line diagram for the Vryburg Road substation project and the surrounding Mmabatho network.

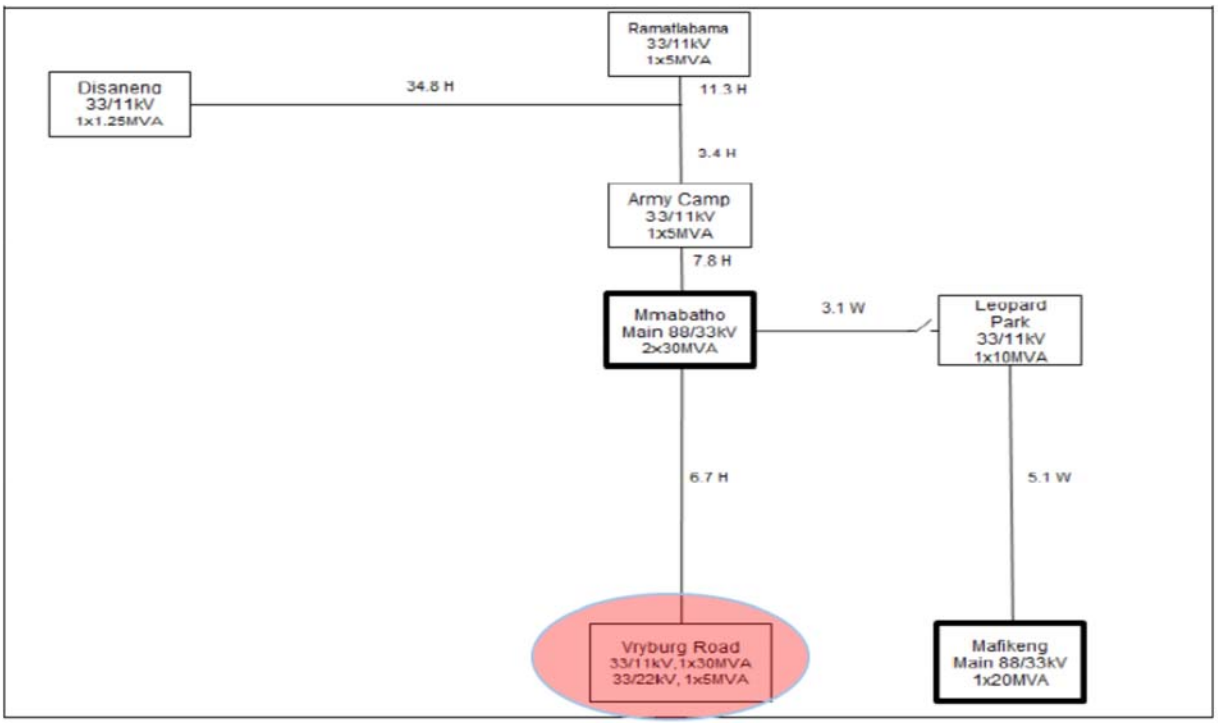

Figure 11: The existing single line diagram for Vryburg Road substation project and the surrounding Mmabatho network

The single line diagram show that Vryburg road substation does not have back-feeding, which poses a huge risk should the 6.7km feeder line be out of service as the five feeders of this substation have a combined number of customers of approximately 15 227.

Also, the load flow studies indicated a poor performance of the MV network in the area which negatively affect SAIDI and SAIFI targets. Therefore there is a need to address the reliability problems and also normalise the MV network within the area.

This project is classified as a shared network investment in terms of section 7.2.3 of the Grid Code and the following sections of the Grid Code were not applicable for this project:

- Section 7.2.4;
- Section 7.2.5;
- Section 7.2.6;
- Section 7.2.7; and
- Section 7.3.

13.2 Alternatives considered

Audit Findings:

The following technical options were considered as options to solve the problems at Vryburg road substation, which include high number of customers in each feeder, back-feeding problems, overloading problems and the ageing substation equipment:

- Option 1: The first option is to replace the existing 1x30MVA, 33/11kV transformer and a 1x5MVA, 33/22kV transformer with 2x20MVA, 33/11kV transformers and to refurbish the Vryburg Road 33/11kV substation's equipment and thereafter convert the Vryburg Road-Vryhof Silo 22kV feeder into an 11kV network. The total project cost for this option is estimated to be R43.4 million.

- Option 2: The second option is to replace the existing 1x30MVA, 33/11kV transformer with 2x20MVA, 33/11kV transformers and also replace the existing 1x5MVA, 33/22kV transformer with 1x10MVA, 33/22kV transformer. The total project cost for this option is estimated to be R45.5 million.

Option 1 is the preferred option because it will standardise the medium voltages of all the substation feeders into 11kV. This will then allow the whole 11kV network to back-feed. This will be achieved after converting Vryburg Road-Vryhof Silo 22kV feeder into an 11kV network.

13.3 Cost/benefit analysis of the preferred option

Audit findings:

The preferred option is cheaper by R2.1 million when compared to option 2 and it will have a back-feeding capability after the Vryburg Road-Vryhof 22kV feeder has been converted into an 11kV feeder.

However, it is not clear how Eskom NW OU will execute this preferred alternative without switching off the 15 227 customers that are reliant on this substation. More specifically, the substation does not have enough space to cater for the execution of option 1, which involves replacing transformers. Meaning that when either of the transformers is being decommissioned, 15 227 customers (i.e. 12 633 customers connected on a 1x30MVA, 33/11kV transformer and 2 564 customers connected on a 1x5MVA, 33/22kV transformer) will be without power supply for the duration of the project.

Also, when the Vryburg Road-Vryhof 22kV feeder is converted into an 11kV feeder, all 2 564 customers on the 22kV feeder will be without power supply for the duration of the project.

The NERSA analysis on this project shows that the practicability of executing this project has not been given due diligence by Eskom NW OU as the cost of shutting down the substation has far reaching consequences and it does not benefit neither Eskom NW OU nor its customers, unless Eskom NW OU makes use of mobile transformers while decommissioning the existing transformers. This additional alternative, including its costs, have not been taken into consideration at the planning stage. When the lack of project planning becomes evident during later stages (i.e. either at ERA or FRA stages) of the project, the total project cost may even be doubled.

13.4 Technical evaluation of the preferred option

Audit findings:

The preferred option will provide back-feeding on the network, provide reliable supply to 15 227 customers, normalise and strengthen Vryburg road

substation and thus improve network performance and also accommodate future load growth.

13.5 Evaluation of the Least Life-Cycle cost

Audit findings:

Eskom NW OU uses PEM to evaluate alternatives on the basis of the LCC approach. PEM selects the best alternative on the basis of the prudent investment decision on the LCC approach.

The preferred option of replacing the existing 1x30MVA, 33/11kV transformer and a 1x5MVA, 33/22kV transformer with 2x20MVA, 33/11kV transformers will result in an LCC of R39 million. The other option will result in an LCC of R40.1 million. Both alternatives assumed a project life expectancy of 25 years. Also, the costs used to arrive at an LCC for both alternatives include the acquisition costs/Capex, technical losses, and O&M costs (O&M after the plant is commissioned).

However, this project will retire or decommission many assets that include a 1x30MVA transformer, 1x5MVA transformer, 60x16kVA transformers, 33x25kVA transformers, 27x32kVA transformers, 6x50kVA transformers, 19x100kVA transformers, 2x315kVA transformers and 1x500kVA transformer. All these big ticket items are being decommissioned before they reach their end life, therefore there is a disposal cost/market value that was not calculated by Eskom NW OU on them as it is not equal to zero as presented on the model.

Furthermore, Eskom NW OU's LCC approach does not indicate all the relevant costs involved to execute either of the evaluated alternatives. It excludes Land and Rights Costs, Engineering Costs, Commissioning Costs. IDC is also one of the biggest costs that is used to determine prudency and efficiency of this project planning exercise. More precisely, if PEM was able to indicate the duration for constructing both alternatives and the associated IDC costs for both alternatives, it could provide a clear indication in terms of making a prudent investment decision as Eskom NW OU still needs to service the debt while assets are being constructed.

It is correct to exclude Overheads and IDC under Capex, but these costs should not be excluded completely in the PEM as they form part of decision-making in order to choose the best alternative on the basis of the LLCC.

13.6 Evaluation of Economic and Financial Parameters

Audit findings:

Eskom NW OU used the approved discount rate of 7.8 per cent, but it did not use the NERSA-approved values of the COUE, which are either of R77.30/kWh for Total COUE or the Direct Economic COUE of R21.63/kWh. These were the COUE values that were approved by the Energy Regulator on 29 October 2015 of which were supposed to be used by Eskom NW OU when it approved its planning proposal for this project on 30 November 2016.

The R77.30/kWh is a value used at a country level as a critical parameter in determining the optimum supply system adequacy for the purposes of power system planning (generation expansion or IRP, transmission and distribution) but not for individual project planning.

Eskom NW OU used R3.13/kWh instead of using the approved value of R21.63/kWh, which is a COUE value used in distribution system planning where there are no major impacts, for example, if a planner checks the impact of a rural feeder or an informal settlement.

It is not clear why Eskom NW OU deviated from the approved values which Eskom submits annually to the Energy Regulator for approval and used its own unapproved values as shown in Table 12.

Customer Type	R/kWh
Industrial/Mining	27,58
Commercial	21,48
Agricultural/Rural	6,31
Residential	3,13
Traction	1,69

Table 12: Unapproved COUE values used by Eskom NW OU for Vryburg Road Substation Project

In conclusion, Eskom NW OU is compliant with Section 7.2.1(6)(a) of the Grid Code but did not comply with Section 7.2.1(6)(b) of the Grid Code.

13.7 Summary of audit findings: Vryburg road substation strengthening and refurbishment project

The compliance with the relevant sections are illustrated in Figure 12 below.

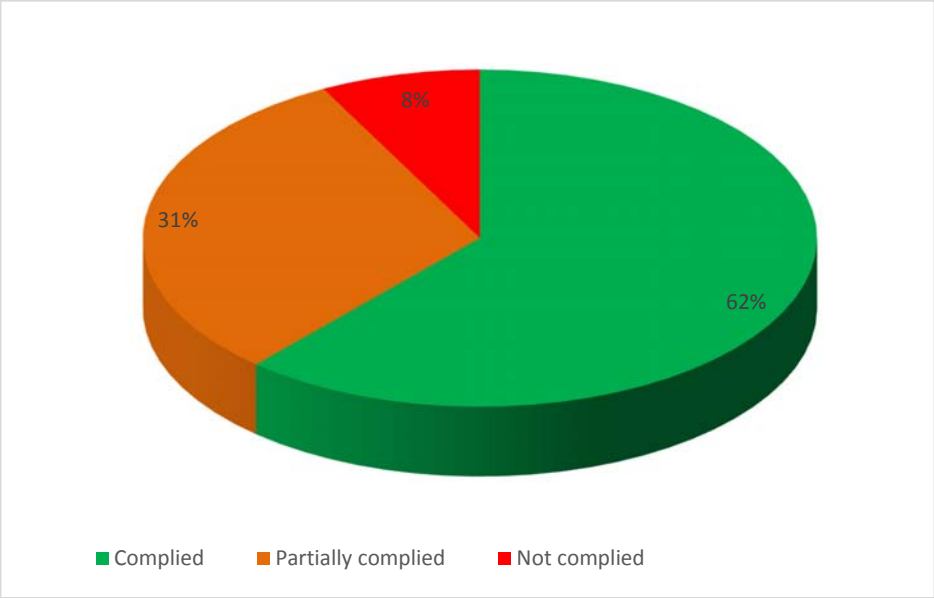

Figure 12: Summary of audit findings for Vryburg road substation strengthening and project

The section of the Grid Code requirements that Eskom NW OU did not comply with on this project are as follows:

- **Section 7.2.1(6) of the Grid Code:** The following key economic and financial parameters shall be determined by a NERSA approved process: discount rate, the COUE and other parameters.

Furthermore, Eskom NW OU partially complied with the following sections of the Grid Code requirements that Eskom NW OU partially complied with on this project:

- **Section 7.2.1(3) of the Grid Code:** The need to invest must first be decided on technical grounds. All investments must be the least life-cycle cost technically acceptable solution;
- **Section 7.2.1(4) of the Grid Code:** The investment choice must be justified by considering technical alternatives on a least life-cycle cost approach.
- **Section 7.2.2(1) of the Grid Code:** Investments should be prudent (that is justified) as a least life-cycle cost solution.
- **Section 7.2.2(2) of the Grid Code:** General (shared) network investments shall be evaluated on the least life-cycle economic cost.

Economic cost will consider the least life-cycle total cost of the electricity related investment to both the Distributor and the customer.

- **Section 7.2.3(3) of the Grid Code:** All shared network investments are to be justified on a least economic cost. The investment must be justified to minimise the cost to the electricity industry not just to the Distributor.

13.8 Recommendations

- Eskom NW OU should use the NERSA-approved values for the COUE.
- PEM should be improved in order to estimate all the relevant costs involved to execute the evaluated alternatives after those alternatives have met the technical requirements. PEM in its current state omits many relevant costs in order to be sure that the preferred option is the least cost alternative as the Grid Code promotes the least cost planning.
- Eskom NW OU should also evaluate the practicability of executing the preferred alternative as the presented scope of work will result in having customers without power supply for months.
- Eskom NW OU should conduct an audit to evaluate the condition of the substation equipment which will detail the refurbishment needs together with the estimated remaining life of the equipment in order to correctly estimate the disposal value(s) of those equipment.
- Eskom NW OU should improve the content of its NDPs as it is too summarised to enable someone who is not involved on a daily planning of Eskom NW OU's network to understand the network problems and solutions. The executive summary of NDPs as presented by Eskom NW OU to the NERSA Audit Team are only meant for Eskom NW OU's management (i.e. mainly for Engineering Manager, Network Services Manager, Capital Programme Manager, Electricity Delivery Manager and Field Services Manager) to make a sound capital investment decisions as detailed in Eskom Planning Methodology for NMPs and NDPs.

13.9 Eskom NW OU Management's response on audit findings

The response by Eskom NW OU Management is summarised in Table 13.

Table 13: Eskom NW OU Management response

Finding	Management response on the finding
• Eskom NW OU did not use the approved values of the COUE by the Energy Regulator.	• Finding accepted. Care will be taken in future to ensure that the COUE values as approved by

• Eskom NW OU did not conduct a plant audit in order to indicate the refurbishment needs and the condition of the substation equipment before commencing with this project. • Eskom NW OU did not evaluate if the preferred solution can be executed without any power supply interruptions as the preferred scope of replacing transformers that are not firm, will result in power shut-downs. Also, if the project scope is not correctly defined at the planning stage, it will result into project delays and cost overruns. • Eskom NW OU's LCC approach does not indicate all the relevant costs involved to execute the evaluated alternatives. Reason being that it excludes land and rights costs, engineering costs, and commissioning costs. Also, IDC is one of the biggest costs that is used to determine prudency and efficiency of this project planning exercise.	NERSA are updated on PEM timeously. • Plants audits are done for every plant/project before it can be prioritised for refurbishment. • The Vryburg Road Substation project will still undergo different phases of the project life cycle to improve scope, costs and implementation plan before it can be executed. The implementation scope on the NDP is very high level and further improvement of the implementation plan is ensured at design stage. This ensures minimum impact to customers in terms of interruption of supply. • PEM improvements will be implemented after consultation with NERSA and other stakeholders
Management Action Plan to correct the findings	• Management will strive to use latest approved values by NERSA at all times. • Existing processes on plant audits will be followed. • Constructability and implementation plan for the Vryburg Road Substation project will further be looked on at design stage to ensure minimum interruptions to customers. This process is in place already and checked by technical evaluation forum (TEF) in all designs for projects to ensure minimum interruption of supply. • Meeting will be arranged with NERSA to further improve the PEM applicability and other components

	that might be included on the PEM tool to better improve the selection of options.
Responsible Person	Mduduzi Msibi/Kurt Dedekind/Barend van der Merwe/ Ahilan Kailasanathan
Action Date	December 2018

14. CONCLUSION

There is a public outcry about the efficiency of Eskom in its decision-making that has become an ongoing concern. Distribution audits are one of the balances and checks that NERSA uses in its role as a watchdog of the Electricity Supply Industry to make sure that licensees like Eskom NW OU execute its responsibilities according to plan and operate its network assets responsibly, while also acting in the national interest by ensuring that the planning decisions it makes benefit both Eskom NW OU and its customers.

The aim of Eskom NW OU's planning department is to make sure that all projects that are in the NDP are technically acceptable solutions and are prudent and viable long-term investment decisions. This can only be achieved if Eskom NW OU estimates its project costs correctly at the planning stage and also provide a correct estimate of the time it will take to construct projects for commissioning. This approach will minimise delays and overspending.

The audit found that Eskom NW OU is not using the approved COUE values that have been approved by the Energy Regulator. The disregard by Eskom NW OU in implementing the Energy Regulator's decision amounts to undermining the Regulator and disregarding the law (i.e. Electricity Regulation Act and the Grid Code).

The audit also found that the PEM in its current form does not indicate all the relevant costs to execute any of the evaluated alternatives using the least cost approach. PEM still needs to be improved so that it can be used as a tool that estimates all the relevant costs that are involved in the execution of the project.

If the recommendations of this audit report are implemented correctly, Eskom NW OU will improve in setting frameworks for distribution network planning and development, network investment criteria, and excluded services in such a way that it allows Eskom to recover the full cost of its licensed activities, including a reasonable return. This will also ensure that the safety and reliability requirements

of the distribution network are met within the specified technical, economical, and financial requirements of the Grid Code.