Transmission development plan 2015-2024

Eskom

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Foreword by Group Executive

The capital constraints being experienced by Eskom meant that the Transmission Development Plan developed in early 2013 was no longer realistic and had to be re-phased and re-prioritised to align with the available funding.

This was an intensive and time consuming exercise; hence an exemption to this effect was applied for and granted by NERSA. Projects were then reprioritised to maximise the benefits to South Africa from remaining funds available for network development. It is regrettable but unavoidable that it will now take longer than previously anticipated to achieve the levels of network redundancy and reliability of supply as defined in the rules contained in the latest version of the South African Grid Code.

Reliable electricity supply of acceptable quality is South Africa's economic lifeblood. It is also essential for the enjoyment of the modern lifestyle that so many of us take for granted, and newly electrified communities are enjoying for the first time. The transmission system plays a pivotal role in the provision of electricity by delivering electricity in bulk from the power stations to load centres located throughout South Africa and the region. From there, the distribution networks owned by Eskom and municipalities deliver electricity to end-users. The transmission system requires not only maintenance to deliver a reliable supply of electricity, but needs to be strengthened to meet changing customer needs.

The plans are focused, firstly, on ensuring that the network complies with the minimum reliability criteria specified in the Grid Code for both loads and power stations.

Secondly, the new power stations being developed by Eskom and IPPs must be connected to the network. The next few years will see the connection of further large-scale renewable generation (wind and solar) to the grid, which will diversify the country's energy mix and reduce its carbon footprint. This will not only create jobs to build and operate the stations, but will also attract development to economically depressed parts of the country. Thirdly, new loads need to be connected to the network, facilitating economic growth and uplifting the lives of all South Africans.

The benefits of a reliable and secure electricity supply to South Africa must be weighed up against the cost of providing it to ensure that electricity consumers who, ultimately, fund the investments through the tariff receive fair value for money.

I hope that this document will assist in this dialogue, and I welcome comments and queries on the content and format.

I would also like to take this opportunity to thank the team that has worked, and continues to work, on the development of these plans. It is a difficult and complex process, requiring extensive consultation and multiple iterations.

Mongezi Ntsokolo

October 2014

Executive summary

Eskom Holdings SOC Limited is a vertically integrated company licensed to generate, transmit, and distribute electricity in South Africa. Eskom Transmission has the responsibility of developing the transmission network. The publication of the TDP is to inform stakeholders about Eskom's plans for the development of the transmission network. This publication fulfils the requirements of the South African Grid Code, which requires the transmission network service provider (TNSP) to publish plans annually on how the network will develop.

The funding constraints being experienced by Eskom meant that the Transmission Development Plan developed in early 2013 was no longer affordable and, hence, no longer realistic. The plan had to be revised to fit within the available budget by reprioritising projects to minimise the impact on customers and the national economy. Insufficient time remained to complete the reprioritisation and, thereafter, publish this document based on the revised plan within the prescribed deadline. Publishing this document based on the original plan would not have served any useful purpose, since it would have been unrealistic in the context of the current funding constraints. An exemption from the requirement to publish this document last year (2013) was applied for from Nersa, which was granted.

It is regrettable, but unavoidable, that the funding constraints will result in it taking a longer period of time to bring the transmission system into compliance with the reliability and redundancy requirements prescribed by the Grid Code. The effects on customers and the national economy will be minimised through consultation with customers. A public forum will be held with identified stakeholders to disseminate the content of this plan further and get feedback on it. These comments will be taken into account when the plan is revised. This publication contains information about projects intended to extend or reinforce the transmission system that have been completed in the past year as well as about projects that are planned for the next 10 years.

The transmission network is the primary network of interest covered in this publication. This covers electrical networks with voltages ranging from 220 kV to 765 kV and the transmission substations where these networks terminate. A few 88 kV and 132 kV electrical networks are included due to their strategic nature.

The projects covered in this document include the generation integration projects required to ensure that the network is adequate to evacuate and dispatch power from the new power stations (conventional and renewable) connecting to the network to the load centres.
This document also contains the reliability projects required to ensure that the levels of reliability and adequacy of the transmission network as a whole prescribed by the Grid Code are sustained as load demand increases and new sources of generation are connected to the network.
The final group of projects are those needed to connect new and growing loads and load centres to the network.
The costs given in the document are, in general, high-level estimates and can change as global economic conditions change; that is, costs are sensitive to fluctuations in foreign exchange and commodity prices and to global demand.

In general, the impact of reliability projects on the customers is to improve availability of supply under normal and contingency operating conditions, whereas load customer and generation integration projects allow generating plant and the load to be optimally connected to the network.

Eskom Transmission also undertakes capital expenditure in respect of the refurbishment of ageing infrastructure, strategic projects (including facilities), production equipment, and strategic capital spares.

Strategic projects are those that do not fall into any of the other categories. These include upgrading of the EMS (Energy Management System) used by the System Operator to control the system and respond to emergencies, as well as security measures to combat criminal activity such as theft and vandalism.

Facilities consist of buildings located at sites other than substations, which Transmission uses for offices, the operation and control of the system, or as maintenance depots and workshops.

Production equipment consists of office furniture and equipment, computer hardware and software, tools and other equipment used by maintenance staff, and vehicles.

Strategic capital spares are items not available from suppliers ex stock, for example, large power transformers, circuit-breakers, etc., which are kept as strategic stock to allow units that fail in service and cannot be repaired on site to be replaced as soon as practicable, thereby minimising the risk that customers may experience a lengthy outage.

Projects dealing with the refurbishment of ageing infrastructure, facilities, production equipment, and strategic capital spares are not explained in greater detail in this document, but a summary of their costs appears in the chapter dealing with capital expenditure.

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Abbreviations

CLN – customer load network

The network within a specific geographical area, which, in turn, is a subdivision of a grid; for example, Johannesburg CLN falls within the Gauteng Province.

TNSP – transmission network service provider

A legal entity that is licensed to own, operate, and maintain a transmission network.

MW – megawatt

A million watts – a watt is a unit of electrical power production or demand.

MVAr – megavolt-ampere reactive

A million volt-amperes reactive – a volt-ampere reactive is a unit of the electrical power required to maintain electromagnetic fields.

MVA – megavolt-ampere

A million volt-amperes of apparent power, being the vector sum of real power (MW) and reactive power (MVAr).

MYPD3 – Multi-year Price Determination 3

The third multi-year price determination for tariff increases awarded to Eskom by Nersa, being 8% per annum over the period 1 April 2013 to 31 March 2018.

Nersa – National Energy Regulator of South Africa

The body established by an Act of Parliament to regulate the production, sale, and pricing of electricity, liquid fuels, and fuel gas in South Africa.

MTS – main transmission substation

These are substations owned and operated by a TNSP.

RTS – return to service

A previously mothballed power station undergoing recommissioning.

IPP – independent power producer

These are power stations owned by independent parties other than Eskom.

REIPPP – Renewable Energy Independent Power Producers Programme

REBID – Renewable Energy Bids Programme

TDP – Transmission Development Plan

A development plan produced annually by Grid Planning detailing how the network will develop in the next 10 years. This comprises the proposed new projects listed in this document as well as the customer projects omitted from this document owing to their commercial sensitivity.

OCGT – open-cycle gas turbine

Combustion turbine fuelled by liquid fuel or gas, used to drive a generator.

CCGT – combined-cycle gas turbine

OCGT fitted with a waste heat recovery boiler and steam turbines to increase electricity output by using the exhaust gases of the combustion turbine to raise steam.

HVDC – high-voltage direct current

ICE – indicative cost estimate

Cost estimate giving a non-binding indication of the order of magnitude costs.

BQ – budget quote

Quotation giving customers costs and scope at an 85% accuracy level.

TOSP – time of system peak

Chapter 1
Introduction

1.1 Context of the transmission development plan

Eskom Holdings is the biggest producer of electricity in South Africa; it also transmits electricity via a transmission network, which supplies electricity at high voltages to a number of key customers and distributors. Eskom is a vertically integrated company licensed to generate, transmit, and distribute electricity. The transmission licence is held by Eskom Transmission, the transmission network service provider (TNSP). Planning the transmission network is the responsibility of the Grid Planning Department in the Transmission Group.

The TNSP is required to abide by the regulatory requirements to publish a document annually, detailing the plans for the way that the transmission network will develop in the next five years. This plan covers a 10-year window. The requirements, furthermore, stipulate that the published document should include:

- the acquisition of servitudes for strategic purposes;
- a list of planned investments, including costs;
- diagrams displaying the planned changes to the transmission system (TS);
- an indication of the impact on customers in terms of service quality and cost; and
- any other information as specified by Nersa from time to time.

A further requirement is that the TNSP should hold public forums to share such plans with stakeholders in order to facilitate a joint planning process with them. The fifth TDP was published early in October 2012; this is the sixth publication based on the TDP for 2015 to 2024 (also called the 2014 TDP internally to Eskom), which was finalised internally during the latter part of 2014.

1.2 Structure of the document

The document is structured in the following manner:

Chapter 2 deals with the electricity demand forecast and generation assumptions. The demand forecast determines how the network is planned, and it contextualises the planning activity, whereas the generation assumptions outline the generation build that informs some of the planned transmission network, as a significant transmission network is required to evacuate power from the power stations to the load.

Chapter 3 focuses on the major changes that have occurred since the completion of the previously published Transmission Development Plan (TDP). The major changes comprise the reprioritisation of projects in line with the reduced funding available for network development as a result of the MYPD3 tariff determination and the changes from the previous generation assumptions to the ones informing this plan. Other changes are the result of the reduced load forecast deferring the need for network strengthening and delays in projects in the execution phase mainly as a result of challenges in the acquisition of sites for new substations or servitudes for new lines.

Chapter 4 focuses on the completed projects and projects nearing completion as well as grid connection applications processed by Transmission.

Chapter 5 deals with the national overview, which gives a high-level explanation of the planned transmission infrastructure. This is intended to give a snapshot of the major projects that are planned for the entire period of the TDP and a high-level summary of the installed transmission infrastructure.

Chapter 6 focuses in detail on the planned projects and the impact they will have on the network. Generation integration and reliability projects are discussed per province. In both instances, sites and servitudes are required to accommodate substations and lines, respectively.

In either case, the National Environmental Management Act requires Eskom to conduct an environmental impact assessment (EIA) and obtain environmental approval, which includes consultation with affected stakeholders, prior to construction.

Chapter 7 deals with the strategic servitudes under investigation.

Chapter 8 deals with the capital expenditure of the TDP.

Chapter 9 deals with various conclusions based on the content of this document.

Chapter 2
Load demand forecast and generation assumptions

The 10-year Transmission Development Plan (TDP) seeks to meet the long-term requirements of the electricity consumers in South Africa by maintaining the legislated adequacy and reliability of the transmission grid.

The objective is to produce a plan containing the expected development projects for the transmission system for this 10-year period. These expected projects will consist of the approved projects, the projects that are to be prepared for approval, and the projects likely to be taken for approval over the defined period.

In order to undertake the system adequacy studies to determine the weakness in the system, a number of assumptions need to be made. These assumptions are required in order to assure consistency in the network studies and analysis as well as to inform the organisation of the basis of the Transmission Development Plan (TDP) for the defined period.

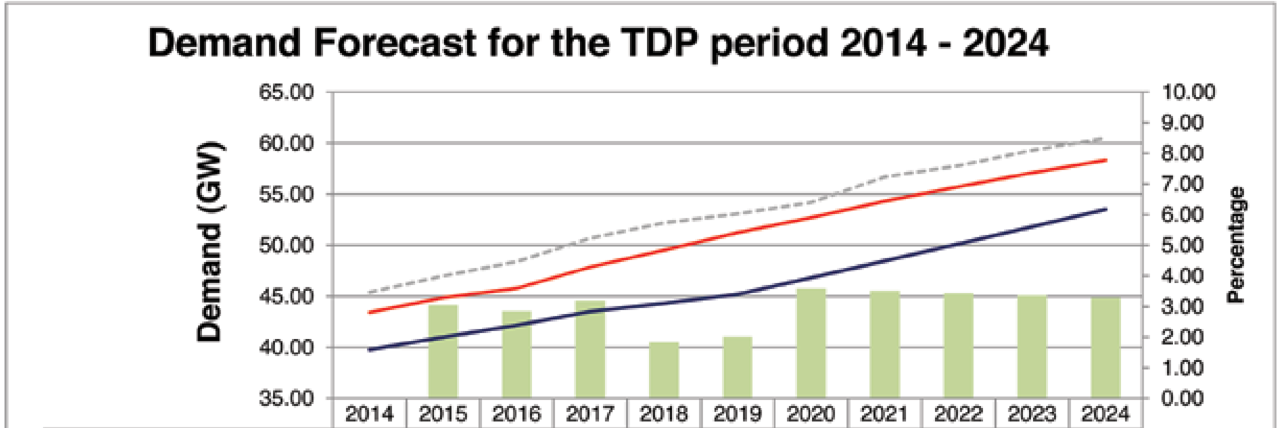
2.1 Load forecast

Load forecasting is a fundamental requirement for a Transmission planning cycle. The availability of sufficient transmission network capacity in any country is important for economic growth. Grid Planning, in consultation with the relevant Distribution operating units, compiles a forecast per point of supply for the network computer model.

A number of improvements have been made to the forecast for this TDP.

At the Combined Forecasting Forum, forecasts were discussed with all parties, and it was agreed that the balanced baseline system demand at the time of system peak (illustrated by the 2014 TDP forecast in Figure 2.1) and its associated point of supply and area forecasts would be used for transmission planning purposes by the Grid Planning Department for the Transmission Development Plan (TDP) network studies for the period 2015 to 2024.

The 2014 TDP forecast is lower than in previous years. This is attributed to slower economic growth estimates. For the purposes of the TDP loads are allocated to a CLN according to the location of the transmission substation supplying them, even if they are physically located in a different CLN.



	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
2014 TDP Growth (%)		3.05	2.85	3.20	1.83	2.01	3.59	3.51	3.44	3.36	3.29
2010 IRP Demand	43.44	44.87	45.79	47.87	49.52	51.23	52.72	54.33	55.73	57.10	58.34
2012 TDP Demand	45.40	47.00	48.40	50.70	52.20	53.10	54.20	56.70	57.80	59.30	60.50
2014 TDP Demand	39.79	41.00	42.17	43.52	44.32	45.21	46.83	48.47	50.14	51.82	53.53

Figure 2.1: Demand forecast for TDP 2015 - 2024

2.2 Generation assumptions

The Department of Energy (DoE) is accountable for the country energy plan. This country energy plan is termed the Integrated Resource Plan (IRP). The IRP is intended to drive all new generation capacity development for South Africa. Nersa will then license new generators according to this determination.

The current IRP is the "Integrated Resource Plan for Electricity 2010 to 2030", referred to as the 2010 IRP in this document, which was gazetted on 6 May 2011 by the government. A new draft updated IRP version was released in December 2013 for comment, and the generation assumptions have taken cognisance of this draft, but are still based primarily on the official 2010 IRP document.

The existing generation plant is assumed to be available over the 2015 to 2024 period, except for the units expected to be decommissioned in line with their decommissioning schedules. New generation will be added to the network over this period in line with the 2010 IRP, which contains both approved new power stations and proposed "New Build" power stations.

The currently approved new major power stations are as follows:

- Medupi – 6 x 800 MW units coal-fired – 738 MW sent out
- Kusile – 6 x 800 MW units coal-fired – 738 MW sent out
- Ingula – 4 x 333 MW units pumped-storage – 333 MW sent out

In order to achieve the proposed plan of the IRP 2010, a number of assumptions regarding size and location of the future planned generation plant had to be made. These assumptions are discussed below.

Return to Service stations

The return-to-service (RTS) units at Grootvlei, Camden, and Komati Power Stations are all assumed to be in service before the system peak of 2015.

DoE OCGT power stations

The IRP indicates that the Department of Energy (DoE) should have implemented the two OCGT power stations by 2013. They have not yet been confirmed, but it is assumed that they will be completed in time for the 2015 system peak. These are assumed to be located as previously proposed by the DoE, with one close to the Dedisa MTS and one close to the Avon MTS. They will be based on 147 MW units and will be modelled as follows:

- 2 x 147 MW units at Dedisa
- 4 x 147 MW units at Avon

Ingula Pumped Storage

The Ingula Pumped-storage Power Station is an approved project. The project has been rescheduled, and it is now assumed to only have Units 1 and 2 completed in time for the 2015 system peak, with Unit 3 completed in late 2015 and Unit 4 completed in 2016, in time for the 2016 system peak.

Base Load Coal (Medupi and Kusile)

The baseload coal-fired power stations at Medupi and Kusile are approved projects. However, both projects have been rescheduled, with Medupi delayed and Kusile brought forward.

Medupi has been delayed from 2013 to late 2014, with the first unit only available for the 2015 system peak; the last unit will be completed before the 2017 system peak. Kusile has been brought forward from 2017, with the first unit available for the 2016 system peak. The roll-out will be slower than Medupi, with the last unit in place for the 2019 system peak.

No further large Eskom-built baseload coal-fired power stations are expected for the TDP period of 2015 to 2024.

Co-generation Projects and MTPPP

A total of 390 MW of cogeneration plant is included in the 2010 IRP by 2013. There is no indication of what size plant and where these plants will be located. Based on the studies for the proposed Sasol cogeneration plant, two 200 MW units will be assumed to be located at Sol B as per the project studies. The third 200 MW unit, as assumed for the previous TDP study, will not be included until there is clarity on the programme. The MTPPP programme that offered PPA contracts to any generators that fell below a certain price level was not considered at Transmission level, as most were less than 20 MW in size.

New Coal options

The 2010 IRP has provision for new coal-fired power stations under the New Build options. These are smaller than the traditional Eskom baseload coal power stations, and it has been assumed that these will be IPP coal stations with smaller units to match the 2010 IRP requirements. This is in line with the DoE programme to have a coal IPP procurement programme. In order to model the potential integration for this programme, a number of separate IPP coal stations are assumed for the TDP analysis.

A total of four new IPPs have been assumed, referred to as Coal IPP 1, Coal IPP 2, Coal IPP 3, and Coal IPP 4. Two are assumed to be the same as for the previous TDP, namely, Coal IPP 1 and Coal IPP 3. The first two, Coal IPP 1 and Coal IPP 2, have been allocated as a 600 MW station for 2019 and a 750 MW power station for 2022, based on current IPP projects under investigation. Coal IPP 1 will be in the Witbank area (the Khanyisa project) and Coal IPP 2 will be in the Lephalale area (the Exxaro project).

Coal IPP 3 is modelled as a 400 MW power station in 2020 in the greater Witbank area, to be connected to the Kriel Power Station HV yard via a 25 km 400 kV line. Coal IPP 4 is a new 1 000 MW (4 x 250 MW) power station in the Lephalale area, to be connected to the Massa substation via two 400 kV lines from 2022 to 2024.

Nuclear Generation

For this TDP update, the Nuclear 1 Power Station has been included in line with the 2010 IRP allocation from 2023. It has been assumed to be established at the Thyspunt site near Port Elizabeth. The network integration remains unchanged from the previous TDP, with five 400 kV lines. A plant size of 4 200 MW is assumed.

RE IPP Generation

The procurement phases of the first three rounds of the government RE IPPP have been completed. The REBID allows IPPs to bid tariffs, with maximum tariff limits for the following renewables:

- Wind
- Small hydro
- Landfill gas

- Concentrated solar
- Photovoltaic (PV)

Window 1 and 2 successful and shortlisted IPPs will be in place for the system peaks of 2015 and 2017, respectively. The Window 3 shortlisted projects are assumed to be in service as per their bid submission dates between 2016 and 2017.

The renewable generators are assumed to be connected to the substation that either supplies the distribution network that they are connected into or is the point of connection.

Wind Generation

From 2018 onwards to 2024, the wind generation as per the 2010 IRP has been allocated as four 100 MW units per year to various transmission substations.

PV Solar Generation

A significant amount of PV has been allocated under New Build options in the 2010 IRP, with over 3 600 MW by 2023. The government REBID IPP programme has resulted in a large amount of PV solar plants being installed. PV can only operate when there is sunlight and will, therefore, not be available for the system peak, which occurs in the evening during winter. While PV does not contribute to meeting the peak system demand, it does make a significant contribution to energy supplied to the system during daylight hours and a reduction of South Africa's carbon footprint

Concentrated solar power (CSP) generation

The concentrated solar power (CSP) generation has been set at 900 MW in the 2010 IRP document. For the purposes of this TDP update, the three successful CSP projects from the REBID programme have been allocated as explained in the section on RE IPP generation, with two 50 MW units at Garona substation and a 100 MW unit at Paulputs. It is assumed that, from 2018 to 2019, 100 MW plants will be connected at Upington in line with the IRP.

For the purposes of the TDP, the 100 MW units will be connected to a new 400/132 kV substation at Upington, initially connected to the new Nieuwehoop substation by a single 400 kV line. The integration of the Upington 400 kV substation will be in accordance with the proposed 1000 MW Solar Park scheme. One 100 MW unit will be added each year, starting from 2018 up until 2024.

These units will be run at maximum output during system peak, since they will have sufficient heat stored to operate for several hours after sunset. They will not be run during the low load conditions at night.

Open and Combined Cycle Gas Generation (OCGT & CCGT)

There are a number of open-cycle gas turbine (OCGT) and combined-cycle gas turbine (CCGT) generation plants proposed as New Build options in the 2010 IRP, giving a total of 711 MW OCGT and 805 MW CCGT. Based on the assumption that the CCGT would require an LNG plant and that a minimum of 2 000 MW would be required to make this economically viable, the site has been selected as Dedisa. This will result in more than 2 000 MW of gas generation in the Coega area.

Their unit sizes at Dedisa to match the 2010 IRP have been assumed as follows:

- OCGT (2 x 237 MW) from 2019 to 2021
- CCGT (3 x 269 MW) in 2022

Imported Hydro power

In the 2010 IRP, there is an assumption of 1 143 MW of imported hydropower in 2022 and a further 1 183 MW in 2023. The most likely place that this hydro will come from is Northern Mozambique. This will be transported down to the Maputo area via the proposed Mozambique transmission backbone project (referred to as CESUL). This will, in effect, relocate the power to Maputo. For the purposes of the TDP, this will relieve the Mozal load in Maputo, which Eskom is required to supply. Therefore, the hydro import is modelled as four 570 MW generators placed at the Maputo 400 kV busbar.

Other RE IPP Renewable Generation

The majority of the Government REBID IPP program is expected to be wind generation, PV and CSP with the balance of the RE IPP made up of landfill and small hydro. The landfill and small hydro are a mixture of relatively small units and they are most likely to be connected to the Distribution networks, and are ignored for the purposes of the TDP.

Decommissioning of Coal Units

The 2010 IRP indicates that the first decommissioning of large coal units will start in 2022. This will be an equivalent of five 380 MW units at Camden in 2022. However, Eskom has started to consider the decommissioning of the older coal-fired power station units. According to the proposed Eskom schedule, from 2020, units will start to be decommissioned at Camden and Hendrina. In 2022, units will start to be decommissioned at Arnot.

For the purposes of this TDP, the proposed Eskom decommissioning will be assumed to start one year later than what was assumed in the last TDP period, namely, starting from 2021 instead of 2020.

New generation summary

A summary of the new plant and the year that the last unit at the power station will become commercially available appears in Appendix A. These generation units were assumed to be in service at the expected dates.
This is graphically illustrated in Figure 2.2 and Figure 2.3.

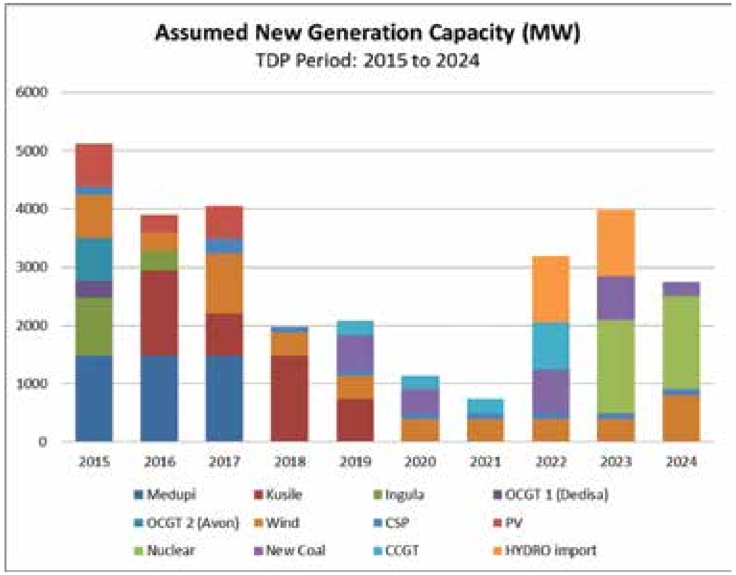


Figure 2.2: Power station capacity introduction by year

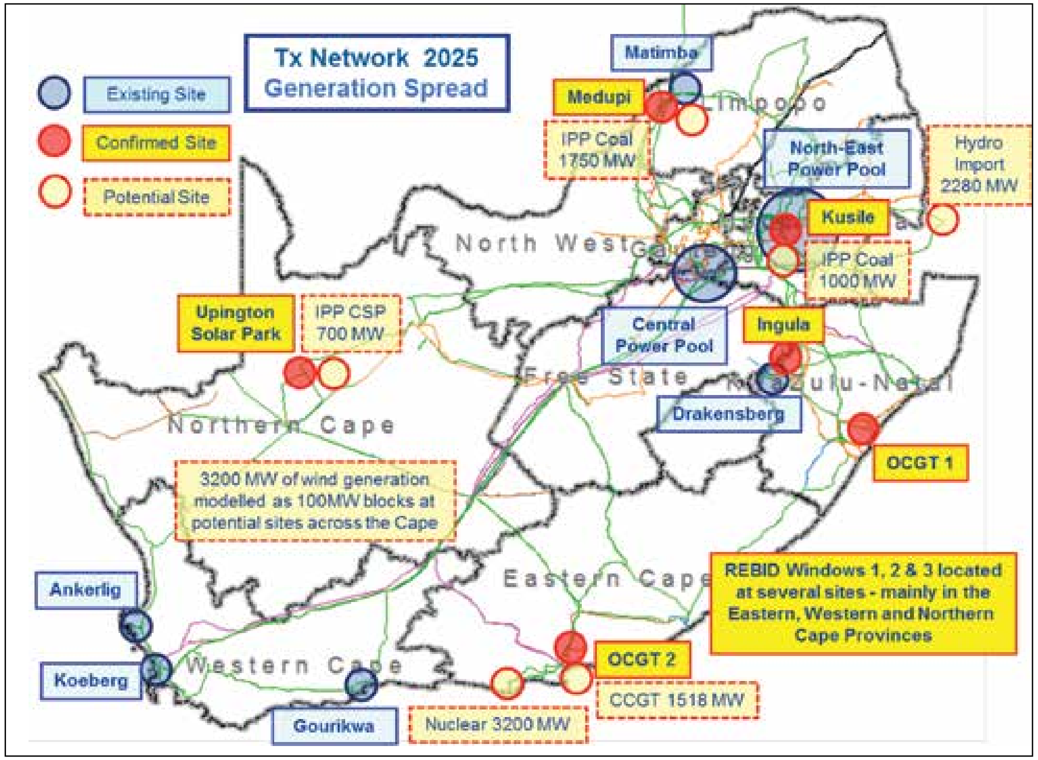


Figure 2.3: Planned power station capacity by 2025

Chapter 3
Major changes from previous TDP

There have been some changes in the factors influencing the selection and timing of projects for this TDP from the previous TDP published in 2012. The main factor was the funding constraints arising from the MYPD3 tariff increases awarded by Nersa, followed by the potential generation scenarios. These two factors are briefly discussed in this section as background to the motivation of the projects and their timing in the TDP. Other changes are deferment of projects resulting from deferment of the need for system strengthening due to the lower load forecast, as well as delays in projects currently in the execution phase, mainly as a result of challenges in the acquisition of substation sites and servitudes for lines.

3.1 The MYPD3 tariff award

The funding constraints being experienced by Eskom meant that the Transmission Development Plan developed in early 2013 was no longer affordable and, hence, no longer realistic. Unfortunately, it was necessary to reprioritise projects to fit within the constraints of the remaining budget available to fund them. The reprioritised projects maximise the benefits accruing from the remaining funds to South Africa, while minimising the risks to security and reliability of supply.

3.2 Generation Assumptions

A number of generation projects that were assumed to be in place for the TDP studies for the period 2013 to 2022 have been changed in the generation assumptions for this TDP update period. These were discussed in chapter 2.2.

Chapter 4
Update on projects and connection applications

4.1 Update on transmission reliability

This chapter shows the projects completed and nearing completion since the previous TDP publication in 2012/13. The project lists exclude feeder bay projects resulting from connection applications received.

Table 4.1: Completed projects 2012/2013 and 2013/2014 FY be completed by FY 2014/2015

SUB-PROJECT NAME	PROVINCE
Zeus-Mercury 765 kV line	*Free State*
Mercury-Perseus 765 kV line	*Free State*
Lewensaar-Ferrum 275 kV line	*Northern Cape*
Lewensaar-Garona 275 kV line	*Northern Cape*
Witkop 3rd transformer	*Limpopo*
Witkop-Tabor 400 kV line	*Limpopo*
Tabor 400/132 kV transformer	*Limpopo*
Witkop 30 MW solar PV	*Limpopo*
Khanyazwe (Malelane) 250 MVA 275/132 kV transformer	*Mpumalanga*
Marathon-Komatipoort 275 kV loop-in	*Mpumalanga*
Kusile-Minerva 400 kV line	*Mpumalanga*
Hydra-Gamma 1st 765 kV line	*Eastern Cape*
Cookhouse 140 MW wind farm	*Eastern Cape*
Koeberg-Muldersvlei 400 kV line	*Western Cape*
Acacia 3rd transformer	*Western Cape*
Bighorn 2nd 800 MVA 400/275 kV transformer	*North West*

4.2 Grid connection applications

During 2013, the Grid Code was amended to remove feasibility quotations from the range of quotations available to customers, after experience had shown that their preparation increased costs and lead times, without delivering commensurate value to customers, and they will, henceforward, no longer be reported on. The term "indicative quotation (IQ)" was also changed to "indicative cost estimate (ICE)" in the Grid Code. This was done, as the cost estimate is based on quick desktop estimation techniques issued to customers without obligation on either party. The cost estimate is also compiled purely to allow customers to assess whether their project is worth further development towards financial closure. Table 4.3 outlines the number of indicative cost estimates (ICEs) and budget quotations (BQs) that were processed during the financial year April 2013 to March 2014. These were as a result of applications for grid connections, as per the Grid Code.

As shown in Table 4.3, the number of customer applications for grid connections processed is fairly high. The primary driver has been the first three rounds of the DoE's RE IPP programme. One of the reasons for the dramatic reduction in BQs applied for when compared with ICEs issued is that only RE IPP projects selected as preferred bidders by the DoE for the first three rounds applied for BQs. The identities of individual applicants are not reported on to protect the confidentiality of the parties involved.

Table 4.2: Projects planned to be completed by FY 2014/2015

SUB-PROJECT NAME	PROVINCE
Kusile-Duvha 400 kV line	*Mpumalanga*
Kusile loop 2 (Kusile-Apollo, Kusile-Kendal 400 kV lines)	*Mpumalanga*
Vulcan bypass (Kendal-Arnot, Duvha-Vulcan)	*Mpumalanga*
Medupi-Spitskop 1 400 kV line	*Limpopo*
Medupi-Spitskop 2 400 kV line	*Limpopo*
Medupi-Marang 400 kV line	*Limpopo*
Spitskop-Dinaledi 1 400 kV line	*Limpopo*
Spitskop-Dinaledi 2 400 kV line	*Limpopo*
Gamma-Kappa 765 kV line	*Western Cape*
Kappa 400 kV lines turn-ins (Hydra-Omega 765 kV line)	*Western Cape*
Pelly 20 MVA 132/22 kV transformer	*Gauteng*

Table 4.3: Connection applications quoted and accepted

Indicative cost estimates		Budget quotations	
Issued	*Accepted*	*Issued*	*Accepted*
124	*35 (28%)*	*23*	*8 (35%)*

Chapter 5
National overview

Significant lengths of new transmission lines and associated substations and substation equipment are being added to the system. These additions are mainly due to the major 765 kV network reinforcements required for the supply to the Cape and KwaZulu-Natal. The integration of the new Medupi Power Station in the developing Limpopo West Power Pool also requires significant lengths of transmission line, as it is a long distance away from the main load centres. The HVDC lines/system required for further generation developments in the Limpopo province are also not included, since they will only be required after 2024, and details can only be confirmed once more is known about the size, location, and timing of these developments.

The establishment of large-scale renewable energy generation is becoming the primary driver of network development in the three Cape provinces, apart from the Cape Corridor projects, the base metals mining area in the Northern Cape, and the established metropolitan load centres of Cape Town, Port Elizabeth, and East London.

These new transmission lines form part of the long-term strategy to develop a main transmission backbone from which regional power corridors can be supported. These power corridors will connect generation pools to one another and to the major load centres in the country. This backbone and regional power corridor network structure will allow the increasing system demand to be supplied and the power from new power stations to be integrated more efficiently into the transmission network and distributed where required, both under system-healthy and system-contingency conditions.

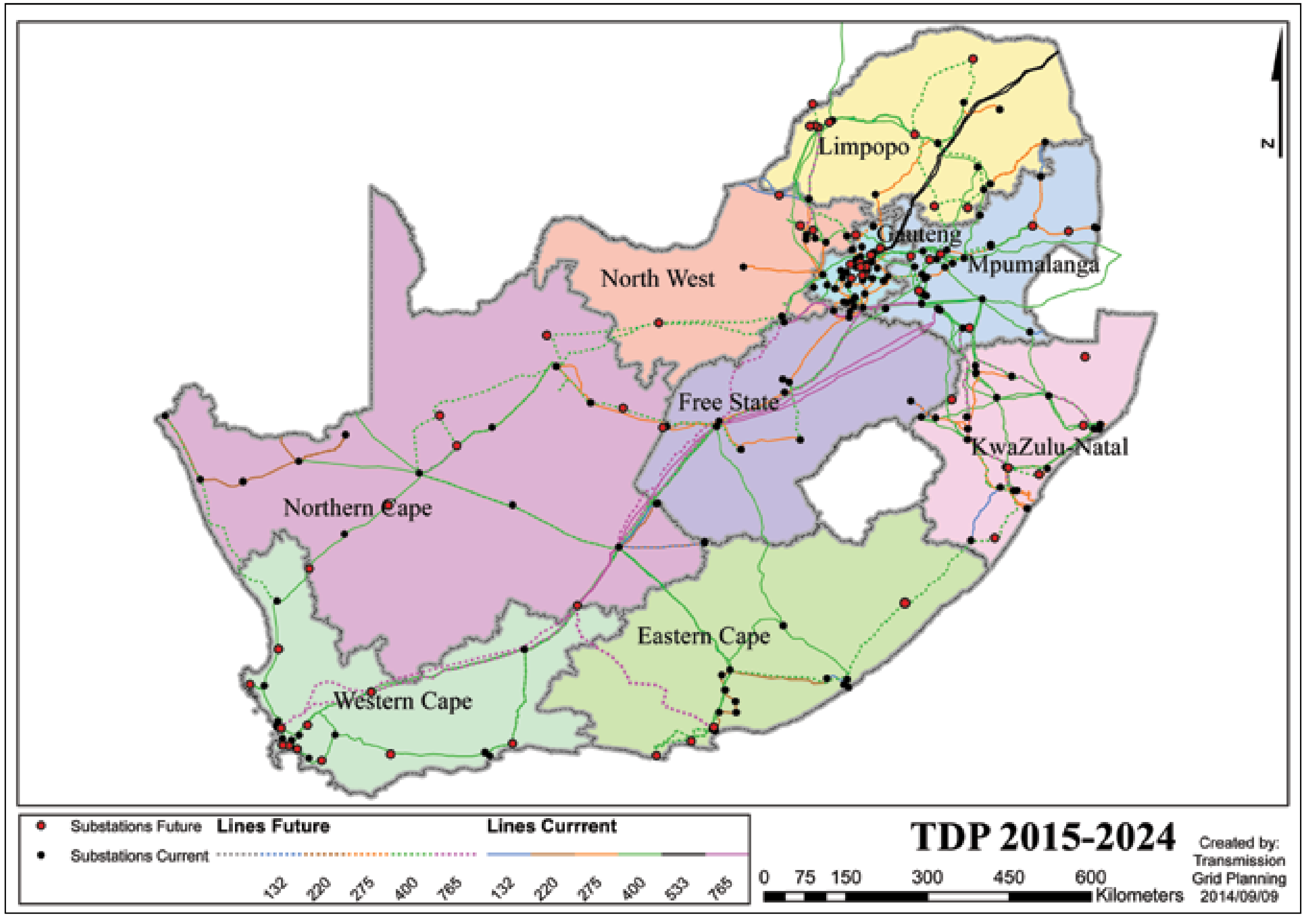


Figure 5.1: Map showing relative location of the major TDP scheme projects

The development of the transmission backbone and the associated regional power corridors was reviewed as part of the Strategic Grid Study, which considered the potential development scenarios beyond the 10-year horizon of the TDP. The objective of this strategic study was to align the transmission network with the requirements of the generation future options and those of the growing and future load centres. This Strategic Grid Study has enabled the 10-year TDP to be aligned with the future long-term development of the whole Eskom system. It also ensures that the most appropriate technologies are used for this purpose by testing whether other technologies (for example, HVDC) would likely yield better, more practical, and more cost-effective solutions.

The additional transformer capacity added to the transmission system is an indication of the increase in load demand and in the firm capacity requirements of the customers, as well as what is required to achieve compliance with the minimum N-1 redundancy requirements contained in the Grid Code.

Additional capacitive support is required to support areas of the network under contingency conditions to ensure that the required voltage levels are maintained and enable more expensive network strengthening such as additional lines to be deferred. It also improves system efficiency by reducing network losses. A number of series compensation projects are also required on the 765 kV and 400 kV lines in order to improve the power transfer capability of the Cape power corridors.

Additional shunt reactors are a direct result of the long lengths of the 765 kV and the 400 kV transmission lines that will be constructed over this period. They are needed to enable safe and secure operation of the system and to prevent overvoltages during light loading conditions.

Some projects have associated distribution projects to enable customers to benefit from them. For example, a new MTS substation may require distribution infrastructure to link it to the existing distribution network or to connect new bulk loads. Distribution infrastructure and individual feeder bays to connect distribution infrastructure or bulk loads are not individually included in this report.

The map in Figure 5.1 shows a high-level view of the major TDP scheme projects. The relative location of the new transmission lines and associated transmission substations is indicated schematically in the figure.

The major new assets that have either been approved or that it is planned to be added to the transmission system over the next 10 years are summarised in Table 5.1.

Table 5.1: Major TDP transmission assets expected to be installed

Transmission assets	New assets expected in 2015 to 2019	New assets expected in 2020 to 2024	Total new assets
Total km of lines	*5 235*	*8 161*	*13 396*
765 kV lines (km)	*760*	*3 180*	*3 940*
400 kV lines (km)	*4 315*	*4 782*	*9 097*
275 kV lines (km)	*160*	*199*	*359*
Total transformer MVA	*29 490*	*51 895*	*81 385*
Transformers (no. of)	*72*	*109*	*181*
Capacitors (no. of)	*20*	*12*	*32*
Reactors (no. of)	*17*	*14*	*31*

Chapter 6
Breakdown of the TDP projects by province

6.1 Gauteng province

The current transmission network is shown in Figure 6.1 below.

The load forecast for the Gauteng province is shown in Figure 6.2 on the next page.

The major TDP schemes for the Gauteng province are as follows:

Johannesburg East Strengthening

This scheme addresses the network constraints in the East Rand and Johannesburg South CLN. The transfer limits in the East Rand and Johannesburg South CLN are expected to increase with the commissioning of the North Rand MTS as well as the 2 x Apollo-North Rand 275 kV lines. The Apollo-North Rand 275 kV lines will be formed by the bypass of Esselen with the planned Apollo-Esselen double-circuit 400 kV line (energised at 275 kV) and the existing Esselen-North Rand 275 kV lines, currently operated at 132 kV.

The 2 x Matla-Jupiter B 400 kV lines (energised at 275 kV) will also contribute to the increase in transfer limits in the East Rand and Johannesburg South CLN.

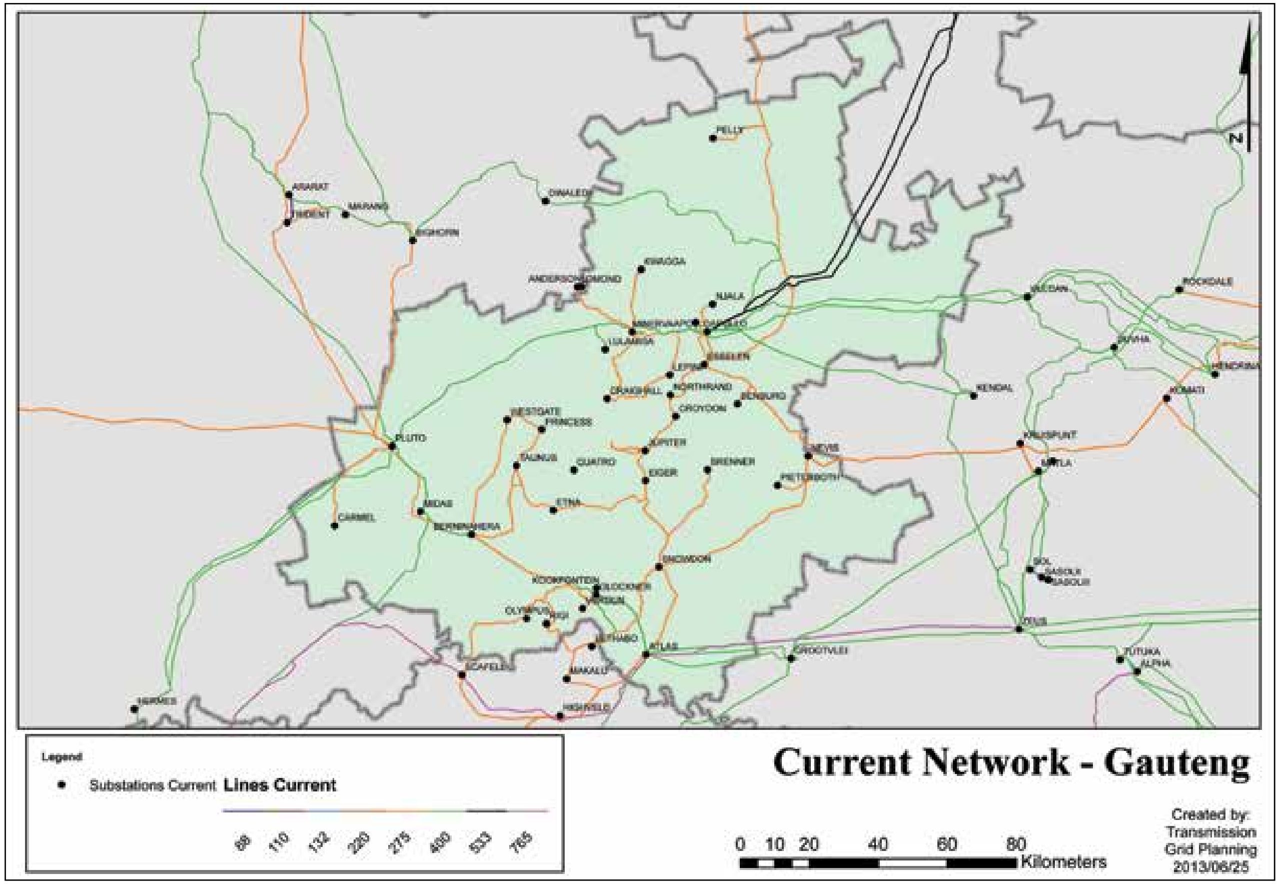
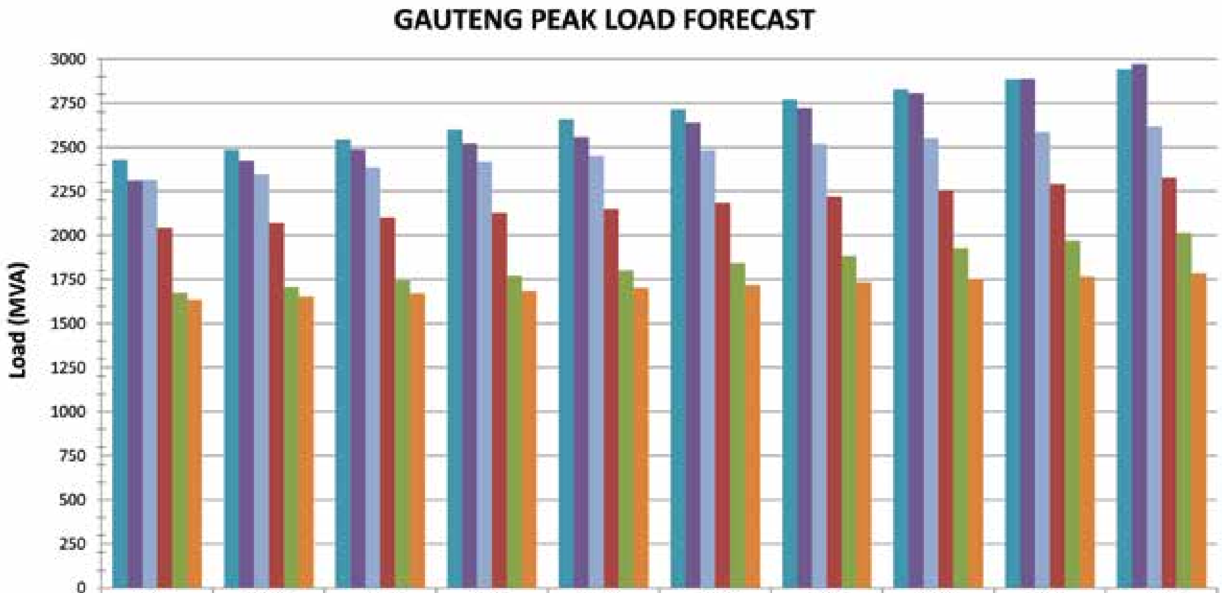


Figure 6.1: Current Gauteng province network diagram



	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Tshwane	2430	2486	2543	2600	2657	2714	2771	2828	2885	2941
JHB South	2311	2423	2487	2520	2559	2639	2721	2804	2888	2973
West Rand	2314	2348	2382	2417	2450	2484	2518	2552	2585	2618
East Rand	2041	2070	2101	2125	2150	2185	2220	2255	2291	2326
JHB North	1672	1706	1743	1770	1799	1841	1884	1927	1971	2015
Vaal	1636	1652	1669	1685	1701	1718	1734	1751	1767	1783
Total	12404	12685	12926	13117	13318	13582	13848	14116	14385	14656

Figure 6.2: Gauteng province load forecast

Johannesburg North Strengthening

The scheme is needed to resolve the thermal and low-voltage constraints in the Johannesburg North CLN and support future loads in the CLN. The scheme entails construction of Apollo-Lepini 400 kV line (operated at 275 kV) and installation of 2 x150 MVAr 275 kV capacitor banks at Lepini substation.

Subsequently, the new Kyalami, Demeter, and Craighall B 400 kV substations will also be introduced to support load growth in the Johannesburg North CLN.

Simmerpan 275 kV integration

Simmerpan Strengthening addresses unfirm transformation at Jupiter substation and overloading of the Simmerpan distribution substation due to load increases in the Ekurhuleni and East Rand area. This will be done, firstly, by conversion of the Simmerpan distribution substation to a 275/88 kV substation and installation of 2 x 160 MVA 275/88 kV transformers. The substation construction will be at 400 kV, but will be operated at 275 kV.

The existing Jupiter-Simmerpan 88 kV lines will then be uprated to 275 kV. Later, the substation will be extended to 275/132 kV. It will have 2 x 250 MVA 275/132 kV transformers to cater for the expected load increase in the area.

Soweto Strengthening

The focus of this scheme is to ensure Grid Code compliance for Taunus, Etna, and Fordsburg substations and address the distribution constraints in the Soweto supply area. The scheme introduces a new transmission substation, Quattro 275/132 kV. This substation will be built at 400/132 kV specification, and 2 x 500 MVA transformers will be installed.

Two new Etna-Quattro lines will be built at 400 kV specifications and energised at 275 kV. Quattro 275/88 kV (built at 400/88 kV specification) will also be built at the same site to cater for City Power network expansion.

Vaal Strengthening

The scheme proposes the building of 2 x Glockner-Etna 400 kV lines (operated at 275 kV), closing the Hera-Bernina 275 kV link, and uprating of underrated equipment at substations in the project vicinity. This will result in deloading of Glockner-Hera 275 kV lines and other thermally constrained lines in the Vaal and West Rand CLNs.

West Rand Strengthening

This scheme addresses future thermal, substation compliance, and distribution network constraints in the West Rand CLN. The scheme will entail the extension of the existing Westgate 275 kV substation to accommodate the new Hera-Westgate 400 kV line and a 400/132 kV 500 MVA transformer.

The second phase of the scheme will introduce a 400 kV HV yard at Etna substation. Two 400/275 kV 800 MVA transformers and a 400/88 kV 315 MVA transformer will be installed at Etna. The two Glockner-Etna lines (energised at 275 kV) established by the Vaal Strengthening Project will then be energised and operated at 400 kV. The Taunus substation will be extended to accommodate the new Etna-Taunus 400 kV line and a 400/132 kV 500 MVA transformer.

Tshwane Reinforcement

The Tshwane Reinforcement Scheme addresses unfirm substations due to load increases in the Tshwane CLN. This will be done by introducing new transmission 400 kV substations, namely, Verwoerdburg, Phoebus, Wildebees, and Anderson.

The increase in transmission assets by the end of 2019 and the end of 2024 and the accumulative total are shown in Table 6.1.

Table 6.1: Cumulative TDP transmission assets for Gauteng province

Transmission assets for Gauteng province	New assets expected 2015 to 2019	New assets expected 2020 to 2024	Total new assets expected
Total km of line	*137*	*721*	*858*
765 kV lines (km)	*0*	*0*	*0*
400 kV lines (km)	*127*	*651*	*778*
275 kV lines (km)	*10*	*70*	*80*
Total installed transformer MVA	*880*	*6 940*	*7 820*
Transformers (no. of)	*5*	*18*	*23*
Capacitors (no. of)	*8*	*1*	*9*
Reactors (no. of)	*0*	*0*	*0*

The timelines have been reassessed based on capital constraints and various execution challenges that have been encountered. This has meant that the project commissioning dates have been delayed for some projects, thus aggravating the network constraints up until the issues have been resolved via these projects.

The following projects are planned for the 2015 to 2024 period:

Table 6.2: Gauteng province – summary of projects and timelines

Scheme name	Project name	Expected year
Benburg Ext. 3rd 250 MVA 275/132 kV	*Benburg Ext. 3rd 250 MVA 275/132 kV transformer*	*2014*
Demeter 400 kV Integration	*Loop in Pluto-Verwoerdburg 400 kV into Demeter*	*2022*
	Demeter Ext. 400/88 kV transformation (1st, 2nd, and 3rd 315 MVA transformers and 400 kV busbar)	*2022*
Johannesburg East Strengthening	*Build a double-circuit 400 kV line from Apollo towards Esselen (energised at 275 kV)*	*2022*
	Bypass Esselen and connect 2 x Esselen-North Rand 275 kV lines (existing 132 kV) to the double-circuit line from Apollo to form the 2 x Apollo-North Rand 275 kV lines	*2022*
	Establish North Rand 400/132 kV substation (to be operated as 275/132 kV), and install 2 x 500 MVA transformers	*2022*
Johannesburg East Strengthening	*Jupiter B 275 kV loop-ins (Prospect-Sebenza 1 and 2, Jupiter-Prospect 1, Jupiter-Fordsburg 1)*	*2022*
	Matla-Jupiter B 1st and 2nd 400 kV lines (operated at 275 kV)	*2022*
	Prospect-Sebenza 1st and 2nd 275 kV lines (energise existing 88 kV line)	*2022*
	Jupiter B 275 kV switching station	*2021*
Johannesburg East Strengthening	*North Rand-Sebenza 1st and 2nd 275 kV lines*	*2022*
	Sebenza substation (400 kV busbar operated at 275 kV)	*2022*

Table 6.2: Gauteng province – summary of projects and timelines

Scheme name	Project name	Expected year
Johannesburg North	*Lepini Ext. 275 kV 2 x 150 MVAr capacitors*	*2017*
	Apollo-Lepini 1st 275 kV line	*2021*
Kookfontein Phase 2	*Kookfontein Ext. 3rd 315 MVA 275/88 kV transformer and 3rd Glockner-Kookfontein 275 kV line establishment*	*2016*
Kyalami 400 kV Integration	*Kyalami 400 kV loop-in (Kusile-Lulamisa 1st 400 kV line) (Kyalami bays are GIS)*	*2022*
	Kyalami 400/132 kV substation (1st and 2nd 500 MVA transformers) (all bays are GIS)	*2022*
Simmerpan 275 kV Integration	*Simmerpan Ext. 275/132 kV transformation (2 x 250 MVA)*	*2024*
	Jupiter B-Simmerpan 1st and 2nd 275 kV lines (uprate of 88 kV lines)	*2021*
	Simmerpan 275/88 kV substation (expand existing Dx station) (2 x 160 MVA transformers)	*2021*
Soweto Strengthening	*Etna-Quattro 1st and 2nd 400 kV lines (energised at 275 kV)*	*2021*
	Quattro 275/88 kV substation (City Power 1st and 2nd 315 MVA transformers) (400/88 kV construction)	*2021*
	Quattro 275/132 kV substation (1st and 2nd 500 MVA transformers) (400/132 kV construction)	*2021*
Vaal Strengthening	*Hera-Bernina 275 kV link closed (uprate of breakers)*	*2015*
	Glockner-Etna 1st and 2nd 400 kV lines (operate at 275 kV)	*2017*
West Rand Strengthening	*Etna Ext. 400/275 kV transformation (2 x 800 MVA)*	*2024*
	Etna Ext. 400/88 kV 315 MVA transformation	*2024*
	Glockner-Etna 1st and 2nd 400 kV lines (operate at 400 kV)	*2024*

Table 6.2: Gauteng province – summary of projects and timelines (continued)

Scheme name	Project name	Expected year
West Rand Strengthening	*Westgate 400/132 kV substation (1st 500 MVA transformer)*	*2021*
	Hera-Westgate 1st 400 kV line	*2021*
West Rand Strengthening	*Etna-Taunus 1st 400 kV line (energised at 275 kV)*	*2024*
	Taunus Ext. 400/132 kV transformation (1 x 500 MVA)	*2024*
Pelly Integration	*Pelly 20 MVA 132/22 kV transformer*	*2015*
Tshwane Reinforcement – Verwoerdburg Phase 1	*Apollo-Pluto 400 kV loop in-out Verwoerdburg*	*2015*
	Verwoerdburg 400/132 kV substation (1st and 2nd 250 MVA transformers)	*2015*
Verwoerdburg Phase 2	*Verwoerdburg 400/132 kV substation (3rd 250 MVA transformer)*	*Customer dependent*
Tshwane Reinforcement – Phoebus Phase 1	*Phoebus 400/275/132 kV Substation (1st and 2nd 400 MVA 400/275 kV transformer)*	*Customer dependent*
	Phoebus Ext 400/132 kV transformation (1st 250 MVA transformer)	
	Pelly – Phoebus 1st 275 kV line (energize Hangklip – Pelly 132 kV line)	
	Phoebus 400 kV loop-in (Apollo – Dinaledi 1st 400 kV line)	
Phoebus Phase 2	*Phoebus – Kwagga 1st 275 kV line*	*Customer dependent*
Anderson Phase 1	*Anderson 400/132 kV substation (1st and 2nd 250 MVA transformers)*	*2023*
	Dinaledi-Anderson 400 kV line	
Wildebees Phase 1	*Wildebees 400/132 kV (customer 250 MVA transformers)*	*2021*
	Wildebees 400 kV loop in-out (Apollo-Dinaledi 1st 400 kV)	
New: Johannesburg Strengthening	*Craighall B and Sebenza-Craighall B 400 kV line operated at 275 kV*	*2024*
New: West Rand Reactive Power Project	*1st 48 MVAr capacitor bank at Etna 88 kV*	*2021*
	2nd 48 MVAr capacitor bank at Etna 88 kV	
	1 x 72 MVAr capacitor at Quattro 132 kV	
New: Brenner Strengthening	*Brenner 2 x 88 kV 48 MVAr capacitors*	*2024*
	Siluma (Brenner B) 275/88 kV substation (built at 400 kV)	

A network diagram of the major projects in the Gauteng province network is shown in Figure 6.3 below:

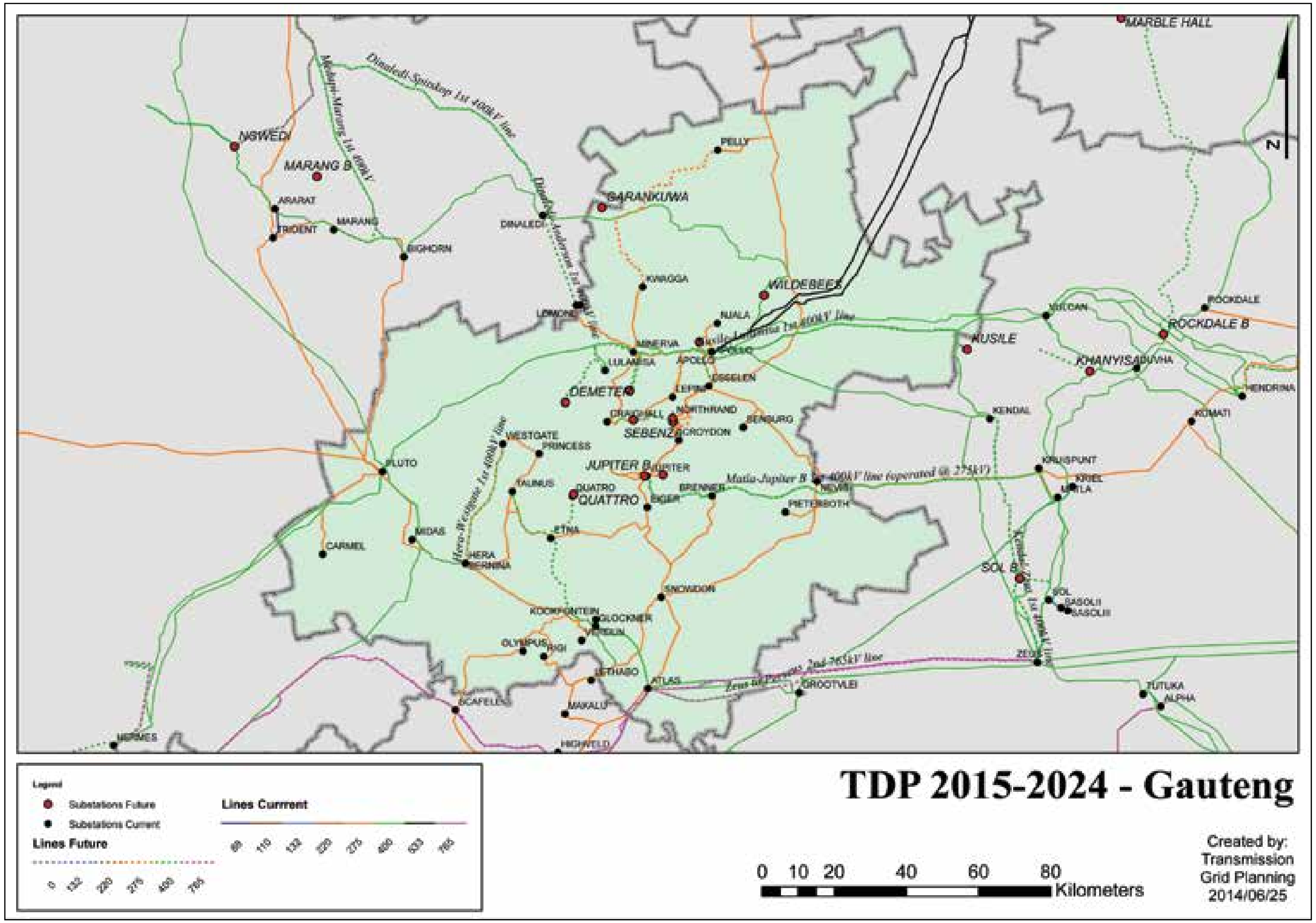


Figure 6.3: Future Gauteng province network diagram

6.2 KwaZulu-Natal (KZN) province

The current transmission network is shown in Figure 6.4 below.

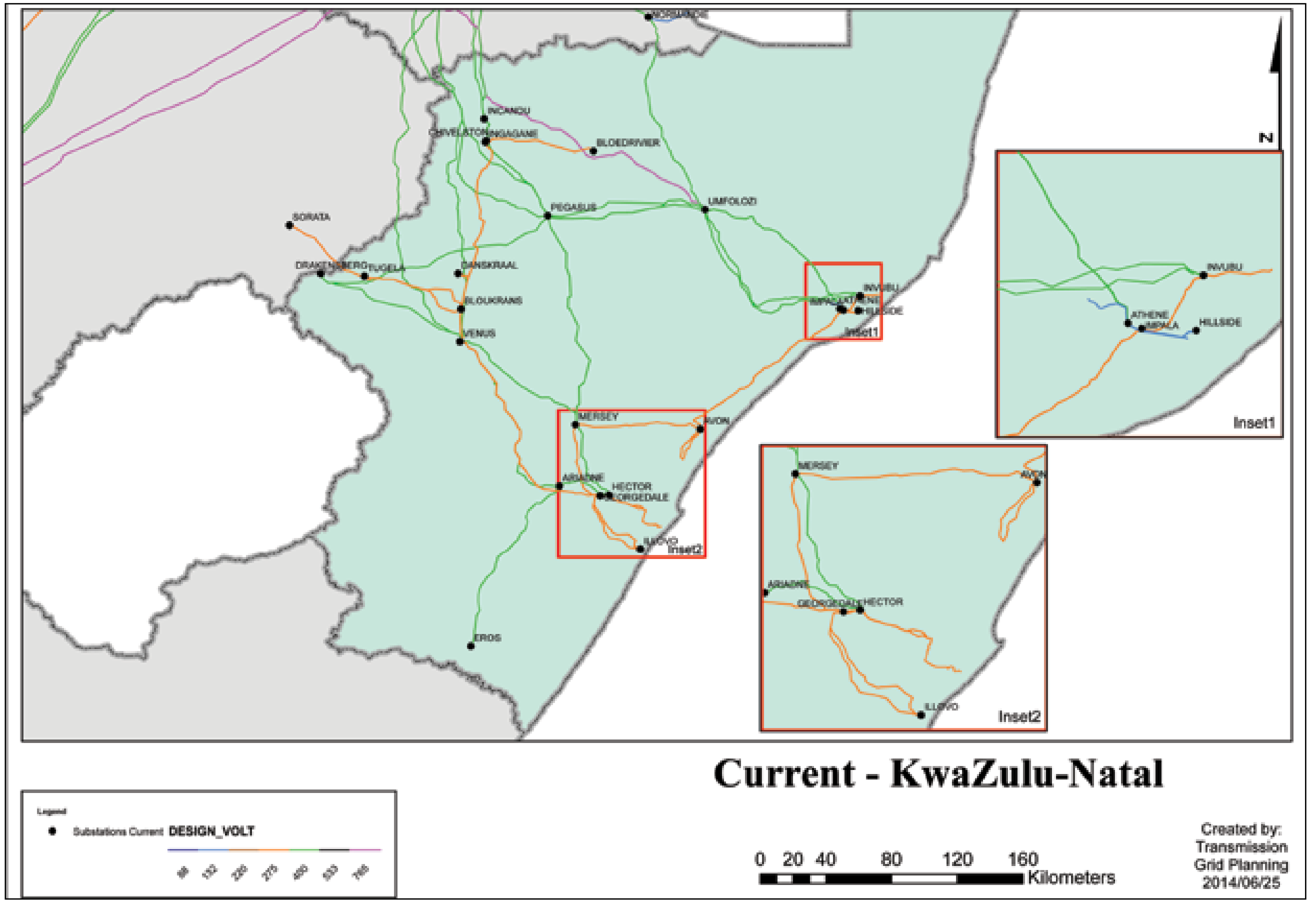


Figure 6.4: Current KZN province network diagram

The single-line diagram for the KZN province is shown in Figure 6.5 below.

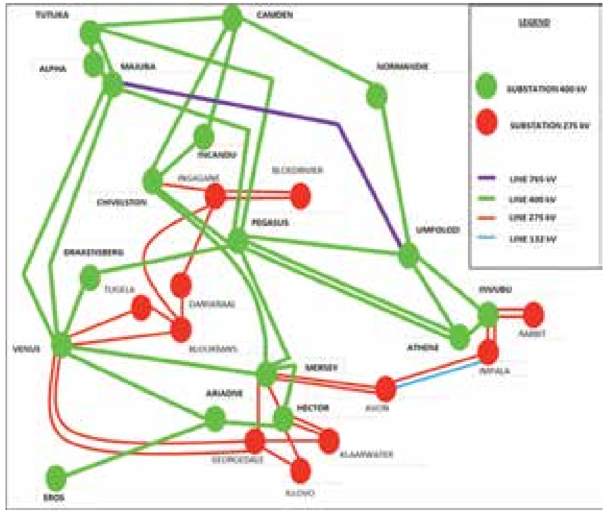
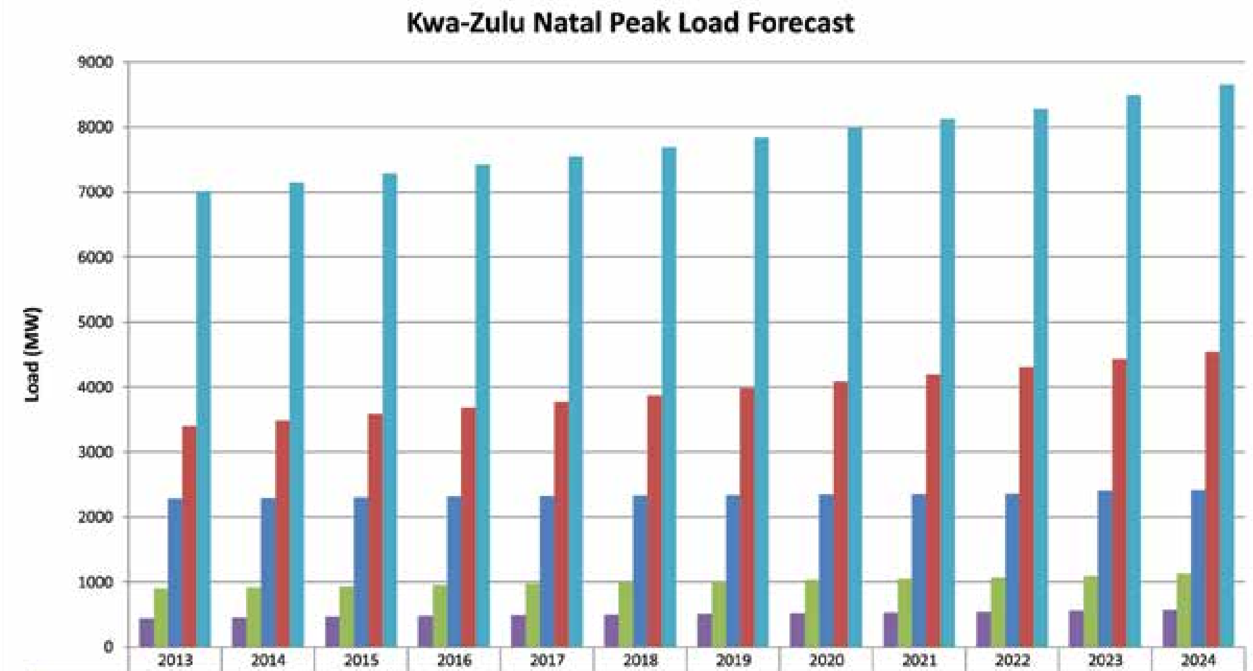


Figure 6.5: Current KZN province network single-line diagram

The load forecast for the KZN province is shown in Figure 6.6 below.



	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Ladysmith	439	449	467	478	488	498	509	521	531	543	559	570
Newcastle	899	917	937	955	976	994	1013	1033	1052	1070	1095	1130
Empangeni	2280	2289	2297	2311	2320	2328	2337	2346	2352	2358	2407	2414
Pinetown	3398	3489	3584	3682	3769	3871	3981	4090	4194	4309	4433	4540
Total	7016	7144	7285	7425	7553	7691	7841	7990	8129	8280	8494	8654

Figure 6.6: KZN province load forecast

The major schemes for KZN province are listed below:

KZN 765 kV Strengthening

The KZN 765 kV Strengthening Project entails establishing 765 kV in the Pinetown and Empangeni areas, which will run from the power pool in the north, integrating it into the 400 kV network in both areas. The Pinetown and Empangeni 765 kV networks will also be linked via two 400 KV lines.

South Coast Strengthening

This includes construction of the 2nd Ariadne-Eros 400 kV and 132 kV multi-circuit line and establishment of St Faiths 400/132 kV substation near Port Shepstone.

Greater East London Strengthening Scheme

This project involves strengthening of the network from the KwaZulu-Natal OU to the Eastern Cape OU. This includes establishment of Vuyani 400/132 kV substation and construction of the Eros-Vuyani, Vuyani-Neptune, and Neptune-Poseidon 400 kV lines. This project provides a much-needed 400 kV injection into the Umtata area.

eThekwini Electricity Network Strengthening

The original eThekwini Electricity Strengthening Plan involved the extension of Umgeni substation to include 275/132 kV transformation and supply it from Hector substation by recycling the Klaarwater-Umgeni 132 kV double-circuit servitude to a 275 kV double-circuit Hector-Umgeni line. The plan also involved the construction of

2 x Mersey-Ottawa 400 kV lines (operated at 275 kV). This plan was revised due to servitude constraints and further load growth around La Mercy (King Shaka International Airport).

The revised plan involves the establishment of Shongweni 2 x 500 MVA 400/132 kV substation and the construction of two 400 kV single-circuit lines from Hector to the proposed Shongweni substation to de-load Hector-Klaarwater 275kV lines and Klaarwater substation. It also involves the establishment of Inyaninga 2 x 500 MVA 400/132 kV substation, looped into one of the planned Isundu-Mbewu 400 kV lines to form Isundu-Inyaninga 400 kV line and Inyaninga-Mbewu 400 kV line.

Candover 132 kV Switching Station Extension (2 X 500 MVA 400/132 kV Transformers)

This project involves the extension of Candover 132 kV switching station to a 400/132 kV substation in 2021 in order to address supply constraints around Pongola, Makhatini Flats, and iSimangaliso (Greater St Lucia) Wetland Park. The proposed Candover 400/132 kV substation will be supplied from Nzalo 400/88 kV substation via two 400kV lines. Nzalo substation is part of the proposed Ermelo-Richards Bay Coal Link Upgrade.

The increase in transmission assets by the end of 2019 and the end of 2024 and the cumulative totals are shown in Table 6.3

Table 6.3: Cumulative TDP transmission assets for KwaZulu-Natal province

Transmission assets for KZN province	New assets expected 2015 to 2019	New assets expected 2020 to 2024	Total new assets expected
Total km of line	*450*	*1 135*	*1 585*
765 kV lines (km)	*0*	*110*	*110*
400 kV lines (km)	*450*	*1 025*	*1 475*
275 kV lines (km)	*0*	*0*	*0*
Total installed transformer MVA	*1 545*	*11 750*	*13 295*
Transformers (no. of)	*7*	*13*	*20*
Capacitors (no. of)	*0*	*0*	*0*
Reactors (no. of)	*0*	*3*	*3*

The following projects are planned for the 2015 to 2024 period:

Table 6.4: KZN province – summary of projects and timelines

Scheme name	Project name	Expected year
South Coast Strengthening	*Ariadne-Eros 2nd 400 kV line*	*2021*
Normandie transformer upgrade	*Normandie 2nd 250 MVA 400/132 kV transformer*	*2016*
Greater East London Strengthening – Phase 1	*Eros-Vuyani 1st 400 kV line*	*2015*
Avon transformer upgrade	*Avon 3rd 250 MVA 275/132 kV transformer*	*2015*
Transnet Coal – Line Upgrade	*3 of 1 x 160 MVA 400/88 kV substations* *Loop-in Camden-Normandie 1 400 kV line, Normandie-Umfolozi 1 400 kV line, and Pegasus-Athene 1 400 kV line, respectively*	*Customer Dependant*
Avon IPP	*DoE OCGT IPP at Avon 275 kV*	*2015*
Ariadne-Venus 2nd 400 kV Line	*Ariadne-Venus 2nd 400 kV line (recycle Georgedale-Venus 1 or 2 275 kV line)*	*2020*
Ingula Pumped-storage Power Station Integration	*Ingula 400 kV busbar* *Loop-in Majuba-Venus 2 400 kV line into Ingula* *Ingula-Venus 2nd 400 kV line*	*2014*
Incandu transformer upgrade	*Incandu 3rd 500 MVA 400/132 kV transformer*	*2017*
Georgedale Refurbishment	*Georgedale – replace 2 x 150 MVA 275/132 kV transformers with 2 x 250 MVA transformers*	*2015*
KZN 765 kV Strengthening – Empangeni Integration	*Mbewu 1 x 765/400 kV 2 000 MVA substation* *Loop-in Athene-Umfolozi 1 400 kV line and Invubu-Umfolozi 1 400 kV line into Mbewu* *Umfolozi-Mbewu 765 kV line (extension of Majuba-Umfolozi 1 765 kV line)* *Invubu-Mbewu 2nd 400 kV line*	*2022*
KZN 765 kV Strengthening – Lambda Substation	*Lambda 2 x 400/765 kV 2 000 MVA substation* *Majuba-Lambda 1st 400 kV and Tutuka-Lambda 1st 400 kV lines*	*2022*

Table 6.4: KZN province – summary of projects and timelines (continued)

Scheme name	Project name	Expected year
KZN 765 kV Strengthening – Pinetown Integration	*Isundu 1 x 765/400 kV 2 000 MVA substation* *Loop-in Ariadne-Hector 2 400 kV (de-energised) circuit into Isundu* *Lambda-Isundu 1st 765 kV line*	*2024*
KZN 765 kV Strengthening – Isundu-Mbewu 1st and 2nd 400 kV Lines	*Isundu-Mbewu 1st and 2nd 400 kV lines*	*2025*
eThekwini Electricity Network Strengthening	*Inyaninga 2 x 500 MVA 400/132 kV substation* *Loop-in Isundu-Mbewu 1 400 kV line into Inyaninga*	*2026*
	Shongweni 2 x 500 MVA 400/132 kV substation *2 x Hector-Shongweni 1st and 2nd 400 kV lines*	*2024*
Harrismith Strengthening – Phase 1	*Sorata 400 kV busbar (operated at 275 kV)* *Sorata 1st 250 MVA 275/132 kV transformer*	*2021*
Mersey transformer upgrade	*Mersey Ext. 3rd 250 MVA 275/132 kV transformer*	*2017*
South Coast Strengthening	*St Faiths 2 x 500 MVA 400/132 kV substation* *Loop-in Ariadne-Eros 2 400 kV line into St Faiths*	*2021*
Candover 400/132 kV	*Candover 400 kV busbar* *Nzalo-Candover 1st and 2nd 400 kV lines* *Candover 2 x 500 MVA 400/132 kV transformers*	*2022*
KZN 765 kV Strengthening – Camden Ext.	*Camden Ext. 1st 400/765 kV 2 000 MVA transformer* *Camden-Mbewu 1st 765 kV line* *Mbewu Ext. 2nd 765/400 kV 2 000 MVA transformer*	*2028*

Geographical network diagrams indicating the major projects in the KZN province for the 10-year period are shown in Figure 6.7, Figure 6.8 and Figure 6.9 below.

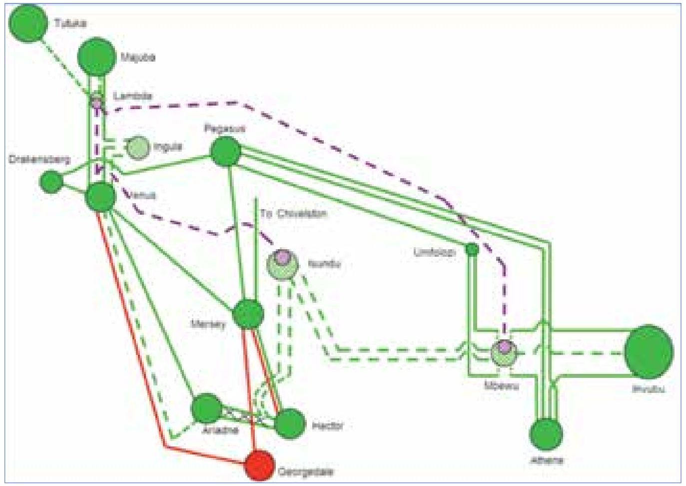


Figure 6.7: KZN 765 kV strengthening, including Ingula integration

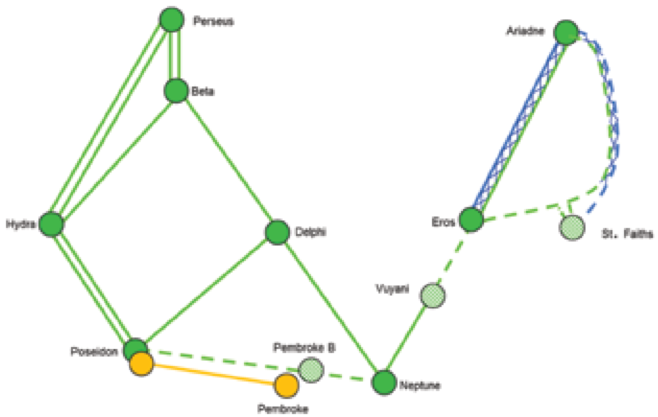


Figure 6.8: South Coast Strengthening and Greater East London Strengthening Scheme

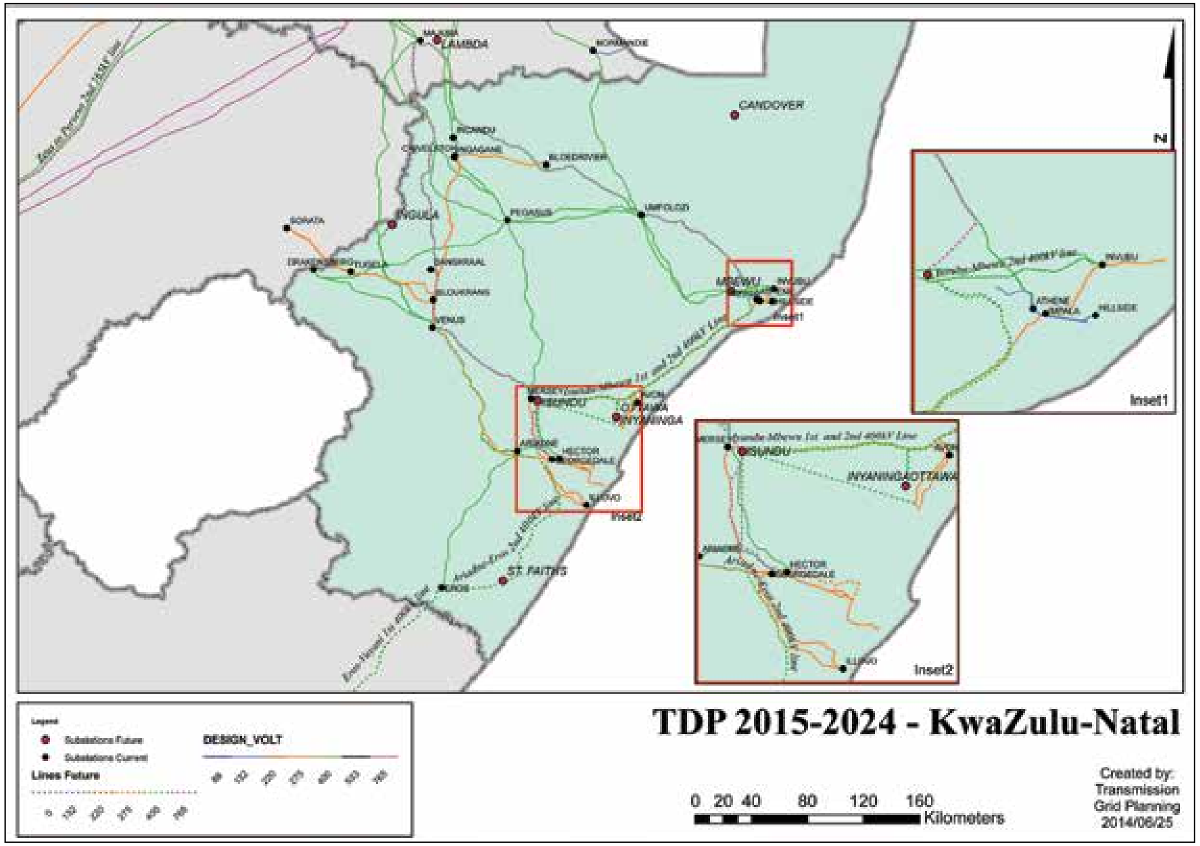


Figure 6.9: Future KZN province network diagram

6.3 Limpopo province

The Limpopo province load growth is mainly due to the platinum group metals (PGM) and ferrochrome mining and processing activities located in the Polokwane and Steelpoort areas.

The TDP scheme projects for the province consist of extending the 400 kV and 275 kV networks as well as establishing the 765 kV network, (operated at 400 kV) integrating the Medupi Power Station, and installing additional transformers at existing and new substations.

The current transmission network is shown in Figure 6.10 below.

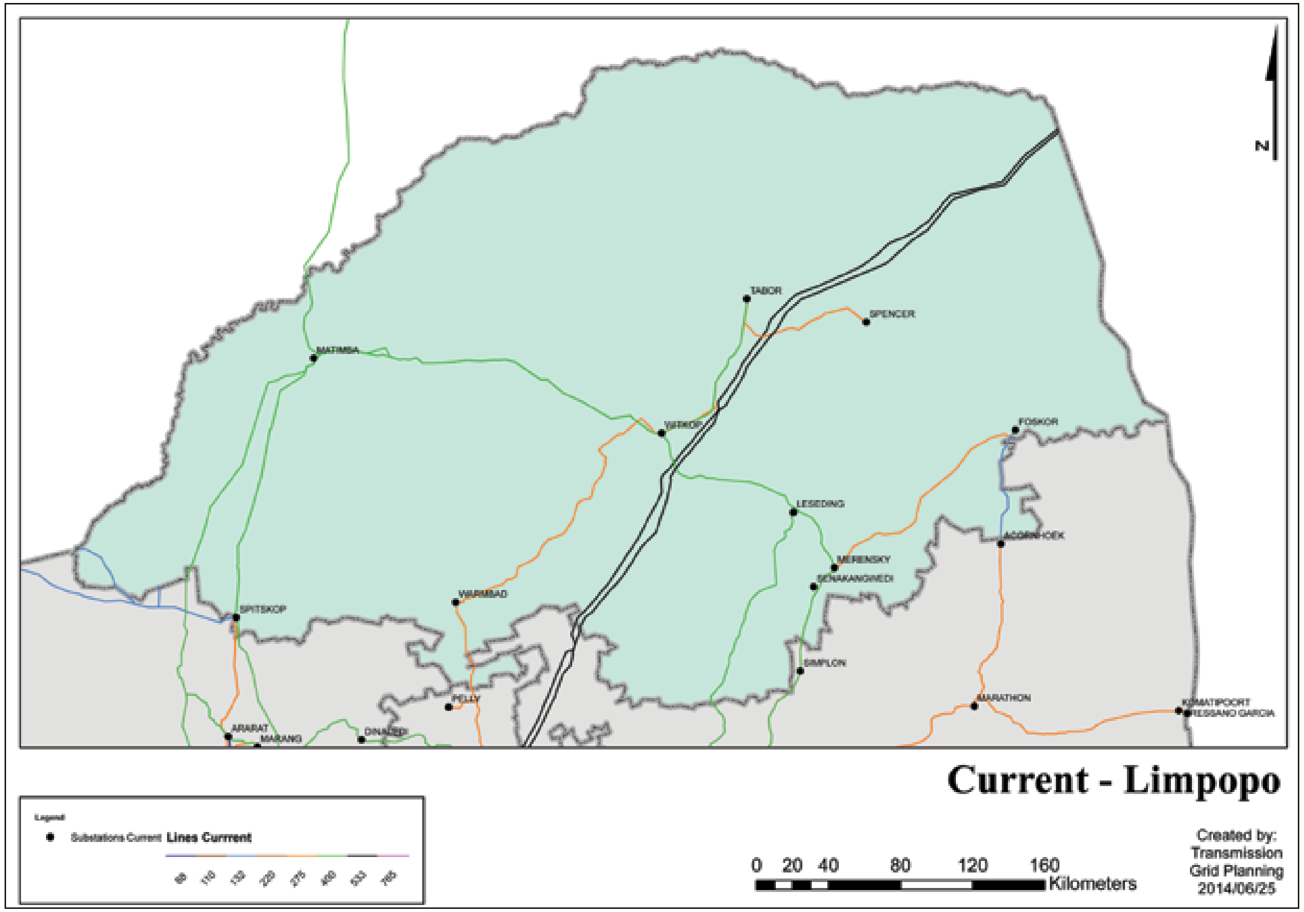
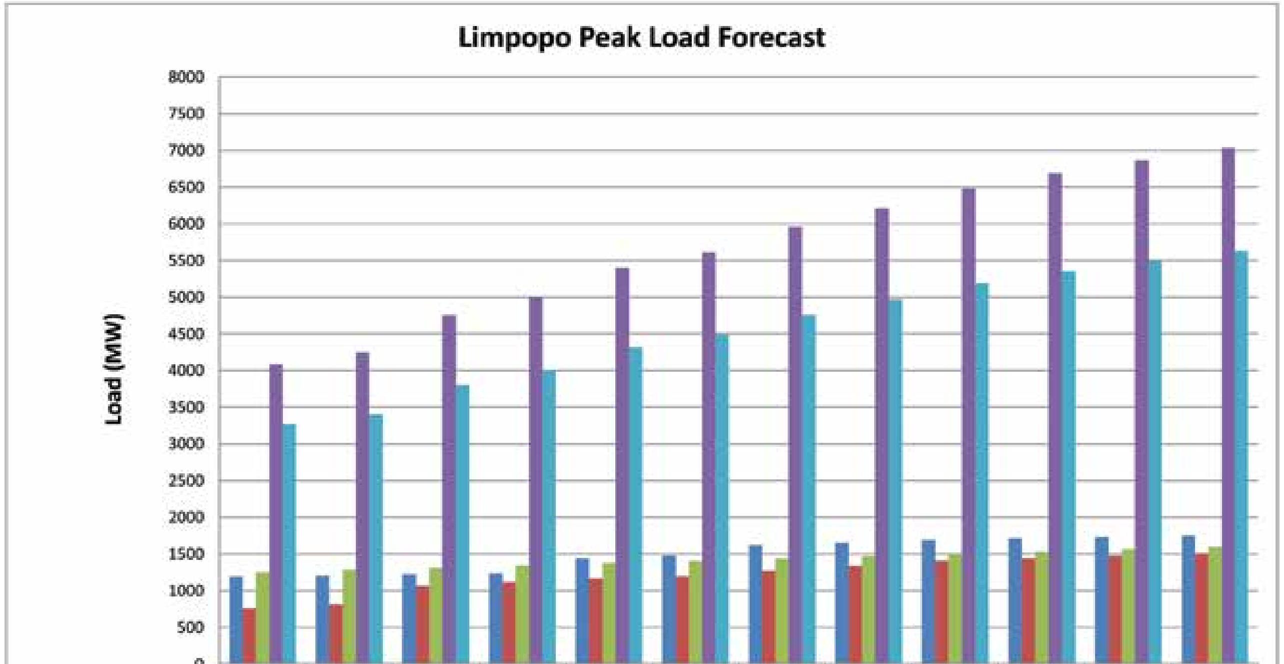


Figure 6.10: Current Limpopo province network diagram

The load forecast for the province is shown in Figure 6.11 below.



	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Phalaborwa	1195	1209	1223	1236	1441	1478	1618	1656	1690	1711	1731	1752
Lephalale	759	808	1070	1115	1162	1199	1268	1341	1411	1441	1475	1511
Polokwane	1249	1280	1311	1343	1374	1406	1437	1468	1500	1531	1562	1594
Undiversified Limpopo	4087	4250	4756	5007	5400	5609	5955	6208	6481	6692	6864	7034
Diversified Limpopo	3269	3400	3805	4006	4320	4487	4764	4966	5185	5353	5491	5627

Figure 6.11: Limpopo province load forecast

The main schemes in Limpopo are as follows:

Nzhelele 400 kV Integration

Establish a 2 x 250 MVA 400/132 kV substation at the Nzhelele site to supply loads between the Soutpansberg Mountains and the Zimbabwe border currently fed from Tabor and Spencer. It will be fed via two 400 kV lines from Tabor and Borutho, respectively.

Medupi Transmission Integration (400 kV and 765 kV)

The project was part of the original scope from the outset, which was identified for integrating Medupi Power Station into the national grid. It entails the construction of the following 400 kV and 765 kV lines:

- Construct 2 x 400 kV lines from Medupi to Spitskop (~ 192 km).
- Construct 2 x 400 kV lines from Spitskop to Dinaledi (~ 113 km).
- Construct 1 x 400 kV line from Medupi to Marang (~ 281 km).
- Establish Borutho 2 x 500 MVA, 400/132 kV substation.
- Construct 1 x 400 kV line from Medupi to Borutho (~ 150 km).
- Build turn-ins of Matimba-Witkop 400 kV line into Borutho substation (2 x 10 km).
- Construct 1 x 400 kV line from Borutho to Witkop (~ 60 km).
- Establish Ngwedi (Mogwase) 2 x 500 MVA, 400/132 kV substation.

- Construct 1 x 400 kV line from Medupi to Ngwedi (Mogwase) (~ 200 km).
- Construct Medupi-Ngwedi (Mogwase) 1st 765 kV line (energised at 400 kV ~ 200 km).
- Build turns-ins of Matimba-Midas 400 kV line into Ngwedi substation (2 x 10 km).
- Build turns-ins of Marang-Midas 400 kV line into Ngwedi substation (2 x 5 km). (North-West Province)

Medupi 400 kV Integration Enhancements

Transient stability studies based on the final electromechanical data for the 6 x 800 MW generators being installed at Medupi received from the manufacturers showed that additional network strengthening was required to comply with minimum Grid Code transient stability performance criteria in the event of a network fault. The following projects were later added to ensure that Medupi Power Station and Matimba Power Station were in compliance with the Grid Code in terms of transient stability:

- Installation of series busbar reactors at Medupi and Matimba 400 kV busbars
- Construction of 1 x 400 kV line from Medupi to Witkop (~ 200 km)
- Construction of 1 x 400 kV line from Witkop to Senakangwedi B substation (~ 160 km)
- Construction of 1 x 400 kV line from Borutho to Silimela (~ 100 km)
- Installation of shunt reactors in the vicinity of Medupi and Matimba
- Rerouting the existing Matimba-Phokoje 400 kV line to create the Medupi-Phokoje 400 kV line
- Reconfiguration of the lines at the Medupi and Matimba 400 kV busbars

Borutho Transmission Substation

Medupi integration identified Borutho as one of the nodal points to evacuate power within the Lephalale CLN. The Borutho project also aims to strengthen the transmission and distribution networks in the Mokopane area by addressing undervoltages in the Polokwane area following 400 kV line faults and undervoltages in the distribution network in the Mokopane area as a result of the long distances from Witkop. These network deficiencies are expected to worsen as the load grows.

Spitskop Substation Transformation Upgrade

Load growth in the Lephalale CLN in the vicinity of Spitskop has influenced the upgrading of the existing 2 x 250 MVA, 400/132 kV transformers to 2 x 500 MVA, 400/132 kV transformers.

Silimela (Marble Hall) Transmission Substation

The load of Marble Hall, Wolwekraal, Naledi, Dikgalopeng, and Mapoch distribution substations is supplied from Simplon and partially from Rockdale through 132 kV networks. The supply from Simplon MTS via 2 x 132 kV lines towards Mapoch distribution substation is approaching its transfer limit. The existing Mapoch-Marble Hall and Mapoch-Wolwekraal 132 kV networks will not be capable of supplying the additional load growth beyond 2017. It is also difficult to carry out maintenance work on the 132 kV networks, as the existing networks no longer comply with N-1 criteria.

To solve the network constraints mentioned above, it is proposed that a new transmission substation be constructed next the existing Wolwekraal Distribution substation. The new transmission substation will deload Simplon MTS. In addition, the new substation will be able to supply the long-term future load growth in the south-western part of the Phalaborwa CLN.

The most cost-effective way of supplying it is to establish a 400 kV switching station at Tubatse, fed by looping in the existing Duvha-Leseding 400 kV line, and to supply Silimela via two 400 kV lines from Tubatse and Emikhiweni (Rockdale B near Middelburg in Mpumalanga), respectively.

Senakangwedi B Transmission Substation

The north-western parts of the Tubatse area are currently supplied from Leseding and Merensky transmission substations via an interconnected 132 kV distribution network. Merensky substation also supplies the towns of Ohrigstad and Lydenburg through the 132 kV distribution network. Lydenburg town is also supplied from Simplon and Prairie substations via the 132 kV transmission network. Senakangwedi substation, which is situated in the southern parts of Tubatse, is dedicated to Xstrata Ferrochrome Smelter.

According to the load forecast for the Tubatse area, the load growth between 2013 and 2030 is expected to accelerate due to further developments in ferrochrome and platinum mining in the study area. The resulting network constraints indicate the need for a new transmission substation 10 to 15 km south of the existing Senakangwedi.

Foskor and Acornhoek 275/132 kV Transformation Upgrades

In order to ensure that the transmission network has sufficient transformation capacity for the expected 132 kV load growth, the Foskor and Acornhoek 275/132 kV transformer capacities should be upgraded. Foskor MTS and Acornhoek MTS are interconnected via the 275 kV and 132 kV networks, allowing load on the 132 kV network to be shared by the two substations. A 3rd 250 MVA 275/132 kV transformer has been approved for installation at Foskor. The existing 2 x 75 MVA 275/132 kV transformers at Acornhoek are over 40 years old and approaching the end of their useful life, so they will be replaced with 2 x 125 MVA 275/132 kV transformers, which will provide the needed extra capacity and extend the useful life of the substation. A 2nd Foskor-Merensky 275 kV line will also be built to address undervoltage and voltage stability constraints.

Dwaalboom 132 kV Switching Station

This project is required to provide full firm supply to Dwaalboom PPC and improve performance of the supply to the Gaborone area in Botswana. The existing tee-off arrangement supplying Dwaalboom substation will be replaced with a switching station.

The increase in transmission assets by the end of 2019 and the end of 2024 and the cumulative totals are shown in Table 6.5.

Table 6.5: Cumulative TDP transmission assets for Limpopo province

Transmission assets for Limpopo province	New assets expected 2015 to 2019	New assets expected 2020 to 2024	Total new assets expected
Total km of line	*1 610*	*325*	*1 935*
765 kV lines (km)	*200*	*0*	*200*
400 kV lines (km)	*1 260*	*310*	*1 570*
275 kV lines (km)	*150*	*15*	*165*
Total installed transformer MVA	*4 125*	*2 320*	*6 445*
Transformers (no. of)	*12*	*5*	*17*
Capacitors (no. of)	*0*	*0*	*0*
Reactors (no. of)	*4*	*0*	*4*

Table 6.6: Limpopo province – summary of projects and timelines

Scheme name	Project name	Expected year
Spitskop Transformation Upgrade	*Spitskop 2 x 500 MVA 400/132 kV transformer upgrade*	*2016*
Borutho 3rd 500 MVA 400/132 kV Transformer	*Borutho 3rd 500 MVA 400/132 kV transformer*	*2025*
Nzhelele 400 kV Integration	*Nzhelele 400/132 kV substation (1st and 2nd 250 MVA transformers)*	*2022*
	Tabor-Nzhelele 400 kV line	
	Borutho-Nzhelele 1st 400 kV line	
Tubatse Strengthening Scheme Phase 1	*Senakangwedi B 400/275 kV substation (1st 800 MVA 400/275 kV transformer)* *Arnot-Merensky 400 kV loop in-out into Senakangwedi B* *Tubatse-Senakangwedi B 1st 400 kV line* *Senakangwedi B-Senakangwedi 1st 275 kV line* *Senakangwedi B 400/132 kV substation (1st and 2nd 500 MVA 400/132 kV transformers)*	*2020*
Highveld North-West and Lowveld North Reinforcement – Phase 2	*Silimela 400/132 kV substation* *Emkhiweni (Rockdale B)-Silimela 400 kV line* *Tubatse 400 kV switching station* *Turn in Duvha-Leseding 400 kV line into Tubatse switching station* *Tubatse-Silimela (Marble Hall) 400 kV line*	*2020*
Foskor and Acornhoek 275/132 kV Transformation Upgrades	*Foskor - Merensky 2nd 275 kV line*	*2019*
	Acornhoek Upgrade Phase 1 – 2 x 125 MVA 275/132 kV transformers *Foskor 3rd 250 MVA 275/132 kV transformer*	*2017*

Table 6.6: Limpopo province – summary of projects and timelines (continued)

Scheme name	Project name	Expected year
Dwaalboom 132 kV Switching Station	*Dwaalboom 132 kV switching station*	*2016*
Medupi Transmission Integration	*Medupi-Spitskop 1st 400 kV line*	*2014*
	Medupi-Spitskop 2nd 400 kV line	*2014*
	Medupi-Marang 1st 400 kV line	*2014*
	Medupi-Ngwedi (Mogwase) 1st 400 kV line	*2017*
	Medupi-Ngwedi (Mogwase) 1st 765 kV line (energised at 400 kV)	*2017*
	Borutho 400/132 kV substation (2 x 500 MVA transformers)	*2015*
	Borutho 400 kV loop-in (Matimba-Witkop 1st 400 kV line)	*2015*
	Medupi-Borutho 1st 400 kV line	*2016*
	Borutho-Witkop 2nd 400 kV line	*2016*
Medupi Transmission Integration Medupi Stability Integration at 400 kV	*Medupi 400/132 kV 2 x 250 MVA substation*	*Commissioned*
	Borutho-Marble Hall 1st 400 kV line	*2021*
	Medupi-Phokoje 1st 400 kV line	*2021*
	Medupi-Witkop 1st 400 kV line	*2022*
	Witkop-Senakangwedi B 1st 400 kV line	*2023*
	Remote-end reactors	*2022*

The future network diagram for the Limpopo province is shown in Figure 6.12 below.

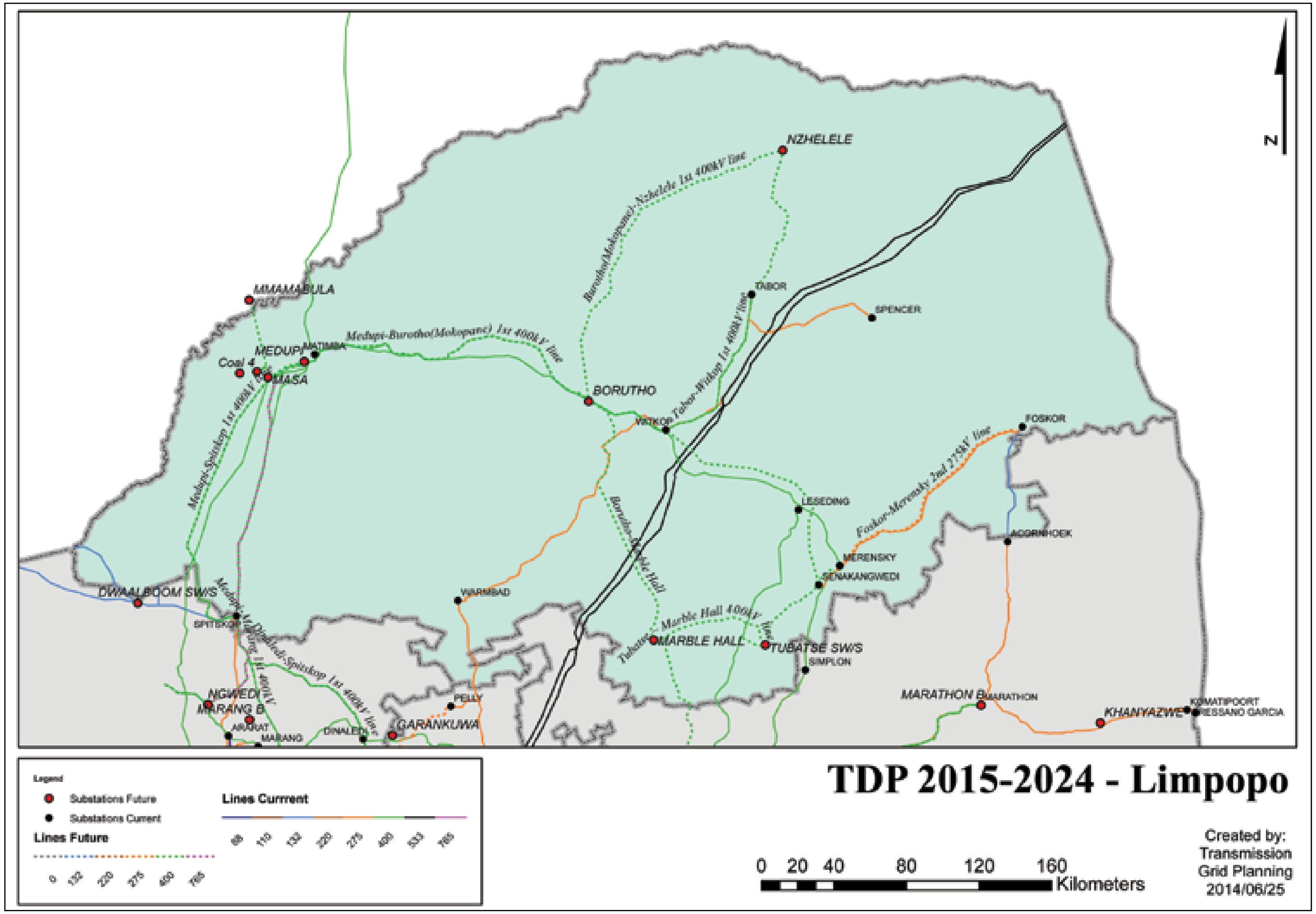


Figure 6.12: Future Limpopo province network diagram

6.4 Mpumalanga province

The TDP schemes for the Mpumalanga province consist of extending the 400 kV network, the integration of the Kusile Power Station, and the installation of additional transformers at existing and new substations added.

Several projects and schemes that aim to address the long-term requirements of the network have been initiated in order to accommodate the forecasted load and maintain overall network integrity under normal and contingency operation.

The current transmission network is shown in Figure 6.13 below.

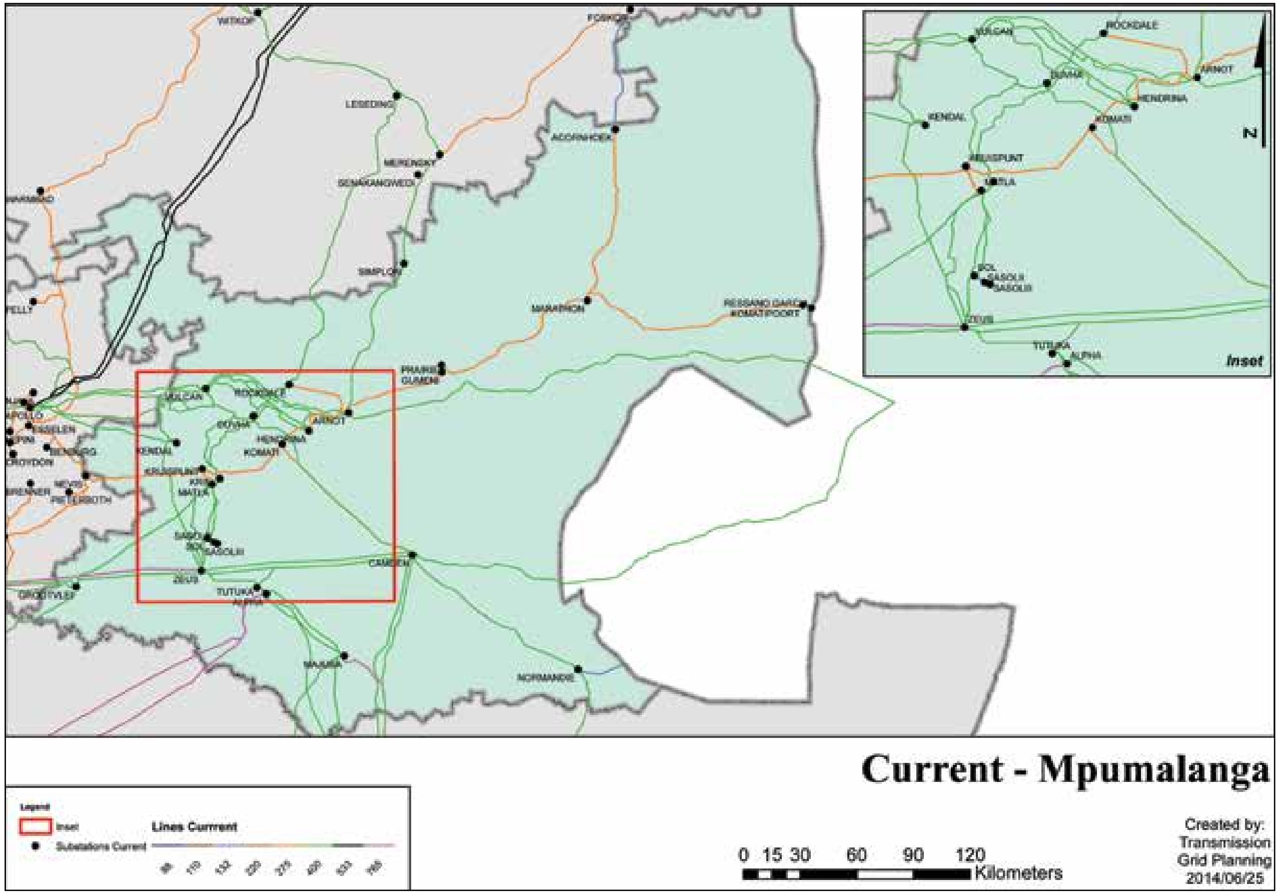
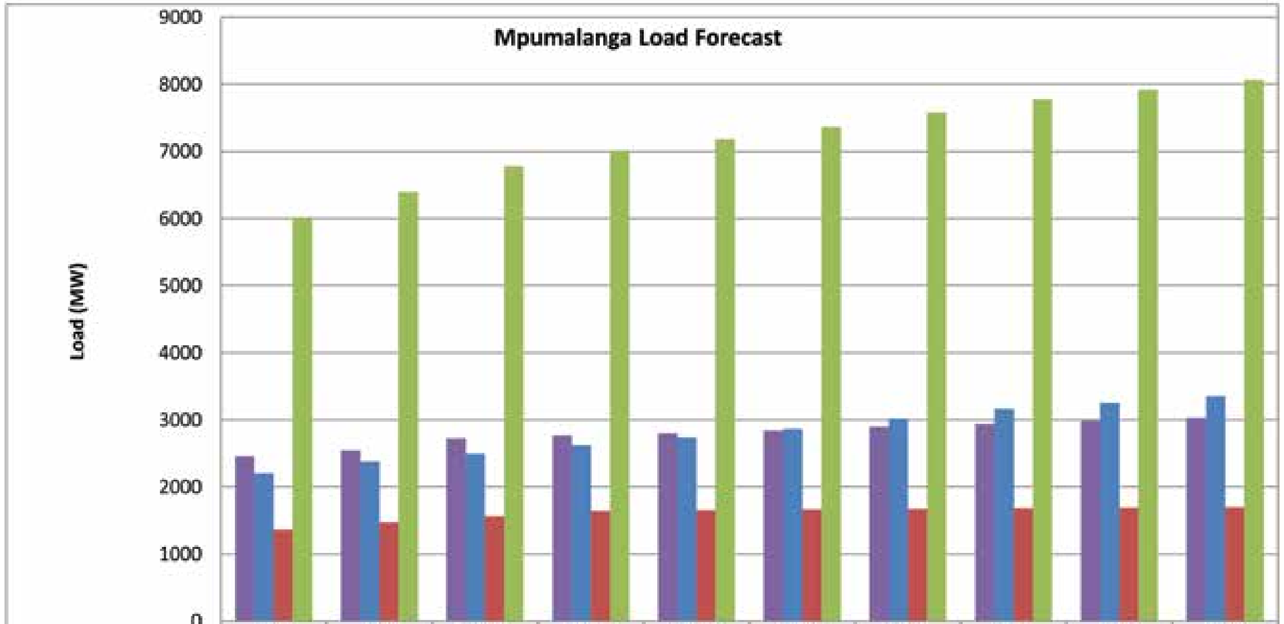


Figure 6.13: Current Mpumalanga province network diagram

The load forecast for the Mpumalanga province is shown in Figure 6.14 below.



	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Highveld North	2450	2542	2719	2760	2800	2840	2894	2938	2984	3028
Lowveld	2203	2379	2498	2613	2733	2863	3017	3158	3253	3350
Highveld South	1361	1471	1561	1641	1650	1659	1668	1676	1684	1691
Regional TOSP load	6014	6392	6778	7014	7184	7363	7580	7773	7921	8069

Figure 6.14: Mpumalanga province load forecast

Substation firm capacity

- A 2nd 400/132 kV 250 MVA transformer is planned for Normandie substation, to be commissioned in 2016.
- Silimela (Marble Hall) and Emkhiweni (Rockdale B) substation integration will be commissioned within this TDP period to support Simplon MTS and Rockdale MTS, respectively.
- Sol B MTS will be commissioned within this TDP period to mitigate existing transformation constraints at Sol MTS.
- The 400/132 kV, 300 MVA, and 250 MVA transformers at Vulcan MTS will be replaced with 500 MVA transformers as part of substation refurbishment/ planning.
- Marathon 132/66 kV is going to be decommissioned by 2016.

Underrated equipment

The underrated equipment at the transmission substations in the Mpumalanga province will be addressed as follows:

Highveld terminal equipment replacement

Equipment replacement (circuit-breakers, isolators, and CTs) at both ends of the following lines to ensure alignment with revised line thermal capacity to enable the additional capacity to be utilised: Apollo-Kendal 1 and 2 400 kV, Duvha-Minerva 400 kV, Duvha-Matla 400 kV, Kendal-Minerva 400 kV, and Kriel-Zeus 400 kV, as well as the upgrade of 5.63 km Twin Dinosaur (normal rating – 1280 MVA at 50 °C) section of the Kriel-Zeus 400 kV line to Triple Dinosaur (normal rating – 2 820 MVA at 80 °C).

Highveld South Reinforcement Phase 1: FLR and equipment replacement

The commissioning date for Sol B MTS integration has been moved from 2018 to 2023 in this TDP due to transmission capital funding constraints. However, fault-limiting reactors and underrated equipment replacement, which form part of this project, are justified in 2017 in terms of the statutory investment criteria, as they are needed to satisfy the requirements of the Occupational Health and Safety Act of 1993. As a result, the project will now be staggered in two phases, as follows.

- Phase 1: Sol MTS fault-limiting reactors and equipment replacement

  Sol MTS fault-limiting reactors in series with existing 400/132 kV transformers

  Replacement of all underrated equipment at Sol MTS
- Phase 2: Sol B MTS integration

Mpumalanga Fault Level Mitigation Phase 1

Replace underrated equipment due to rising fault levels at Duvha 400 kV, Vulcan 400 kV, Rockdale 132 kV, Kendal 400 kV, Hendrina 400 kV, Prairie 132 kV, Kruispunt 132 kV, Komati 275 kV, Zeus 400 kV, Arnot 400 kV and 275 kV, and Marathon 275 kV/132 kV.

Mpumalanga Fault Level Mitigation Phase 2

Bypass Tutuka MTS by joining the Majuba-Tutuka and Kendal-Tutuka 400 kV lines to form Kendal-Majuba 400 kV. Replace underrated equipment due to rising fault levels at Tutuka 400 kV, Alpha 400 kV, Majuba 400 kV, and Matla 275 kV. Install fault current-limiting reactors at Matla 400 kV.

Major schemes in the Mpumalanga province are as follows:

Major Schemes

Kusile Power Station Integration

The transmission integration plan for Kusile Power Station is as follows:

- Bypass Zeus with 2 x Sol-Zeus 400 kV lines and 2 x Zeus-Camden 400 kV lines to obtain 2 x Sol-Camden 400 kV lines.
- Loop the Kendal-Duvha 400 kV line in and out of Vulcan to form Kendal-Vulcan 400 kV line and the 2nd Duvha-Vulcan 400 kV line.
- Bypass Vulcan with Kendal-Vulcan 400 kV line and Vulcan-Arnot 400 kV line to obtain Kendal-Arnot 400 kV line.
- Establish Kusile HV yard. Loop the Duvha-Minerva 400 kV line in and out of Kusile to obtain Kusile-Duvha 400 kV line and Kusile-Minerva 400 kV line.
- Loop the Kendal-Apollo 400 kV line 1 in and out of Kusile to obtain Kusile-Kendal 400 kV line and Kusile-Apollo 400 kV line.
- Build Kusile-Lulamisa 400 kV line (this line would later be looped in and out of the planned Kyalami substation as part of Gauteng Strengthening).
- Bypass Duvha with Kusile-Duvha 400 kV line and the 2nd Duvha-Vulcan line to obtain Kusile-Vulcan 400 kV line.
- Build the 1st Kendal-Zeus 400 kV line.
- Bypass Kendal with Kusile-Kendal 400 kV line and the 1st Kendal-Zeus 400 kV line to obtain Kusile-Zeus 400 kV line.
- Build the 2nd Kendal-Zeus 400 kV line.

Lowveld Strengthening Phase 2a

Establish Gumeni 400/132 kV substation (1st 500 MVA 400/132 kV transformer) near Prairie, and build Hendrina-Gumeni 400 kV line.

Lowveld Strengthening Phase 2b

Establish a 400 kV busbar at the existing Marathon transmission substation, and install the 1st 500 MVA 400/132 kV transformer. Construct Marathon-Gumeni 400 kV line.

Lowveld Strengthening Phase 3a

Provide firm supply to Gumeni by installing the Gumeni 2nd 500 MVA 400/132 kV transformer and building the Arnot-Gumeni 400 kV line. This project is, however, dependent on the expected step load increase at Machadodorp and generation developments in Mozambique.

The increase in transmission assets by the end of 2019 and the end of 2024 and the cumulative totals are shown in Table 6.7.

Table 6.7: Cumulative TDP transmission assets for Mpumalanga province

Transmission assets for Mpumalanga province	New assets expected 2015 to 2019	New assets expected 2020 to 2024	Total new assets expected
Total km of line	*487*	*112*	*599*
765 kV lines (km)	*0*	*0*	*0*
400 kV lines (km)	*487*	*112*	*599*
275 kV lines (km)	*0*	*0*	*0*
Total installed transformer MVA	*2 300*	*3 300*	*5 600*
Transformers (no. of)	*4*	*6*	*10*
Capacitors (no. of)	*1*	*0*	*1*
Reactors (no. of)	*0*	*0*	*0*

Table 6.8: Mpumalanga province – summary of projects and timelines

Scheme name	Project name	Expected year
Highveld Terminal Equipment Replacement	*Mpumalanga underrated terminal equipment upgrade (Apollo-Kendal 1st and 2nd, Duvha-Minerva, Duvha-Matla, Kendal-Minerva, and Kriel-Zeus)*	*2021*
Highveld North-West and Lowveld North Reinforcement – Phase 1	*Rockdale 132 kV breakers upgrading*	*2015*
	Turn in Kendal-Arnot 400 kV line into Emkhiweni (Rockdale B)	
	Emkhiweni (Rockdale B) 400/132 kV substation	
Highveld North-West and Lowveld North Reinforcement – Phase 2	*Turn in Duvha-Leseding 400 kV line into Tubatse switching station*	*2020*
	Tubatse 400 kV switching station	
Highveld North-West and Lowveld North Reinforcement – Phase 3	*Emkhiweni (Rockdale B) 400/132 kV substation extension (3rd 500 MVA 400/132 kV transformers)*	*2024*
Highveld South Reinforcement Phase 1	*Sol MTS fault-limiting reactors and equipment replacement*	*2017*
Highveld South Reinforcement 2	*Turn in Kriel-Tutuka 400 kV line into Sol B MTS*	*2023*
	New Sol B 400/132 kV substation	
	Turn in Kriel-Zeus 400 kV line into Sol B MTS	
	Sol B Ext. and equip 8 x 132 kV feeder bays	
Mpumalanga Fault Level Mitigation Phase 1	*North East Grid underrated equipment replacement – Arnot, Hendrina, Vulcan, Kendal, Duvha, Kruispunt, Komati, Matla, Zeus, Alpha, Majuba, Camden, Marathon, Rockdale, and Prairie*	*2017*

Table 6.8: Mpumalanga province – summary of projects and timelines (continued)

Scheme name	Project name	Expected year
Mpumalanga Fault Level Mitigation Phase 2	*Bypass of Tutuka powerstation by interconnecting the Tutuka end of the Majuba-Tutuka and Kendal-Tutuka 400 kV lines should be implemented; the new line that will be formed by implementing this project is the Kendal-Majuba 400 kV line*	*2018*
Khanyisa PS Integration	*Khanyisa PS 400 kV switching station*	*Customer Dependent*
	Turn in Kusile-Vulcan 400 kV line into Khanyisa PS	
Kruispunt Reinforcement	*Kruispunt 275 kV loop-in Komati-Matla 1st 275 kV line*	*2014*
Kusile Integration Phase 1: 400 kV Loop-ins	*Kusile 400 kV loop-in (Duvha-Minerva 1st 400 kV line)*	*2014*
	Kusile 400 kV busbar HV yard establishment (integration of PS generators)	
	Vulcan 400 kV bypass and reconfiguration (loop in Duvha-Kendal 1st 400 kV line and loop out Arnot-Vulcan 1st 400 kV lines to form Duvha-Vulcan 2nd 400 kV and Arnot-Kendal 1st 400 kV)	
Kusile Integration Phase 2: Lulamisa	*Kusile-Lulamisa 1st 400 kV line*	*2018*
Kusile Integration Phase 3A: 400 kV Duvha Bypass	*Kusile 400 kV bypass Duvha (to form Kusile-Vulcan 400 kV line)*	*2016*
Kusile Integration Phase 3B: 400 kV Loop-in	*Kusile 400 kV loop-in (Apollo-Kendal 1st 400 kV line)*	*2016*
Kusile Integration Phase 4B	*Kendal-Zeus 2nd 400 kV line*	*2017*
	Kusile 400 kV bypass Kendal (Kendal bypass required to form the Kusile-Zeus 400 kV line from Kusile-Kendal and Kendal-Zeus lines)	

Table 6.8: Mpumalanga province – summary of projects and timelines (continued)

Scheme name	Project name	Expected year
Kusile Integration Phase 4A	*Kendal-Zeus 1st 400 kV line*	*2017*
Lowveld 400 kV Strengthening – Phase 2a: Gumeni	*Hendrina-Gumeni 1st 400 kV line*	*2015*
	Gumeni 400/132 kV substation (1st 500 MVA 400/132 kV transformer)	
Lowveld Strengthening Phase 2B	*Gumeni-Marathon 400 kV line*	*2022*
	Marathon 400/132 kV substation	
Lowveld 400 kV Strengthening – Phase 3a	*Gumeni 2nd 400/132 kV transformer*	*2018*
	Arnot-Gumeni 400 kV line	*2021*
Khanyazwe (Malelane) Reinforcement Phase 2	*Khanyazwe (Malelane) 132 kV, 72 MVAr capacitor bank*	*2016*

The future network diagram is shown in Figure 6.15 below.

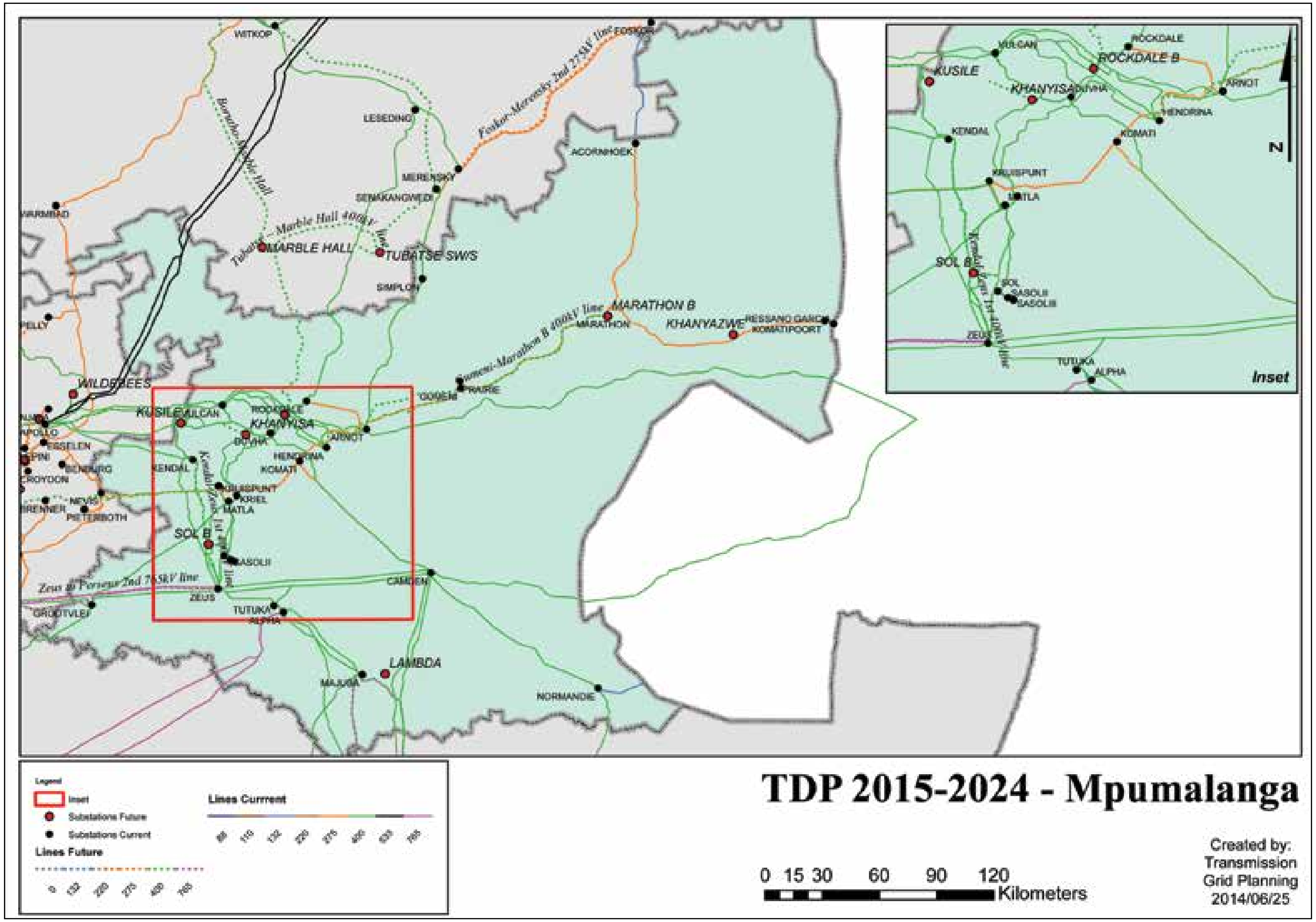


Figure 6.15: Future Mpumalanga province network diagram

6.4 North West province

The projects for the North West province are mainly the introduction of 400 kV lines and transformation to support or relieve the existing networks.

The current transmission network is shown in Figure 6.16 below.

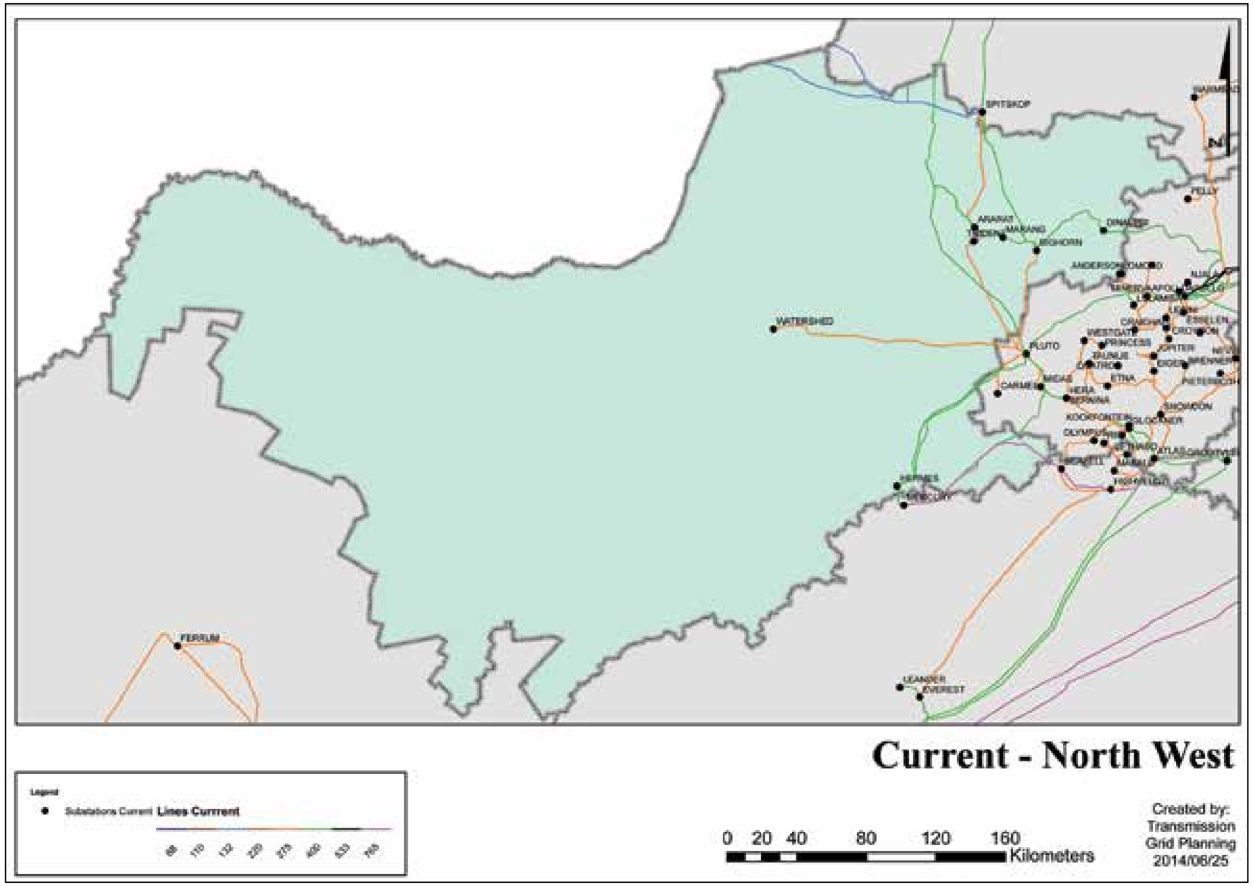
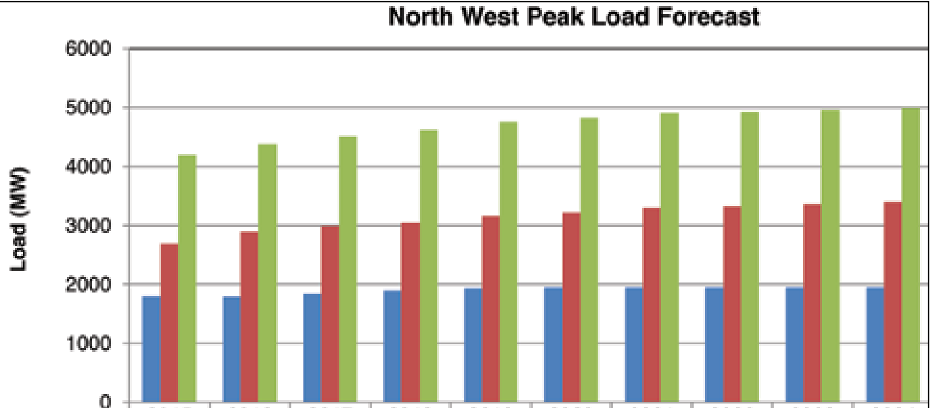


Figure 6.16: Current North West province network diagram

The load forecast for the North West province is shown in Figure 6.17 below.



	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Carletonville	1796	1790	1841	1899	1935	1949	1949	1949	1949	1949
Rustenburg	2694	2897	2991	3044	3159	3215	3301	3326	3362	3397
Total Load	4195	4378	4514	4618	4759	4824	4904	4927	4961	4994

Figure 6.17: North West province load forecast

Substation firm capacity

- Ngwedi 2 x 500 MVA 400/132 kV MTS integration is planned to deload Ararat substation, to be commissioned in 2016.
- Marang B 2 x 500 MVA 400/132 kV MTS integration is planned to deload Marang 400/88 kV substation by 2022.
- A 3rd Dinaledi 500 MVA 400/132 kV transformer is planned to deload Lomond substation, to be commissioned in 2016.
- Bighorn Extension 2 x 500 MVA 400/132 kV is planned to deload Bighorn substation, and is customer dependant.
- A single Watershed 250 MVA 275/132 kV transformer is planned for Watershed substation.
- Mookodi 2 x 250 MVA 400/132 kV integration is planned to deload Watershed and Boundary MTS, planned to be commissioned in 2014.
- Midas 132 kV load shift to Carmel to deload Midas 400/132 kV load by 2016. This project will be executed by Distribution.

Underrated equipment

The underrated equipment at various substations will be addressed as part of the Waterberg Fault Level Plan. The project entails installing fault-limiting reactors at Marang MTS, replacing underrated equipment (breakers, isolators, CTs, etc.), and upgrading earth-mats, where required, at affected substations. In the North West province, the substations and voltage levels requiring work are Ararat 88 kV, Bighorn 88 kV, Marang 88 kV, Trident 88 kV, Hermes 88 kV and 132 kV, Midas 132 kV, and Mercury.

The following projects are planned for the 2015 to 2024 period:

Rustenburg Strengthening Phase 2 (Marang B)

The Rustenburg Strengthening Phase 2, that is, Marang B integration, comprises the integration of a 400/132 kV MTS in the vicinity of Marang. Marang B will introduce a 132 kV voltage and deload Marang MTS. Marang B will be integrated by loop in and out of the existing Marang-Bighorn 400 kV line and will require a number of distribution substations to be upgraded from 88 kV to 132 kV, which will require replacement of many transformers.

Ngwedi 400/132 kV Integration

This includes looping in and out of Matimba-Midas and Marang-Midas 400 kV lines in 2015/16; and new 2 x Medupi-Ngwedi 400 kV lines will be established, with one of these lines built to 765 kV standards, but operated at 400 kV. Ngwedi (Mogwase) MTS was motivated to deload Ararat MTS and create transformation capacity to supply load between Spitskop and Ararat. This, in turn, will allow for load shift from Ararat to Ngwedi and evacuate power from Medupi Power Station into the Rustenburg CLN.

Rustenburg Strengthening Phase 3

This scheme addresses the low voltages in the Rustenburg Customer Load Centre under the N-1 loss of the Medupi-Marang 400 kV line in the year 2024. The low voltages at Marang, Bighorn, and Dinaledi substations will be addressed by installing shunt capacitors. The shunt capacitors are expected to provide reactive power support in the Rustenburg Load Centre and, subsequently, improve voltages to within limits.

The increase in transmission assets by the end of 2019 and the end of 2024 and the cumulative totals are shown in Table 6.9.

Table 6.9: Cumulative TDP transmission assets for North West province

Transmission assets for North West province	New assets expected 2015 to 2019	New assets expected 2020 to 2024	Total new assets expected
Total km of line	*540*	*540*	*1 080*
765 kV lines (km)	*200*	*0*	*200*
400 kV lines (km)	*340*	*540*	*880*
275 kV lines (km)	*0*	*0*	*0*
Total installed transformer MVA	*2 250*	*2 000*	*4 250*
Transformers (no. of)	*6*	*4*	*10*
Capacitors (no. of)	*3*	*6*	*9*
Reactors (no. of)	*0*	*0*	*0*

The following projects are planned for the 2015 to 2024 period:

Table 6.10: North West province – summary of projects and timelines

Scheme name	Project name	Expected year
Watershed Strengthening	*Watershed 275/132 kV substation 250 MVA 275/132 kV transformer*	*2016*
	Watershed MTS 132 kV reactive power compensation *Watershed MTS 88 kV reactive power compensation*	*2018*
Kimberley Strengthening Phase 3	*Hermes-Mookodi (Vryburg) 1st 400 kV line*	*2021*
Rustenburg Strengthening Phase 1	*Bighorn 2 x 500 MVA 400/132 kV transformer*	*2022*
Rustenburg Strengthening Phase 2	*Marang B 2 x 500 MVA 400/132 kV substation* *loop in and out Marang-Bighorn 400 kV line*	*2022*
Medupi Integration (Charlie) Phase 2A: Mogwase	*Medupi-Ngwedi (Mogwase) 1st 400 kV line* *Medupi-Ngwedi (Mogwase) 1st 765 kV line (energised at 400 kV)* *Ngwedi (Mogwase) 400/132 kV substation 2 x 500 MVA transformers* *Ngwedi (Mogwase) 400 kV loop-in (Matimba-Midas 1st 400 kV)* *Ngwedi (Mogwase) 400 kV loop-in Marang-Midas 400 kV line*	*2017*
Dinaledi-Spitskop 400 kV Lines	*Dinaledi-Spitskop 1st and 2nd 400 kV line*	*2015*
Dinaledi	*Dinaledi 3rd 500 MVA 400/132 kV 275 kV transformer*	*2016*

The future network diagram is shown in Figure 6.18 below.

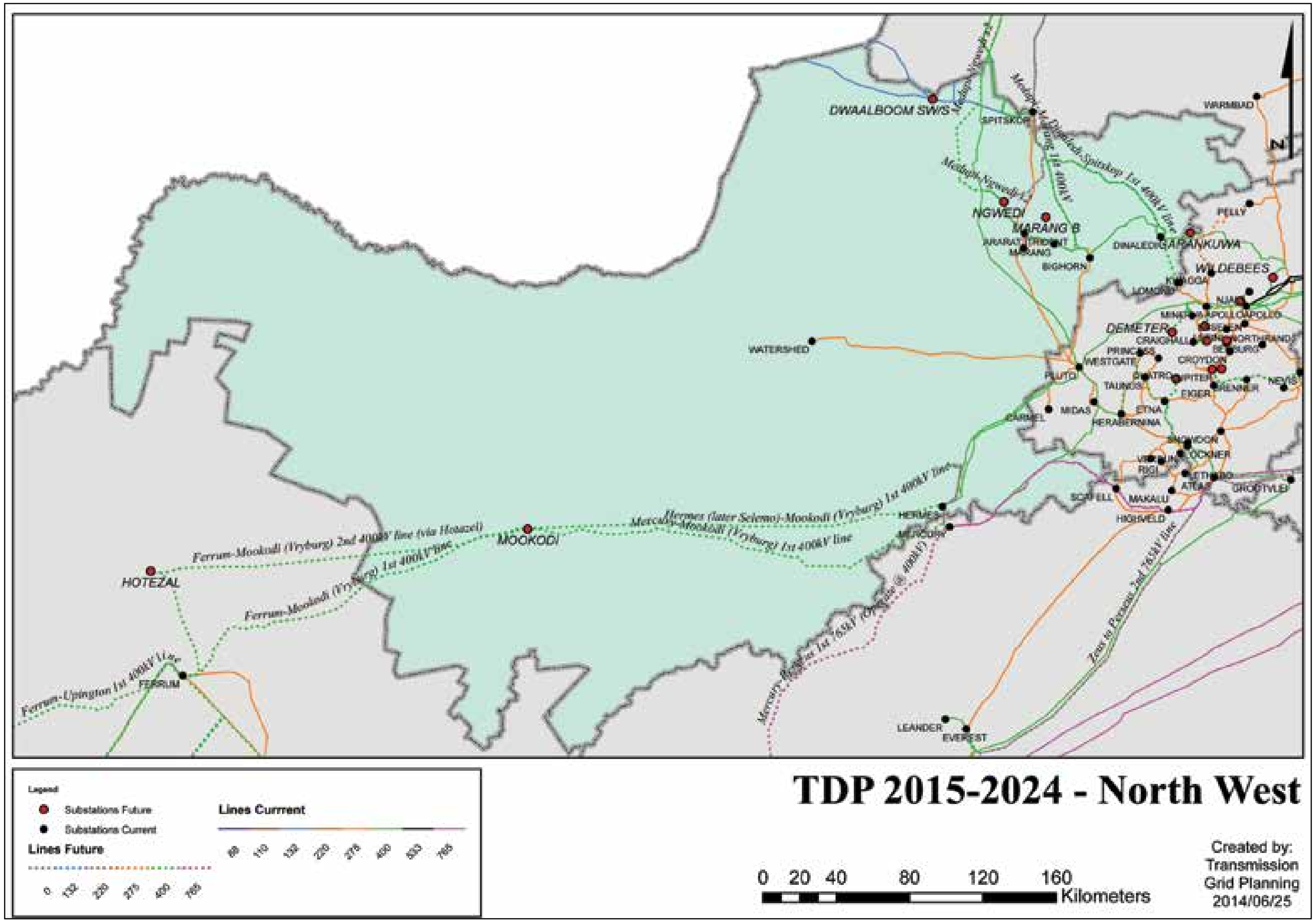


Figure 6.18: Future North West province network diagram

6.6 Free State province

The 765 kV network is primarily used for the transportation of power through the grid to the Cape. The projects for the Free State province are mainly the introduction of 400 kV lines and transformation to support or relieve the 275 kV networks.

The current transmission network is shown in Figure 6.19 below.

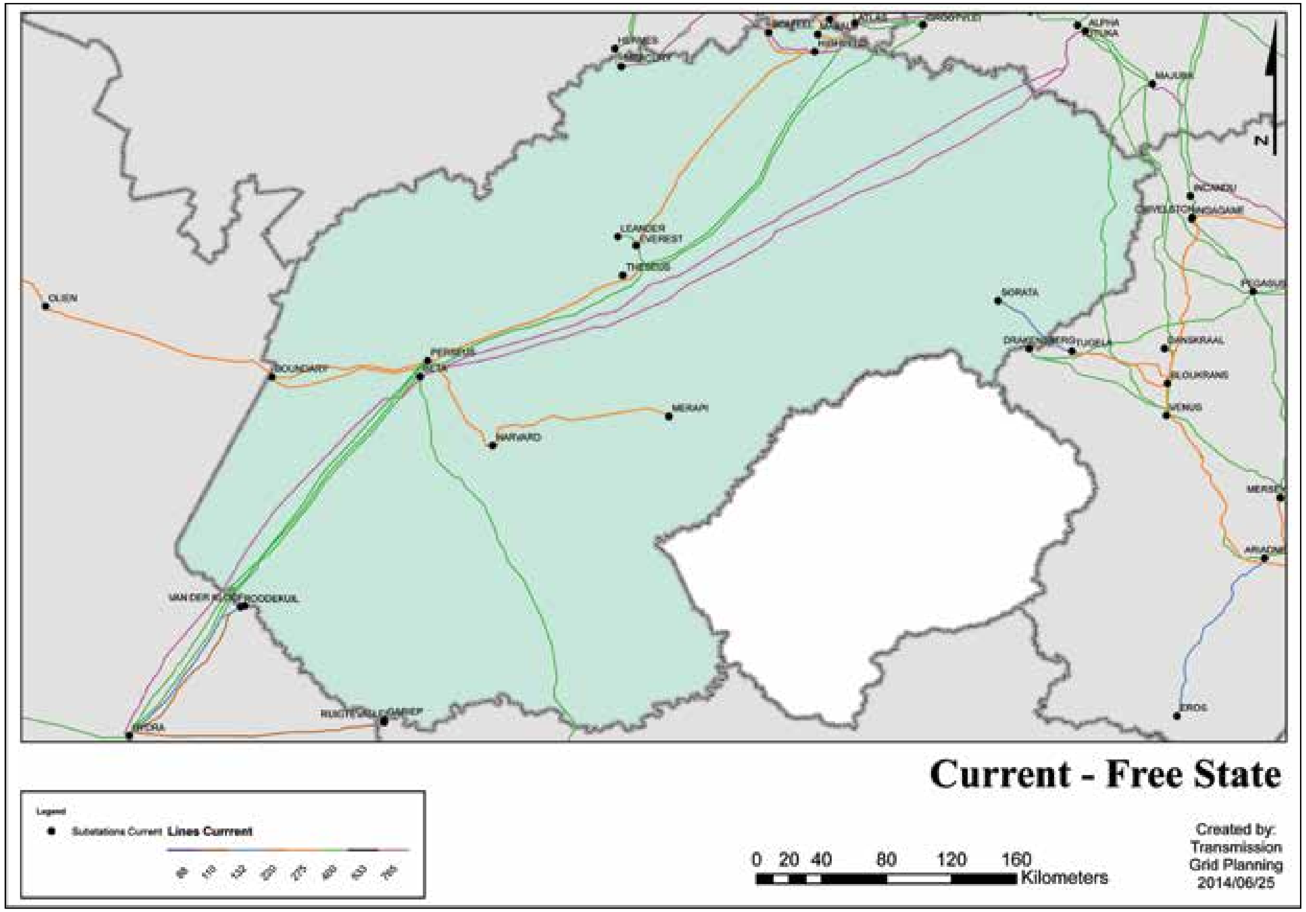
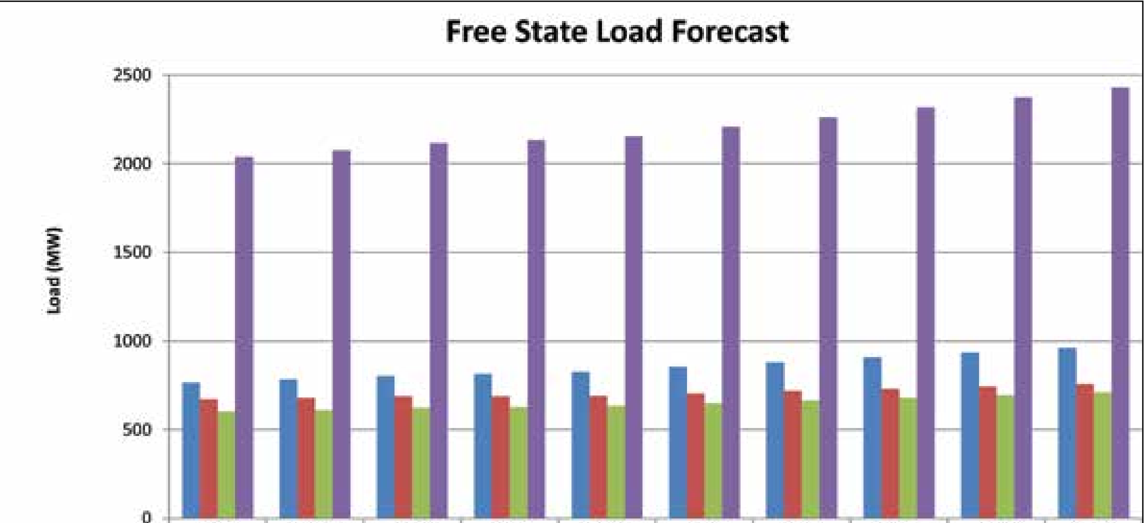


Figure 6.19: Current Free State province network diagram

The load forecast for the Free State province is shown in Figure 6.20 below.



	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Bloemfontein	765	783	804	815	828	854	880	907	934	962
Welkom	673	680	689	689	691	704	717	731	744	757
Sasolburg	601	611	623	628	633	649	664	680	695	711
Total Load (TOSP)	2040	2074	2116	2132	2152	2207	2262	2317	2373	2430

Figure 6.20: Free State province load forecast

Bloemfontein Strengthening Phase 1

The project involves establishing a 275 kV line from Everest substation to Merapi substation, built at 400 kV specifications and operated at 275 kV. The planned Everest-Merapi line will increase the power transfer and improve the security of supply in the Bloemfontein area. The project also includes replacing a 275/132 kV 180 MVA transformer unit with a 275/132 kV 250 MVA unit at Merapi substation by 2015 (Phase 1a). The other transformer will be replaced as part of a refurbishment project in 2014. Merapi substation will reach its installed N-1 transformation due to the increase in LEC demand. The expected commissioning year of Phase 1b (Everest - Merapi 400 kV line) of the project is 2018, and it is currently in the definition stage.

Bloemfontein Strengthening Phase 2

This project involves acquiring servitudes for future 400 kV lines, that is, Beta-Harvard and Harvard-Merapi 400 kV lines, and the expansion of Harvard substation to accommodate the 400 kV network by 2022.
The 400 kV Beta-Harvard line, together with the introduction of 400/132 kV transformation at Harvard substation, will further strengthen the Bloemfontein network.

Cape Corridor Strengthening and Refurbishments

The Free State Grid includes the 400 kV and 765 kV integration required for the Cape Corridor. There are 765 kV expansion plans for strengthening of the corridor, which are currently in the execution phase. These projects are discussed in detail in the Western Cape section of this document.

The increase in transmission assets by the end of 2019 and the end of 2024 and the cumulative totals are shown in Table 6.11.

Table 6.11: Cumulative TDP transmission assets for Free State province

Transmission assets for Free State province	New assets expected in 2015 to 2019	New assets expected in 2020 to 2024	Total new assets expected
Total km of line	*110*	*594*	*704*
765 kV lines (km)	*0*	*400*	*400*
400 kV lines (km)	*110*	*180*	*290*
275 kV lines (km)	*0*	*14*	*14*
Total installed transformer MVA	*250*	*1 630*	*1 880*
Transformers (no. of)	*1*	*5*	*6*
Capacitors (no. of)	*0*	*0*	*0*
Reactors (no. of)	*1*	*0*	*1*

The following projects are planned for the 2015 to 2024 period:

Table 6.12: Free State province – summary of projects and timelines

Scheme name	Project name	Expected year
Bloemfontein Strengthening Phase 1a	*Merapi 2nd 250 MVA 275/132 kV transformer*	*2015*
Bloemfontein Strengthening Phase 1b	*Everest-Merapi 400 kV line (operated at 275 kV)*	*2018*
Bloemfontein Strengthening Phase 2	*Beta-Harvard 400 kV line* *Harvard 500 MVA 400/132 kV S/S*	*2023*
Harrismith Strengthening Phase 1	*Sorata 1st 250 MVA 275/132 kV transformer Tugela-Sorata 275 kV (energise existing line)* *Sorata 400 kV busbar (operated at 275 kV)*	*2021*
Makalu Strengthening	*Establish new Makalu B 2 x 315 MVA 275/88 kV substation* *Makalu-Makalu B 2 x 275 kV 7 km line* *Refurbishment of existing Makalu MTS*	*2022*

A network diagram of the major projects in the Free State province is shown in Figure 6.21 below.

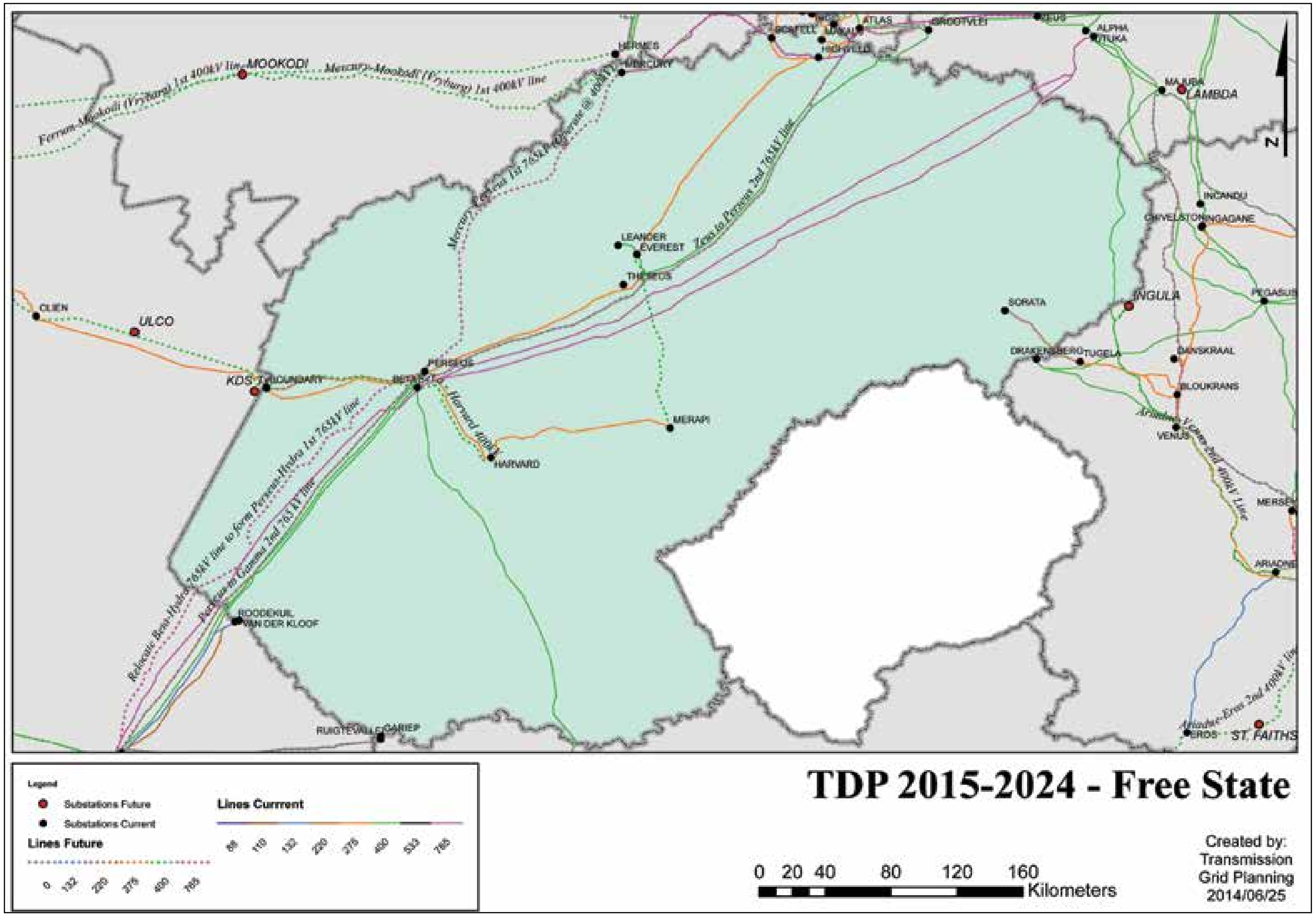


Figure 6.21: Future Free State province network diagram

6.7 Northern Cape province

Northern Cape province is one of the largest provinces by landmass. It consists of vast tracts of land with good sunshine, and for that reason, it has attracted the most solar PV and CSP projects of all the provinces. Unfortunately, the province is supplied by radial lines, and it has traditionally been a weak network. Currently, Kimberley is supplied by means of the 275 kV network at Ferrum and Namaqualand by a radial 220 kV network supported by 400 kV from the main Cape Corridor. There has been a lot of interest in increasing mining operations in the Kimberley area.

The current transmission network is shown in Figure 6.22 below.

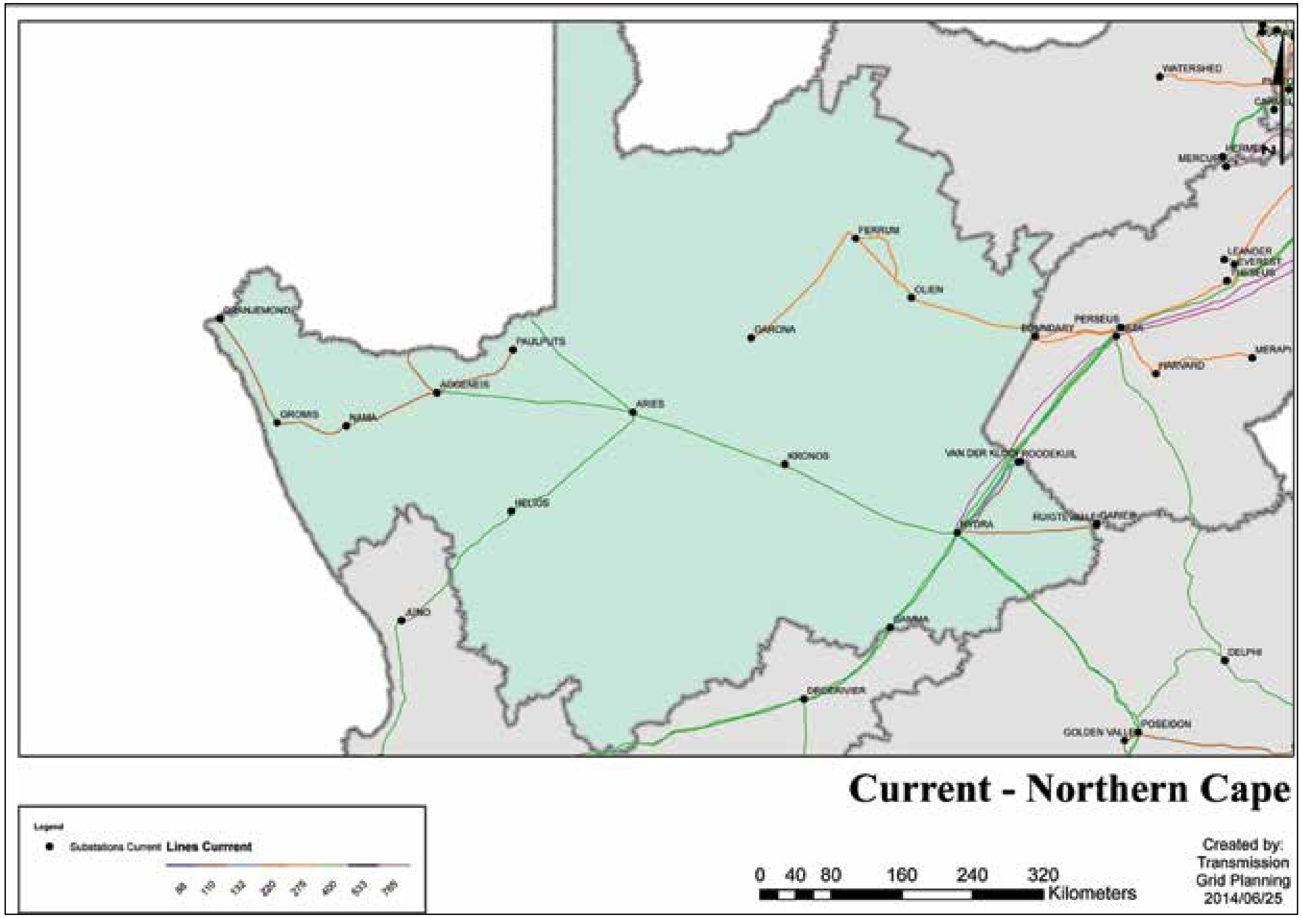
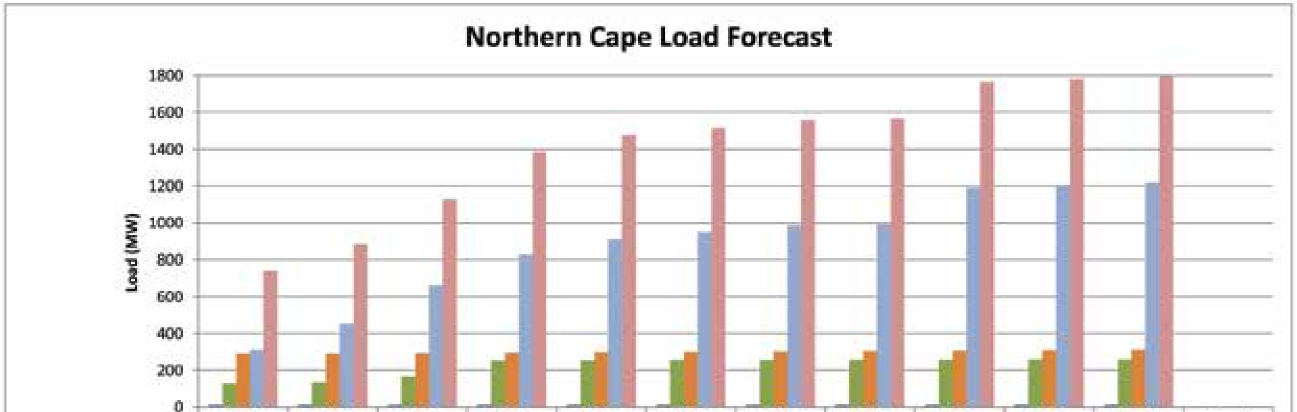


Figure 6.22: Current Northern Cape province network diagram

The load forecast for the Northern Cape is shown in Figure 6.23 below.



	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	Growth
West Coast	12	12	12	13	13	13	13	13	13	13	12.7	0.45%
Namaqualand	129	134	166	252	253	254	255	255	256	256	256.7	7.97%
Karoo	290	289	292	295	298	301	303	305	307	309	310.9	0.79%
Kimberley	310	452	661	827	912	949	986	992	1191	1205	1217	16.39%
Northern Cape Total	741	888	1132	1387	1476	1516	1556	1565	1767	1782	1797.3	10.35%

Figure 6.23: Northern Cape province load forecast

It can be seen that the Kimberley area forms the major part of the growth in the province. This is due to the anticipated manganese and iron ore mining in the area as well as possible smelter operations associated with these mines.

The projects for the Northern Cape province are mainly to increase the reliability of the network, which is mainly radial, to cater for the anticipated ferrochrome and iron ore mining loads in the Kimberley area and to accommodate a huge influx of solar and wind IPPs in the province.
The Northern Cape also consists of a rail corridor that transports iron ore and manganese to the coastal areas. There are currently efforts to increase capacity on these rail networks.

Included in the TDP studies is the future planned electricity export to Namibia via the 400 kV and 220 kV interconnections. The export amount has been assumed to remain constant over the TDP period. There is also a plan to integrate 1 100 MW of solar generation in the Upington area (as indicated in last year's TDP).

Major schemes

Several projects and schemes have been initiated in the last 2014 to 2023 TDP, which aimed at addressing the long-term requirements of the network in order to meet the forecasted load and maintain overall network integrity under normal and contingency operation. Unfortunately, due to capital constraints, some of these projects will be delayed.

Substation firm capacity

The following unfirm substations have been identified over the TDP period:

- Nama 66/22 kV
- Paulputs 220/132 kV
- Hydra 400/220 kV
- Hydra 400/132 kV
- Garona 275/132 kV
- Ruigtevallei 132/66 kV

The following projects will address the above:

- Transformation upgrade at Nama, due to load shift; instead of 2 x 40 MVA 66/22 kV transformers, 2 x 20 MVA transformers will be installed.
- A 2nd 220/132 kV 250 MVA transformer is planned for Paulputs substation. A 220/132 kV 250 MVA transformer is planned to replace the existing 125 MVA transformer to accommodate future successful REBIDs at Paulputs beyond Round 4 of the REIPPP.
- A 3rd 400/132 kV transformer rated at 500 MVA is to be installed at Hydra to accommodate the REBID 3 successful bidders.
- Gariep Strengthening Project will address the Hydra substation 400/220 kV unfirmness, but due to Distribution delays, this project will only be completed in 2020.
- Kronos transformation 400/132 kV under Garona Strengthening will address the Garona unfirmness.

N-1 contingency

Based on the Northern Cape N-1 contingency analysis, the following projects have been identified to alleviate the constraints:

- Aries fast dynamic device will be commissioned and will alleviate the Aries undervoltages under N-1 conditions.
- The Namaqualand radial network redundancy problems are resolved by the Namaqualand Redundancy Project (Juno-Gromis-Oranjemond).
- Uprating of the Roodekuil-Hydra 132 kV line will alleviate the multi-unit trips at Van Der Kloof.
- The loss of Garona transformer leads to undervoltages in the distribution network. Kronos transformation project introduces a 400 kV injection into Cuprum, resolving this problem.
- The Gariep and Ruigtevallei suspected case of small signal stability problem and overloading of the Hydra-Ruigtevallei 132 kV line under N-1 contingency, a project will be raised to address this.

Underrated equipment

The following substations in the Northern Cape have been identified in the fault level analysis as having underrated equipment:

- Aggeneis in 2021
- Hydra 400 kV and 132 kV in 2017
- Kronos in 2016
- Olien in 2023
- Ruigtevallei in 2014

The following projects will address the above:

- Aggeneis substation – a project will be raised to address this substation.
- Hydra substation – as part of the Hydra 400 kV and 132 kV equipment upgrade due to fault levels.
- Kronos substation – as part of Garona Strengthening.
- Olien substation – as part of Kimberley Strengthening Phase 4.
- Ruigtevallei substation – as part of Gariep Strengthening.

Renewable generation

The Northern Cape has high potential for renewables energy due to its climate and proximity to the coast. Under the DoE initiative, Upington Solar Park, with a potential of 1000 MW, is expected during the TDP period, depending on whether government approves these plans or not.

Round 4 of the REBID programme is currently in progress, and based on the applications thus far, Upington, Paulputs, and Kronos may require future strengthening, depending on the capacity approved.

- Namaqualand Redundancy Evaluation – this project introduces redundancy into the Namaqualand CLN. The project entails building the Juno-Gromis 400 kV line operated at Gromis substation to 220 kV and Gromis-Oranjemond 220 kV line (constructed at 400 kV). In addition, Aggeneis-Paulputs 220 kV line is to meet the N-1 security standard for Paulputs area.
- Upington Solar Park – this solar park integration includes the construction of two Upington-Aries 400 kV lines and Upington-Nieuwehoop and Upington-Ferrum 400 kV lines and is highly dependent on the approval of solar parks by government.
- Kimberley Strengthening Phase 3 – this strengthening entails the construction of Hermes (later Selemo)-Mookodi, Mookodi-Hotazel, and Hotazel-Ferrum 400 kV lines.

- Kimberley Strengthening Phase 4 – this is a strategic project to enhance the reliability and support to the existing 275 kV network in the Kimberley area. Boundary and Olien will be approximately 37 years and 47 years old, respectively – hence, requiring refurbishment. Due to the 275 kV network being replaced with 400 kV as in Kimberley Phases 2 and 3, the proposal is to look at a 400 kV corridor from Beta to Ferrum substation in order to replace the existing 275 kV network when refurbishment is required. The strategic EIA includes establishing new 400/132 kV substations at Ulco, Manganore, Boundary, and Olien. Strengthening will look at looping in and out of the Beta-Ferrum 400 kV line into the substations.

New projects

The following projects are new in the TDP:

- Hydra IPP Integration (GP_12/219) Hydra – 3rd 400/132 kV transformer and New Hydra B 400/132 kV for IPP applications from REBID 4 and above.
- Roodekuil Hydra Strengthening (GP_11/100) – this project entails uprating the existing Roodekuil 132 kV line to alleviate the multiple-unit trips (MUTs) at Van Der Kloof Power Station.
- Kronos Transformation (Customer) – this is a customer-driven project entailing connection to the grid at Kronos as well as IPP connections from Round 4 and beyond.
- Paulputs Transformation – this is to accommodate IPP connections from Round 4 and beyond to the grid at Paulputs.
- Ruigtevallei 132/66 kV Transformation – this project entails the upgrade of Ruigtevallei transformers.
- Gariep Strengthening Project Phase 2 – this is a customer-driven project entailing connection to the grid at Kronos as well as IPP connection from Round 4 and beyond. This project will allow for further strengthening of the network that integrates Gariep Hydro Station as well as investigate suspected small signal stability problems.
- Prieska 1 GW Solar Park Integration – this entails the integration of the 450 to 600 MW Solar Park.
- Northern Cape Voltage Unbalance Project – this project entails correction of the existing voltage unbalance in the Northern and Western Cape provinces.
- Kudu Gas Power Station Integration – this project entails the integration of the 950 MW Kudu Gas generator situated in Namibia.

The increase in transmission assets by the end of 2019 and the end of 2024 and the cumulative totals are shown in Table 6.13.

Table 6.13: Cumulative TDP transmission assets for Northern Cape province

Transmission assets for Northern Cape province	New assets expected 2015 to 2019	New assets expected 2020 to 2024	Total new assets expected
Total km of line	*1 289*	*1 050*	*2 339*
765 kV lines (km)	*0*	*0*	*0*
400 kV lines (km)	*1 289*	*950*	*2 239*
275 kV lines (km)	*0*	*100*	*100*
Total installed transformer MVA	*6 935*	*7 635*	*14 570*
Transformers (no. of)	*19*	*32*	*51*
Capacitors (no. of)	*3*	*1*	*4*
Reactors (no. of)	*4*	*1*	*5*

The following projects are planned for the 2015 to 2024 period:

Table 6.14: Northern Cape province – summary of projects and timelines

Scheme name	Project name	Expected year
Garona Strengthening	Kronos 400/132 kV transformation	2016
	Kronos-Cuprum 1st and 2nd 132 kV lines	
Upington Strengthening Phase 1a	Nieuwehoop-Upington 1st 400 kV line	2018
	Upington 1st 500 MVA 400/132 kV transformation	
Upington Strengthening Phase 1b	Aries-Upington 1st 400 kV line	2023
	Aries-Upington 2nd 400 kV line	
	Upington 3rd and 4th 500 MVA 400/132 kV transformers	
Upington Strengthening Phase 1c	Ferrum-Upington 1st 400 kV line	2024
	Upington 5th 500 MVA 400/132 kV transformers	
Kimberley Strengthening Phase 2	Ferrum Ext, 1st and 2nd 500 MVA 400/132 kV transformers	2014
	Ferrum-Mookodi (Vryburg) 1st 400 kV line	
	Mookodi (Vryburg)-Mercury 1st 400 kV line	
Kimberley Strengthening Phase 3	Ferrum-Mookodi (Vryburg) 2nd 400 kV line (via Hotazel)	2020
	Hermes-Mookodi (Vryburg) 1st 400 kV line	
	Hotazel 400/132 kV substation (1st and 2nd 500 MVA 400/132 kV transformers)	
	Hotazel 400 kV loop-in (Ferrum-Mookodi (Vryburg) 2nd 400 kV line)	
	Hotazel Ext. 132 kV 1st 36 MVAr capacitor	

Table 6.14: Northern Cape province – summary of projects and timelines (continued)

Scheme name	Project name	Expected year
Kimberley Strengthening Phase 4A	*Ulco MTS 1st and 2nd 500 MVA 400/132 kV transformers*	*2023*
	Beta-Ulco 1st 400 kV double-circuit line	
	Manganore MTS 1st and 2nd 500 MVA 400/132 kV transformers	
	Ulco-Manganore 1st 400 kV double-circuit line	
	Manganore-Ferrum 1st 400 kV double-circuit line	
Kimberley Strengthening Phase 4B	*Boundary Strengthening: loop in Beta-Ulco 400 kV line into Boundary MTS*	*2024*
Kimberley Strengthening Phase 4C	*Olien Strengthening: loop in Ulco-Manganore 400 kV line at Olien MTS*	*2024*
Gariep Network Strengthening	*Ruigtevallei-Hydra derating of 220 kV line to 132 kV*	*2016*
	Ruigtevallei 132 kV feeder bay to Dreunberg	
Gariep Network Strengthening Phase 2	*Upgrade on the Gariep network to enable for more renewable connections and investigation of possible small signal stability problems*	*2020*
Ruigtevallei Transformation Upgrade	*Ruigtevallei 132/66 kV transformation upgrade*	*2019*
Hydra 400 kV and 132 kV Equipment Upgrade	*Hydra 400 and 132 kV equipment upgrade (fault level requirements)*	*2018*
Kronos Transformation (Customer)	*Kronos 2nd 250 MVA 400/132 kV transformer*	*2019*
Northern Cape Transformation	*Helios transformation*	*2017*
Northern Cape Reinforcement	*Aries 400 MVAr dynamic reactive power device*	*2020*
Namaqualand Strengthening	*Juno-Gromis 400 kV line and 2nd Gromis-Oranjemond 220 kV lines*	*2020*

Table 6.14: Northern Cape province – summary of projects and timelines (continued)

Scheme name	Project name	Expected year
Northern Cape Reinforcement: Ferrum-Nieuwehoop-Aries 400 kV	*Aries-Nieuwehoop 400 kV line*	*2016*
	Ferrum-Nieuwehoop 400 kV line	*2018*
Northern Cape Reinforcement: Aggeneis-Paulputs 2nd 220 kV	*Aggeneis-Paulputs 2nd 220 kV line*	*2021*
Paulputs Ext. 2nd 250 MVA 220/132 kV Transformer	*Paulputs Ext. 2nd 250 MVA 220/132 kV transformer*	*December 2016*
Paulputs 220/132 kV 250 MVA Transformer	*Paulputs 220/132 kV 250 MVA transformer to replace existing 125 MVA*	*2020*
Nama MTS Transformers Upgrade	*Nama MTS transformers upgrade*	*2016*
Hydra Wind Phase 2	*Hydra 3rd 400/132 kV transformer 500 MVA*	*2018*
Hydra B	*New Hydra B 400/132 kV substation*	*2021*
Northern Cape Voltage Unbalance Project	*Northern Cape line transposition*	*2017*
REBID 1 (Preferred Bidders)	*Kaxu Solar 1 – 100 MW CSP plant* *1 x 132 kV feeder bay at Paulputs*	*2014*
REBID 2 (Preferred Bidders)	*Bokpoort CSP – 50 MW* *1 x 132 kV feeder bay at Garona*	*2015*
REBID 3 (Preferred Bidders)	*Loeriesfontein – 140 MW and Khoboeb 140 MW* *Helios 1st and 2nd 500 MVA 400/132 kV transformer and 2 x 132 kV feeder bays at Helios*	*Customer dependent*
	Mulilo-Sonnedix 75 MW and Prieska 75 MW *2 x 132 kV feeder bays at Kronos*	
	Langa-Karoshoek 100 MW CSP at Upington	
	Longyuan-Mulilo-De Aar 138 MW PV plant at Hydra	
	Longyuan-Mulilo-Maanhaarberg 138 MW PV plant at Hydra	

A network diagram of the major projects in the Northern Cape province is shown in Figure 6.24 below.

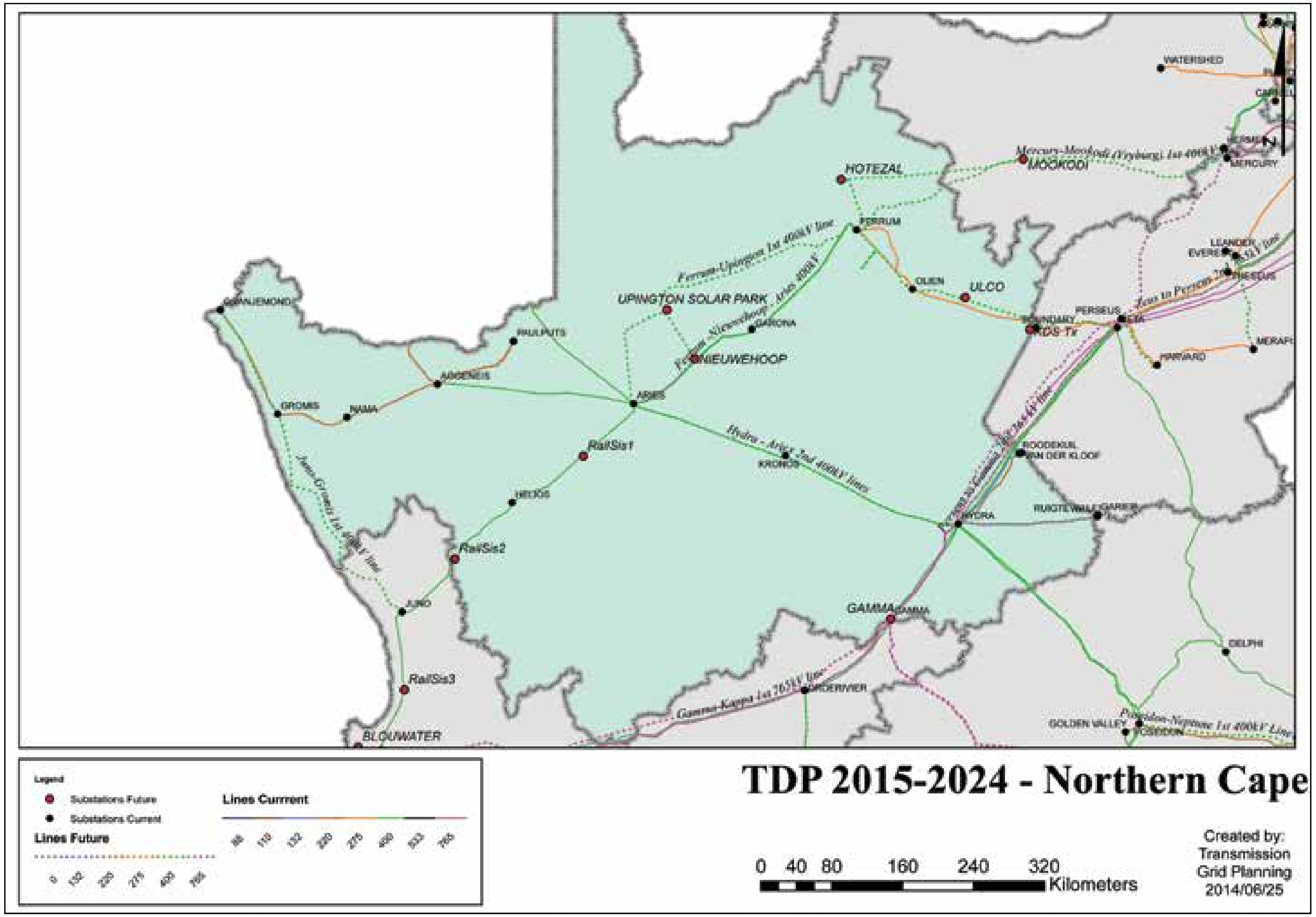


Figure 6.24: Future Northern Cape province network diagram

6.8 Eastern Cape province

The Eastern Cape province is supplied mainly via two 400 kV lines from the main Cape Corridor via Hydra substation and a single 400 kV line from Beta to Delphi. There are also interconnections to the KZN province via 132 kV sub-transmission lines that support the north-eastern parts of the Eastern Cape. The Neptune-Vuyani 400 kV line has already been commissioned, and it has brought relief in the Mthatha area, which has suffered from low-voltage problems in the past. The remaining part of the project to connect 400 kV to the KZN area will be completed in the next 12 months.

The current transmission network is shown in Figure 6.25 below.

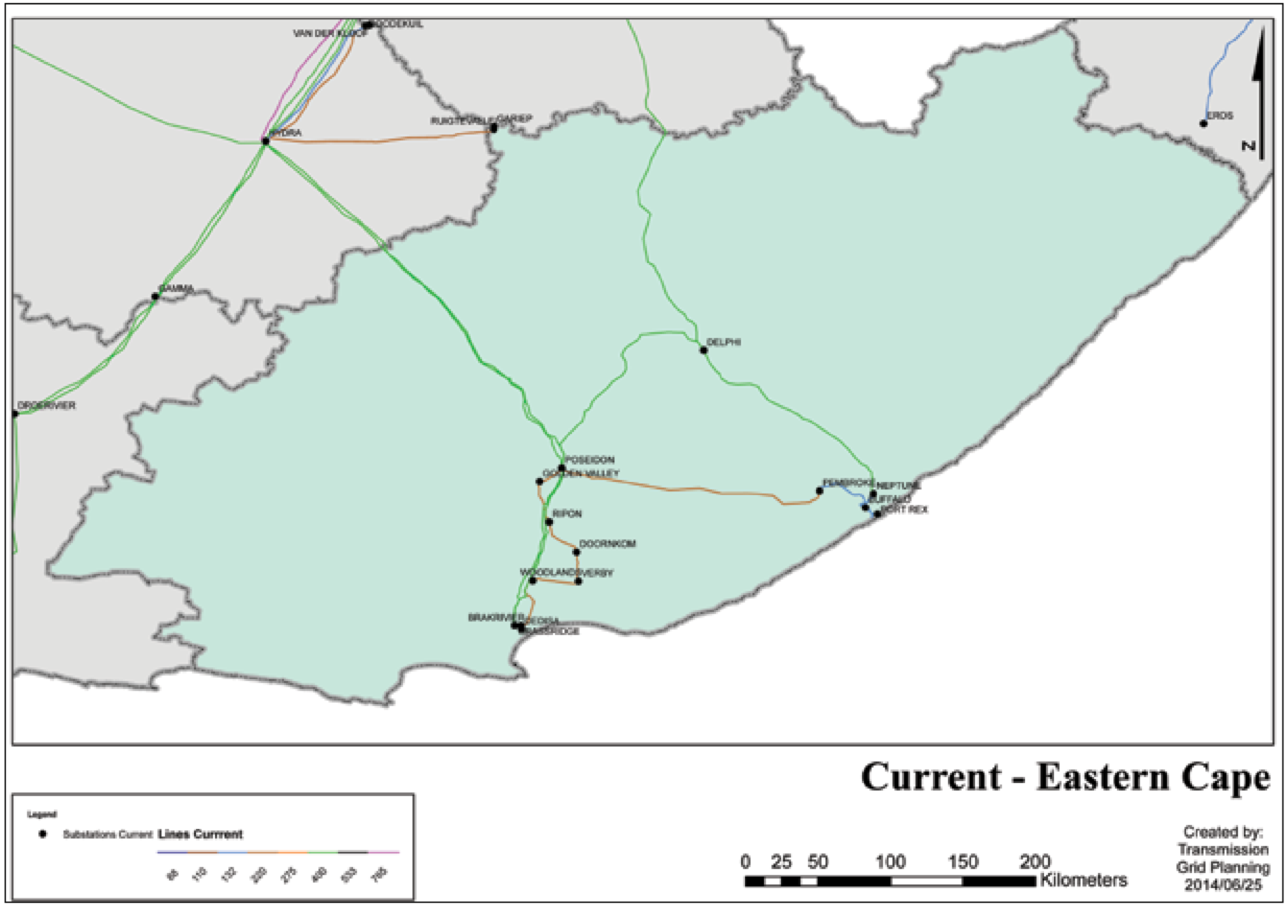
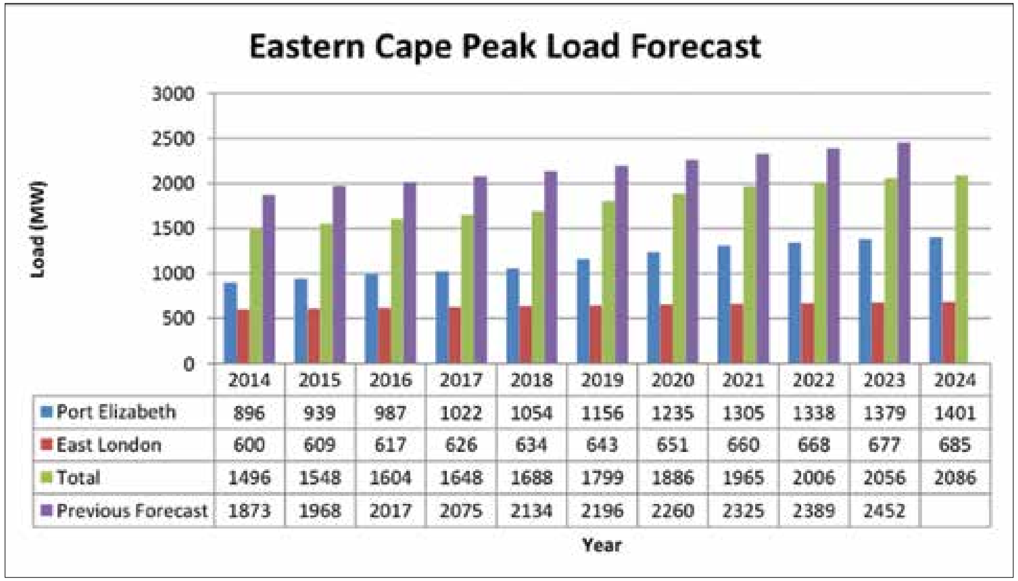


Figure 6.25: Current Eastern Cape province network diagram

The load forecast for the Eastern Cape province is shown in Figure 6.26 below. The major economic drivers in the Eastern Cape are the manufacturing sector, construction, and, in recent times, the renewable IPPs in the form of wind farms. The load forecast has dropped significantly, and as a result, some of the projects have been deferred. The main reason for the decline in load forecast is the slow influx of huge projects in the Coega Industrial Development Zone.



	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Port Elizabeth	896	939	987	1022	1054	1156	1235	1305	1338	1379	1401
East London	600	609	617	626	634	643	651	660	668	677	685
Total	1496	1548	1604	1648	1688	1799	1886	1965	2006	2056	2086
Previous Forecast	1873	1968	2017	2075	2134	2196	2260	2325	2389	2452	

Figure 6.26: Eastern Cape province load forecast

Major schemes

East London Strengthening Phase 3

The re-phasing of the East London Phase 3 project to first inject 400 kV at Pembroke from the Neptune side (instead of constructing the entire line) will alleviate the voltage problem on the 220 kV side.

Gamma-Grassridge 1st 765 kV

The Gamma-Grassridge 1st 765 kV line is needed to address voltage stability constraints in the Port Elizabeth area.

IPP Integration

There has been a huge interest from wind IPPs in the Eastern Cape, resulting in congestion around at least two substations, that is, Poseidon and Grassridge substations, as a result of the huge numbers of approved renewable projects that will be connected there. The long-term strategic plan will ensure that congestion is minimised by making use of collector stations to minimise direct connections at the transmission substations. The approved wind projects in this province amount to just over 1 000 MW up to Round 3 of the REIPPP.

Apart from wind energy, an OCGT plant will be connected at Dedisa substation in the next 12 months. These plans were approved some time ago, and preparatory work is already under way to integrate the 373 MW.

Thyspunt Nuclear Integration

Eskom is conducting a feasibility study of new conventional nuclear generation in the Greater Cape region, with potential sites at Koeberg (Duynefontein), Thyspunt (near Jeffreys Bay), and Bantamsklip (near Pelly Beach). The first phase of this conventional nuclear project is called "Nuclear 1". The preferred location is Thyspunt, and the TDP is based on this assumption. The following 400 kV lines are required based on current assumptions:

- 1 x Thyspunt-Grassridge 400 kV triple Bersfort line – approximately 110 km.
- 2 x Thyspunt-Dedisa 400 kV triple Bersfort lines – approximately 110 km.
- 1 x Thyspunt-PE substation-Grassridge 400 kV triple Bersfort line – approximately 110 km.
- 1 x Thyspunt-PE substation-Dedisa 400 kV triple Bersfort line – approximately 110 km.

The PE substation is required to provide a second injection point from the transmission system into the Port Elizabeth area to the west of the city as well as to integrate Thyspunt.

The increase in transmission assets by the end of 2019 and the end of 2024 and the accumulative total are shown in Table 6.15.

Table 6.15: Cumulative TDP transmission assets for Eastern Cape province

Transmission assets for Eastern Cape province	New assets expected 2015 to 2019	New assets expected 2020 to 2024	Total new assets expected
Total km of line	*165*	*1 422*	*1 587*
765 kV lines (km)	*0*	*700*	*700*
400 kV lines (km)	*165*	*722*	*887*
275 kV lines (km)	*0*	*0*	*0*
Total installed transformer MVA	*4 705*	*3 820*	*8 525*
Transformers (no. of)	*8*	*10*	*18*
Capacitors (no. of)	*4*	*4*	*8*
Reactors (no. of)	*2*	*2*	*4*

The following projects are planned for the 2015 to 2024 period:

Table 6.16: Summary of Eastern Cape province projects and timelines

Scheme name	Project name	Expected year
Greater East London (EL) Phases 1 and 2	*Eros-Vuyani 400 kV line*	*2015*
Grassridge-Dedisa Strengthening	*Grassridge-Dedisa 132 kV line*	*2015*
	3rd Grassridge 500 MVA 400/132 kV transformer	*2019*
	Dedisa 3rd 500 MVA 400/132 kV transformer	*2020*
Southern Grid – Transmission Transformer Normalisation	*Buffalo and Pembroke transformer LV supply normalisation*	*2015*
PE Strengthening Phase 3	*1st shunt capacitor bank at Poseidon, Delphi, Grassridge, and Dedisa*	*2015*
Grassridge 132 kV Equipment Upgrade (Fault Level Requirements)	*Grassridge busbar and equipment upgrade (fault levels)*	*2016*
Pembroke Transformer Upgrade	*Pembroke 400/132 kV 500 MVA transformer*	*2019*
Port Elizabeth Substation Integration – Phase 1	*Port Elizabeth SS integration*	*2022*
Greater EL Phase 3	*Neptune-Pembroke 400 kV line*	*2019*
Greater EL Phase 4	*Poseidon-Pembroke 400 kV line*	*2022*
Southern Grid Phase 3	*1st Gamma-Grassridge 765 kV line*	*2023*
Delphi 3rd 120 MVA 400/132 kV Transformer	*Delphi 3rd 120 MVA 400/132 kV transformer*	*2020*
Greater EL Phase 4	*Pembroke transformer upgrade 250 MVA 132/66 kV*	*2021*
Nuclear 1 Integration	*Nuclear 1 integration: Thyspunt*	*2023*
PE Strengthening Phase 4	*2nd shunt capacitor bank at Poseidon, Delphi, Grassridge, and Dedisa*	*2023*
Southern Grid Phase 4	*2nd Gamma-Grassridge 765 kV line*	*2026*

A network diagram of the major projects in the Eastern Cape is shown in Figure 6.27 below.

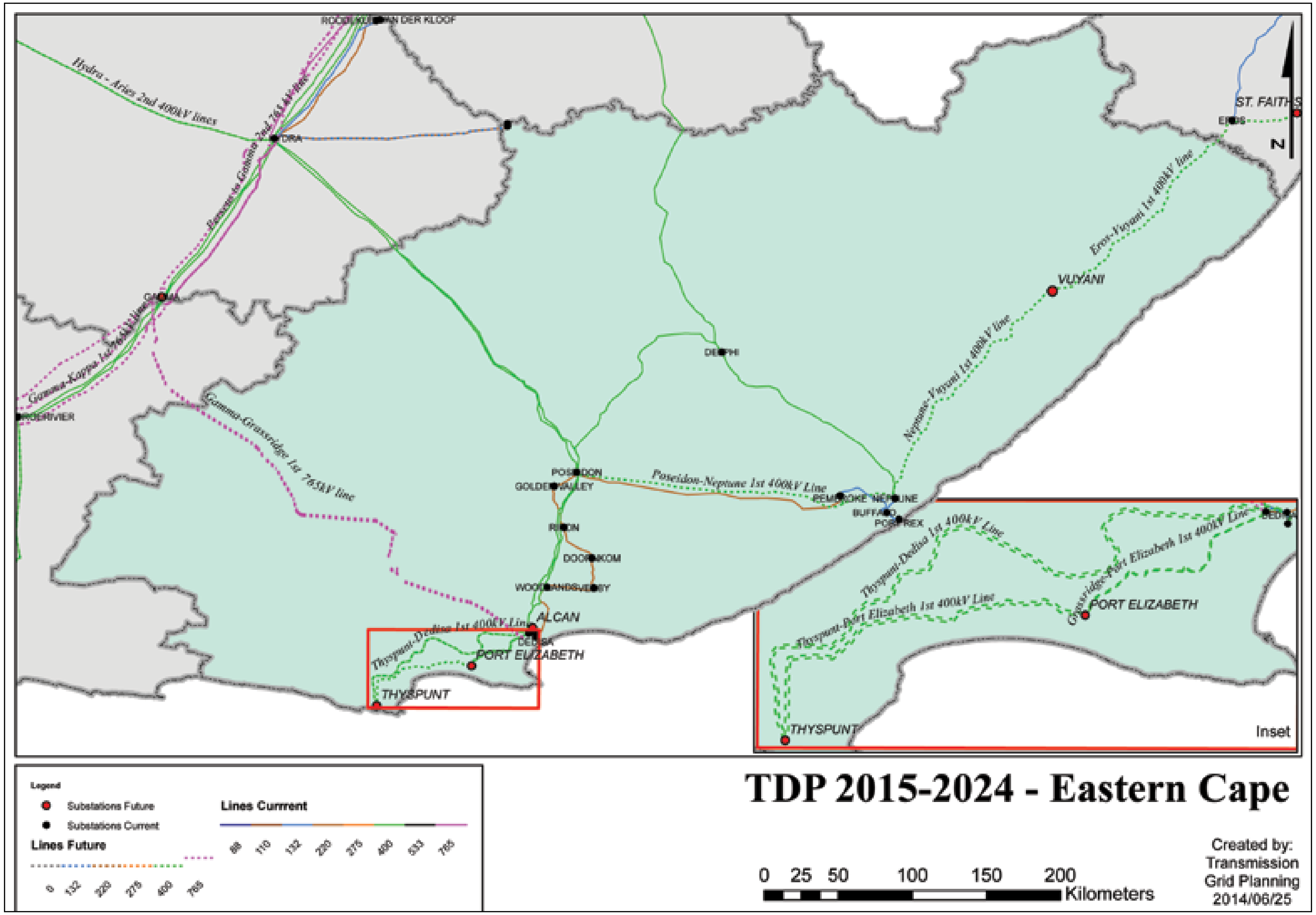


Figure 6.27: Future Eastern Cape province network diagram

6.9 Western Cape province

The Western Cape province development plan consists of 765 kV and 400 kV network integration. The local system peak in the Western Cape occurs almost one hour later than the overall system peak because sunset occurs almost one hour later in Cape Town than in the major load centres in the eastern part of the country, and the evening peak (which is the peak loading period of the day) is dominated by residential load.

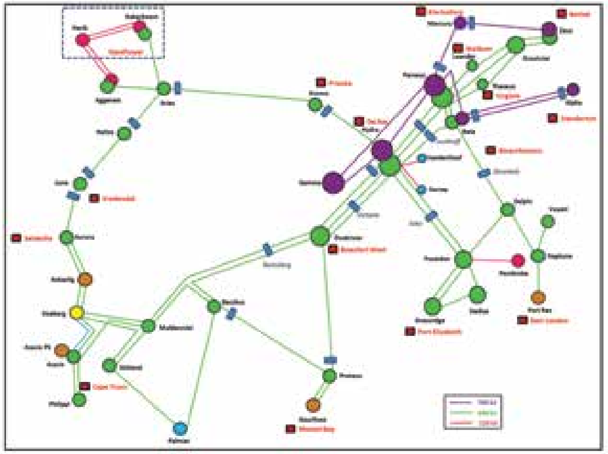


Figure 6.29: Single-line diagram of the existing Greater Cape transmission network and Cape Corridor

The current transmission network is shown in Figure 6.28 below.

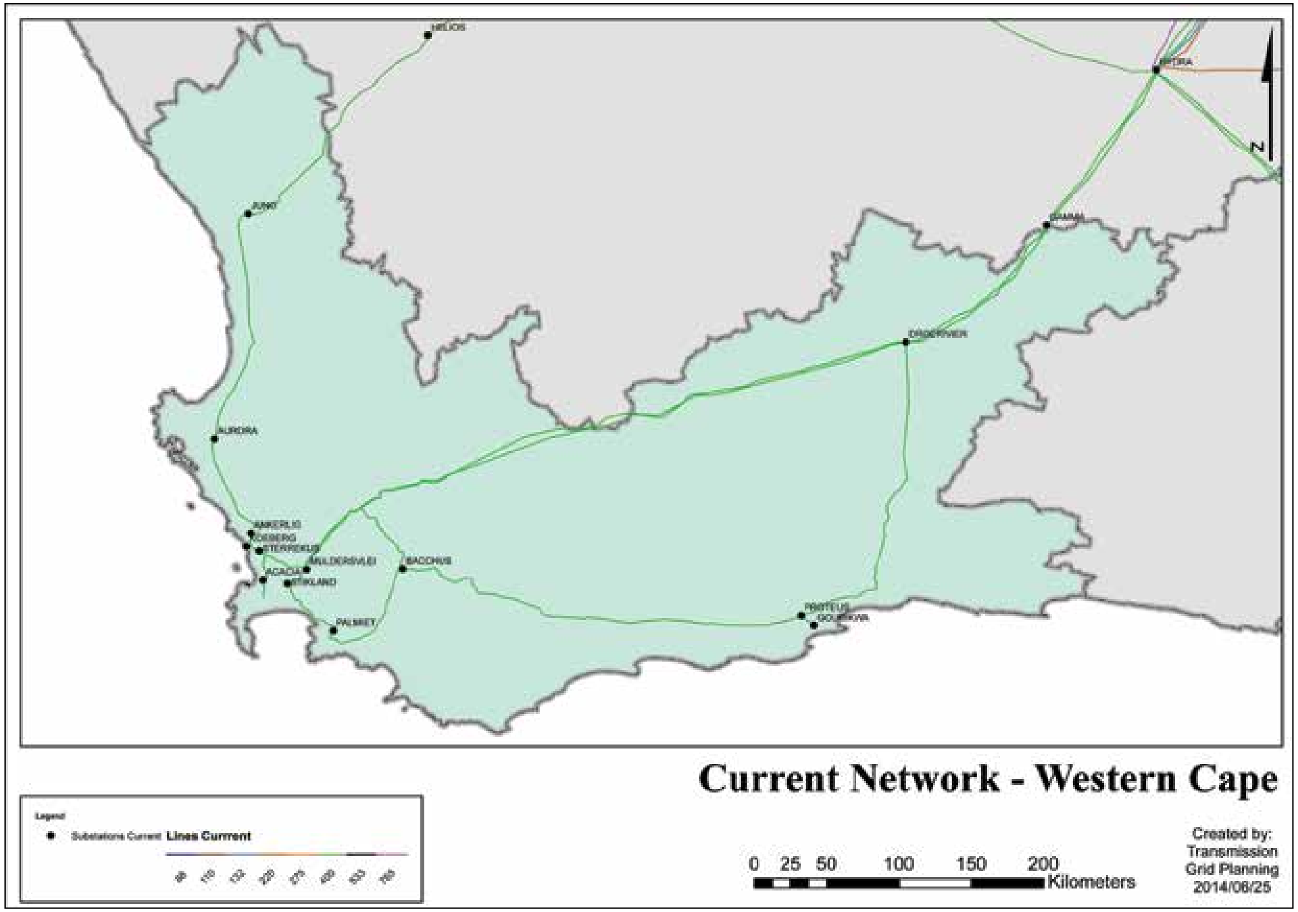
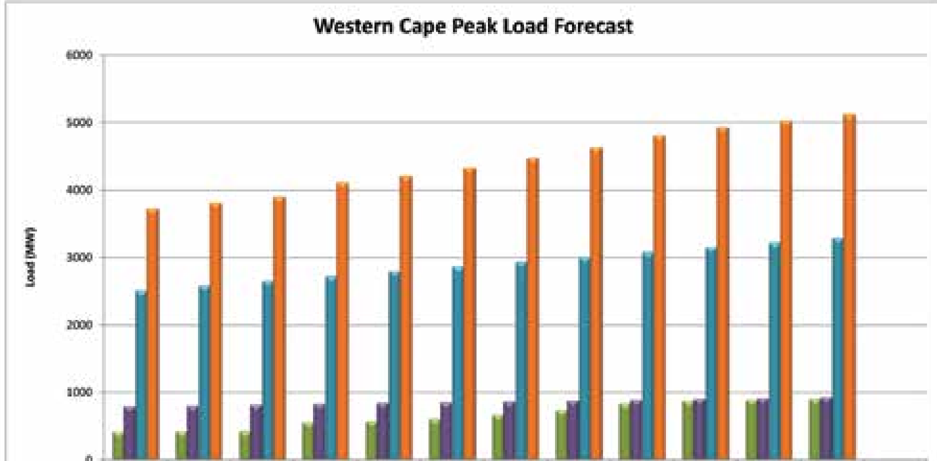


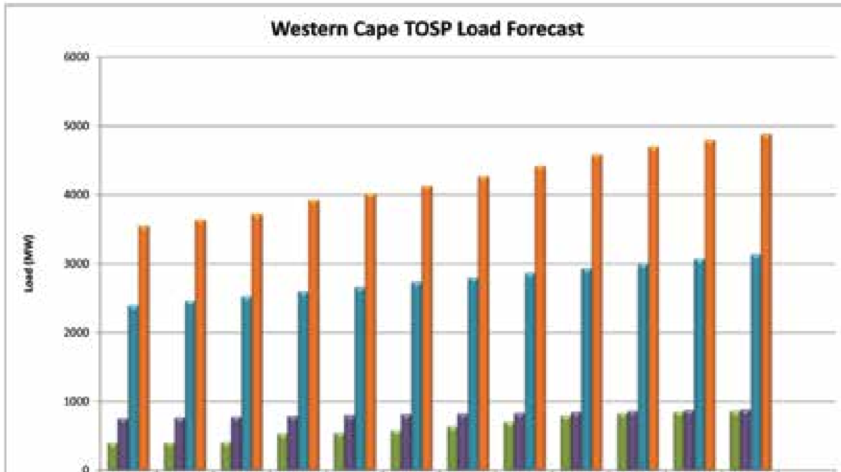
Figure 6.28: Current Western Cape province network diagram

The load forecast is shown in Figure 6.30 and Figure 6.31.



	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	Average Growth (year-on-year)
West Coast	420	425	430	558	574	607	671	741	838	874	893	904	8.61%
Outeniqua	794	806	818	830	843	855	867	879	891	903	916	928	1.40%
Peninsula	2513	2583	2653	2724	2795	2866	2938	3009	3079	3150	3220	3289	2.41%
Total	3727	3814	3901	4113	4212	4328	4476	4628	4808	4927	5029	5120	3.07%

Figure 6.30: Peak load forecast for the Western Cape province



	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	Average Growth (year-on-year)
West Coast	400	405	410	533	547	579	640	706	799	834	852	862	8.61%
Outeniqua	757	769	781	792	804	815	827	839	850	862	873	885	1.40%
Peninsula	2397	2464	2531	2598	2666	2734	2802	2870	2937	3004	3071	3137	2.41%
Total	3555	3638	3721	3923	4017	4129	4269	4415	4587	4700	4796	4884	3.07%

Figure 6.31: TOSP load forecast for the Western Cape province

The TDP schemes for the Western Cape consist of extending the 400 kV network and introducing 765 kV injections at two points. There is also the installation of additional transformers at existing and introduction of new substations.

Generation capacity

Koeberg Nuclear Power Station (KNPS) plans to increase its total output to 2 128 MW through the Thermal Power Uprate Project and the Steam Generator Replacement Project. Adjustments on the nuclear side, together with a more efficient steam generator, will produce more thermal energy and, as a result, increase the generator electricity output.

Ankerlig Power Station plans to implement an OCGT Expansion Project, which will result in the installation of an additional 4 x 150 MW gas turbines at the station.

At Ankerlig and Gourikwa Power Stations, the power output will be increased via the CCGT Conversion Project, which will convert 5 x existing OCGT units at each station to CCGT. This will entail the installation of heat recovery steam generators (HRSGs) that will use the heat from the exhausts of the gas turbines to create steam. The steam from the HRSGs will be used to drive two new steam turbines, leading to increased cycle efficiency. The resultant output per CCGT unit will be 225 MW, comprised of 150 MW (gas turbine) + 75 MW (steam recovery).

Additional transmission network infrastructure is, therefore, required to enable an increase in power output at the generating facilities in the Western Cape in order to ensure compliance in accordance with the Grid Code.

1. *For Koeberg:*

- Koeberg 400 kV GIS busbar is due for refurbishment. It has been in operation for almost 30 years; over eight failures related to post insulators since commissioning have been experienced. The biggest concern with these types of failures is that they result in long-duration outages. As a result of this, a new 400 kV busbar or substation (Weskusfleur substation) has been proposed. The Koeberg Power Uprate Project will cause marginal overloading of a section of the remaining 400 kV GIS busbar when one of the main busbars is out of service. Weskusfleur substation (or a new 400 kV busbar) will address this and is, therefore, a prerequisite for the Koeberg Thermal Power Uprate Project.

2. *For Koeberg and Ankerlig generation pool:*

- The existing Koeberg-Acacia 2 400 kV line, which is currently operated at 132 kV, must be energised at 400 kV in order to evacuate the existing generation in the Koeberg-Ankerlig generation pool under N-2 conditions. This is expected to be commissioned when the Koeberg off-site supply, a nuclear regulatory requirement currently provided by the Acacia OCGTs, is relocated to Ankerlig.
- Ankerlig-Sterrekus 1st and 2nd 400 kV lines. These lines were originally planned as a single 400 kV line, but will now have to be built as two lines on a double-circuit structure to cater for generation increase at Koeberg and Ankerlig.

3. *For Gourikwa:*

- Gourikwa-Blanco 400 kV line and Blanco-Droërivier 2nd 400 kV line to provide N-2 compliance for Gourikwa after the CCGT conversion. This line was originally planned as a Droërivier-Proteus 400 kV line. A strategic EIA has been initiated in order to ensure that servitudes are acquired.

Renewable generation

The Western Cape has high potential for renewables energy due to its climate and proximity to the coastline. Sere Wind Farm is an Eskom wind generating facility that will have a capacity of 100 MW when completed in 2015. It is located north-west of Vredendal in Skaapvlei, approximately 300 km north of Cape Town. A number of projects have also been approved in the Western Cape under the DoE's RE IPP programme for Rounds 1 to 3.

Substation firm capacity

- At Muldersvlei substation, as part of the substation refurbishment project, the 2 x 240 MVA, 400/132 kV transformers will be replaced with a single 500 MVA, 400/132 kV transformer. Fault current-limiting reactors (FCLRs) will be installed in series with the 3 x 500 MVA, 400/132 kV transformers on the 132 kV side of the transformers.
- The unfirm problem at Stikland substation will be resolved by installing FCLRs and interconnecting the 132 kV network to Muldersvlei substation and later by establishing Pinotage substation (Firgrove transmission

substation), which will deload both Stikland and Muldersvlei substations. However, the estimated load transfer to Pinotage substation indicates a potential unfirm condition at Pinotage substation from the outset. Distribution will have to investigate further.

- Erica substation (Mitchell's Plain transmission substation) will be established in order to address the loading at Philippi substation. A 3rd 500 MVA, 400/132 kV transformer is also planned for Philippi substation, the commissioning to be determined after the establishment of Erica substation.
- The unfirm problem at Bacchus substation will be resolved by establishing Asteria and Agulhas substations (Houhoek and Vryheid transmission substations).
- With the establishment of the City of Cape Town's Richmond Estate 132/11 kV substation, all of the 11 kV load will be transferred off Acacia substation.
- The unfirm problem at Proteus substation will be resolved by establishing Narina substation (Blanco transmission substation).
- The transformation capacity at Juno substation will be upgraded by:
  - replacing the 2 x 120 MVA 400/132 kV units with 2 x 500 MVA units;
  - replacing the 2 x 40 MVA 132/66 kV units with 2 x 80 MVA units; and
  - installing an additional 20 MVA 66/22 kV unit with the existing 10 MVA unit.
- The unfirm problem at Aurora substation will be resolved by establishing Blouwater transmission substation, the trigger being commitment of load in the Saldanha Bay area and the Saldanha Bay IDZ.

Reactive power compensation

- Additional capacitor banks will be installed at Aurora 132 kV, Muldersvlei 132 kV, Bacchus 132 kV, and Proteus 132 kV.

Underrated equipment

The underrated equipment at the following substations will be addressed as follows:

- Muldersvlei substation – as part of the substation refurbishment project, the 2 x 240 MVA, 400/132 kV transformers will be replaced with a single 500 MVA, 400/132 kV transformer. Fault-limiting reactors will be installed in series with the 3 x 500 MVA, 400/132 kV transformers on the 132 kV side of the transformers. The 400 kV and 132 kV under-rated equipment at Muldersvlei will also be upgraded as part of the project.
- Stikland substation – fault-limiting reactors will be installed in series with the 2 x 500 MVA, 400/132 kV transformers on the 132kV side of the transformers. The 132 kV equipment will also be upgraded to 40 kA as part of a Distribution refurbishment and upgrade project.
- Philippi substation – a 3rd 500 MVA, 400/132 kV transformer is planned, the commissioning to be determined after the establishment of Erica substation (Mitchell's Plain transmission substation). Fault-limiting reactors are planned to be installed in series with the 3 x 500 MVA, 400/132 kV transformers on the132 kV side of the transformers. This will result in a reduction of fault levels at Philippi substation.
- Refurbishment is planned for Aurora substation, the scope of which will include upgrading the underrated equipment.
- Refurbishment is planned for Acacia substation, the scope of which will include upgrading the 400 kV circuit-breakers to 50 kA.

Schemes (Cape Corridor)

A geographical view of the Cape network with Kappa and Sterrekus substation is shown in Figure 6.32 below. This will provide a sizeable (~ 2 000 MW) improvement in overall power transfer capacity.

Additional strengthening of the Cape Corridor in the form of 765 kV series compensation is required after 2016, the details of which are yet to be finalised. This will provide for network adequacy until 2022, after which the preferred strengthening option will be Cape Corridor Phase 4, which entails a 2nd Zeus-Perseus-Gamma-Kappa-Sterrekus 765 kV line. This will provide a network that is suitable for the next eight years (up to 2030).

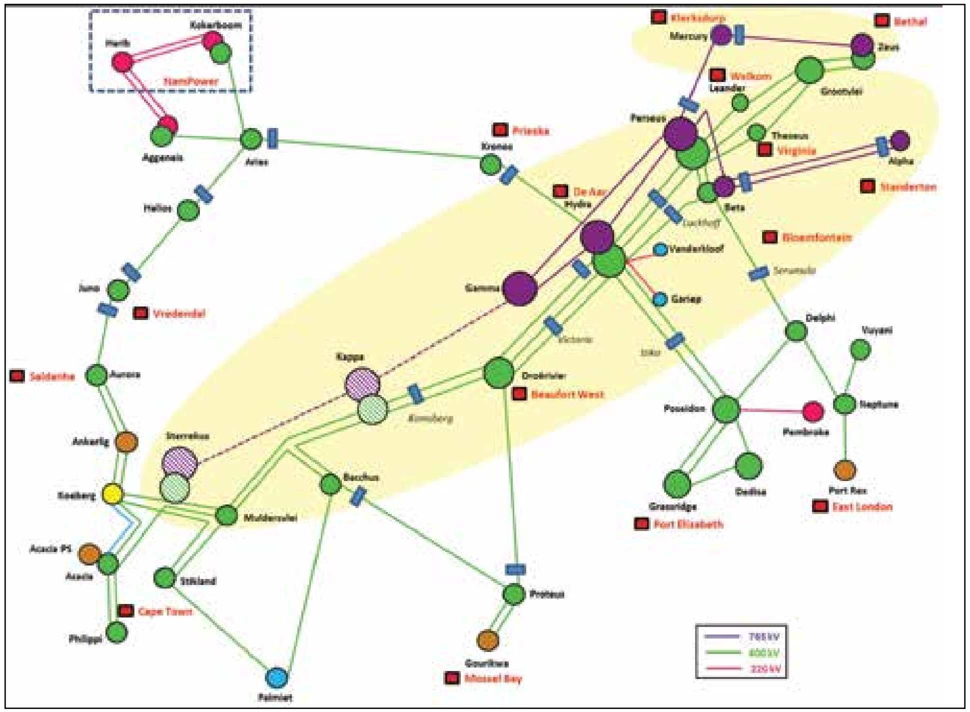


Figure 6.32: Single-line diagram highlighting the Cape Corridor in 2016

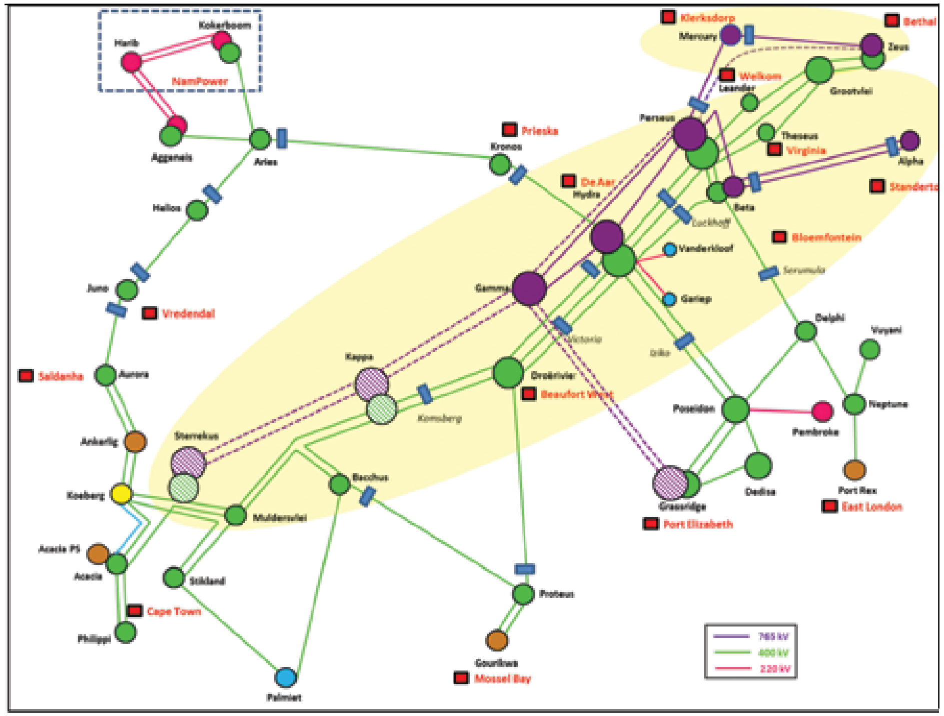


Figure 6.33: Single-line diagram highlighting the Cape Corridor in 2022 (excluding 765 kV series compensation)

The increase in transmission assets by the end of 2019 and the end of 2024 and the cumulative totals are shown in Table 6.17.

Table 6.17: Cumulative TDP transmission assets for Western Cape province

Transmission assets for Western Cape province	New assets expected 2015 to 2019	New assets expected 2020 to 2024	Total new assets expected
Total km of line	*647*	*1 729*	*2 376*
765 kV lines (km)	*560*	*1 430*	*1 990*
400 kV lines (km)	*87*	*299*	*386*
275 kV lines (km)	*0*	*0*	*0*
Total installed transformer MVA	*6 000*	*8 500*	*14 500*
Transformers (no. of)	*10*	*14*	*24*
Capacitors (no. of)	*4*	*0*	*4*
Reactors (no. of)	*6*	*8*	*14*

The following projects are planned for the 2015 to 2024 period:

Table 6.18: Western Cape province – summary of projects and timelines

Scheme name	Project name	Expected year
Aurora 132 kV, Muldersvlei 132 kV, Bacchus 132 kV, and Proteus 132 kV Capacitor Banks	*Aurora 132 kV, Muldersvlei 132 kV, Bacchus 132 kV, and Proteus 132 kV capacitor banks*	*2015*
Muldersvlei Ext. 3rd 500 MVA 400/132 kV Transformer and 132 kV Series Reactors	*Muldersvlei Ext. 3rd 500 MVA 400/132 kV transformer and 132 kV series reactors*	*2016*
Stikland 132 kV FCLRs	*Stikland 132 kV FCLRs*	*2018*
2nd Koeberg-Acacia 400 kV Line	*2nd Koeberg-Acacia 400 kV line*	*2021*
Establish Koeberg Off-site Supply at Ankerlig Power Station	*Establish Koeberg off-site supply at Ankerlig Power Station* *Loop in and out of Koeberg-Dassenberg 132 kV line*	*2016*

Table 6.18: Western Cape province – summary of projects and timelines (continued)

Scheme name	Project name	Expected year
Ankerlig-Sterrekus 1st and 2nd 400 kV Lines	*Ankerlig-Sterrekus 1st and 2nd 400 kV lines*	*2019*
Cape Corridor Phase 2: Gamma-Kappa-Sterrekus 765 kV Line	*Kappa substation 1st 765/400 kV 2 000 MVA transformer* *Gamma-Kappa 1st 765 kV line* *Kappa-Sterrekus 1st 765 kV line* *Sterrekus substation 1st 765/400 kV 2 000 MVA transformer*	*2016*
Pinotage Substation (Firgrove Transmission Substation)	*Pinotage substation (1st and 2nd 400/132 kV 500 MVA transformers)* *Loop in and out of Palmiet-Stikland 400 kV line*	*2017*
Series Compensation on Zeus-Sterrekus 1st 765 kV Line	*Series compensation on Zeus-Sterrekus 1st 765 kV line*	*2017*
Asteria Substation (Houhoek Transmission Substation)	*Asteria substation (1st and 2nd 400/132 kV 500 MVA transformers)* *Loop in and out Palmiet-Bacchus 400 kV line*	*2022*
Narina Substation (Blanco Transmission Substation)	*Narina substation (1st and 2nd 400/132 kV 500 MVA transformers)* *Loop in and out Droërivier-Proteus 400 kV line*	*2022*
Koeberg 400 kV (and 132 kV) Busbar Reconfiguration and Transformers Upgrade Project (Weskusfleur Substation)	*Koeberg 400 kV (and 132 kV) busbar reconfiguration and transformers upgrade project* *Koeberg 400 kV (and 132 kV) lines rerouting to the new busbar(s)*	*2020*
Philippi Ext. 3rd 500 MVA 400/132 kV Transformer	*Establish 400 kV busbar* *Provision for Philippi 3rd 400/132 kV 500 MVA transformer*	*2021*
Juno Substation Transformation Upgrade	*Replace the 2 x 120 MVA 400/132 kV units with 2 x 500 MVA units* *Replace the 2 x 40 MVA 132/66 kV units with 2 x 80 MVA units* *Install an additional 20 MVA 66/22 kV unit with the existing 10 MVA unit*	*2020*
Erica Substation (Mitchell's Plain Transmission Substation)	*Erica substation (1st and 2nd 400/132 kV 500 MVA transformers)* *Loop in and out Palmiet-Stikland 400 kV line*	*2021*
Philippi-Erica 400 kV Line	*Philippi-Erica 400 kV line*	*2021*

Table 6.18: Western Cape province – summary of projects and timelines (continued)

Scheme name	Project name	Expected year
Cape Corridor Phase 4: 2nd Zeus-Sterrekus 765 kV Line	*Zeus-Perseus 1st 765 kV line* *Perseus-Gamma 2nd 765 kV line* *Gamma-Kappa 2nd 765 kV line* *Kappa-Sterrekus 2nd 765 kV line* *Sterrekus Ext. 2nd 765/400 kV 2 000 MVA transformer*	*Beyond 2024*
Blouwater Transmission Substation (Phase 1)	*At Aurora substation, replace two of the four existing 400/132 kV 250 MVA transformers with 2 x 500 MVA transformers as part of refurbishment* *Strategically acquire a substation site in the Saldanha Bay area* *Construct 2 x 400 kV lines (operated at 132 kV) from Aurora substation to the new distribution Blouwater substation*	*2021*
Blouwater Transmission Substation (Phase 2)	*Blouwater transmission substation (1st and 2nd 400/132 kV 500 MVA transformers)* *Loop in Ankerlig-Aurora 400 kV line*	*Beyond 2024*
Agulhas Substation (Vryheid Transmission Substation)	*Agulhas substation (1st and 2nd 400/132 kV 500 MVA transformers)* *Loop in and out Bacchus-Proteus 400 kV line*	*2021*
Windmill Transmission Substation	*Windmill 400/132 kV substation (1st and 2nd 500 MVA transformers)* *Loop in and out Bacchus-Muldersvlei 400 kV line*	*Beyond 2024*
Droërivier-Proteus 2nd 400 kV Line (Droërivier-Narina-Gourikwa 400 kV Line)	*Droërivier-Narina-Gourikwa 400 kV line*	*Strategic EIA*
Cape Corridor Phase 5: 1st Perseus-Kronos-Aries-Helios-Juno-Aurora-Sterrekus 765 kV Line	*Cape Corridor Phase 5: 1st Perseus-Kronos-Aries-Helios-Juno-Aurora-Sterrekus 765 kV line*	*Strategic EIA*

Chapter 7
Strategic servitudes under investigation

All the line projects and new substation projects that are proposed in the document need to go through a full environmental impact assessment (EIA) process before implementation. This process includes public participation meetings, which are advertised in the media. The concerns of the public and affected parties are addressed at the public participation meetings. Eskom Holdings will not commence the construction of any line or substation unless the EIA process (Record of Decision signed and servitudes acquired) has been concluded.

The proposed lines shown in various schematics in this document give an estimation of where the various proposed lines will run. The outcome of the EIA process will determine the exact position of the lines. The projects in this document are at various stages of the EIA and land acquisition processes.

In addition, Eskom sometimes acquires sites and servitudes on a strategic basis to cater for expected future development, if urban development or other changes in land use are expected to make the acquisition impractical or prohibitively expensive or dictate that significantly more expensive network strengthening options be used. Once again, the outcome of the EIA process will determine the exact routing of these servitudes and location of these sites. Interested and affected parties will have an opportunity to voice their concerns at the public participation meetings, as with all other sites and servitudes acquired by Eskom Transmission.

Chapter 8
Capital expenditure plan

The total capital expenditure for Transmission, including expansion, refurbishment, facilities, production equipment, and land acquisition project costs, amounts to R163 billion. This summary is shown in Table 8.1. It is clear that the majority of the cost will be related to expansion because this relates directly to the strengthening of the network to accommodate new customers as well as new generation.

Refurbishment and land acquisition projects are the second- and third-most expensive items in the capital expenditure, respectively. Refurbishment is required to prolong the life of assets, and land acquisition projects are required to purchase the land on which to build the expansion assets.

The detailed costing of the expansion projects is shown in Appendix B. For purposes of confidentiality, the planned or exact costs per project of customer projects have been excluded from the table.

Table 8.1: Capital expenditure per category of projects

Categories	Rand (millions)
	FY 2015 to 2024
Capacity expansion	*145 968*
Refurbishment	*7 680*
Strategic	*1 066*
Capital spares	*2 397*
Production equipment	*519*
Lands and rights	*5 150*
Total	**162 779**

Chapter 9
Concluding remarks

The most visible difference between this TDP and the TDP published in 2012 is the re-phasing of projects necessitated by the significantly reduced budget available to fund network development. There has also been re-phasing of projects in the execution phase using more realistic completion dates. The acquisition of servitudes for lines and sites for new substations continues to be a challenge for Eskom Transmission, sometimes necessitating re-phasing.

Projects required for the 1st three rounds of the DoE Renewable Energy (RE) IPP programme that are under construction have been added. There is an assumed plan for Rounds 4 to 6 of the RE IPP programme based on current estimates of technology, size, and location.

The result is a realistic and achievable development plan, within the constraints imposed by funding, site and servitude acquisition, and supplier and construction lead times. The slower rate of completion of projects, unfortunately, increases the overall risk to the network. However, this risk can be managed, as the N-1 unfirm refers to the strict deterministic level, which assumes that the N-1 event will happen at the time of the loading peak. In reality, there is a limited chance of this happening, and operational mitigation plans will cater for most of the events until the required projects have been completed. Some of the risk mitigation measures under consideration include higher reliance on the following: utilisation of strategic spares, the use of capacitors in the short term for voltage support, as well as emergency preparedness plans. Customers are consulted when compiling or reviewing emergency preparedness plans to ensure that emergencies necessitating load reduction are managed in a way that minimises the impact on customers and South Africa.

Robust and efficient planning requires the timely exchange of credible information between stakeholders. In particular, stakeholders are requested to note that spatial data and information are critical for the effective planning and development of the transmission network.

Transmission infrastructure could easily become the critical path in connecting and integrating large new loads and generation due to the long lead times for securing corridors. We recommend that, for planning purposes, developers should allow for at least seven years' lead time for new corridors. It should also be noted that, in the EIA process, there are increasing objections from landowners and other stakeholders to proposed power line routes, which may further prolong the time to implement projects. The EIA and environmental approval process is prescribed by law, and changes to the relevant environmental legislation can have a significant effect on lead times for new projects.

The conclusion is that the transmission projects in this TDP will result in the overall network becoming Grid Code compliant while catering for increased load growth and the integration of new generation, but at a later date than previously envisaged due mainly to funding constraints. The system will be running at risk in some areas, and careful operational mitigation planning will have to be undertaken until the transmission projects and new generation are in place. Customers can assist in minimising the risks by participating in the consultation process when emergency preparedness plans are compiled or reviewed.

Chapter 10
Appendices

10.1 Appendix A: Generation Assumptions

Table A1: The Conventional Generation Plan for the TDP 2015 to 2024

CONVENTIONAL GENERATION SCHEDULE FOR THE TDP PERIOD 2015 TO 2024

2010 IRP Year	PSS/E Casefile Year	Grootvlei		Komati		Medupi		Kusile		Ingula		DoE OCGT 1		Doe OCGT 2		Nuclear		Nuclear	New Coal		New Coal	O & C CGT		O & C CGT	HYDRO import		HYDRO import	Camden Decomm		Hendrina Decomm		Arnot Decomm	
		Unit	MW	Unit	MW	Unit	MW	Unit	MW	Unit	MW	Unit	MW	Unit	MW	Unit	Location	MW	Unit	Location	MW	Unit	Location	MW	Unit	Location	MW	Unit	MW	Unit	MW	Unit	MW
2015	2015					1	738			1	333	1	147	1	147																		
						2	738			2	333	2	147	2	147																		
														3	147																		
														4	147																		
														5	147																		
	2016									3	333																						
2016	2016					3	738	1	738	4	333																						
						4	738																										
	2017							2	738																								
2017	2017					5	738																										
						6	738																										
	2018							3	738																								
2018	2018							4	738																								
	2019							5	738																								
2019	2019							6	738												1	Coal IPP 1	200	3	Dedisa	237									
																			2	Coal IPP 1	200												
																			3	Coal IPP 1	200												
2020	2020																		1	Coal IPP 3	200	4	Dedisa	237									
																			2	Coal IPP 3	200												
2021	2021																					5	Dedisa	237				6	-160	4	-190		
2022	2022																		1	Coal IPP 2	250	6	Dedisa	269	1	Maputo	570	7	-170	3	-190		
																			2	Coal IPP 2	250	7	Dedisa	269	2	Maputo	570	8	-180	5	-180		
																			1	Coal IPP 4	250	8	Dedisa	269									
2023	2023															1	Thyspunt	1600	3	Coal IPP 2	250				3	Maputo	570	5	-180	2	-190	3	-380
																			2	Coal IPP 4	250				4	Maputo	570	4	-185			2	-380
																			3	Coal IPP 4	250												
2024	2024															2	Thyspunt	1600	4	Coal IPP 4	250							3	-185	1	-190	1	-376
																												2	-190				
																												1	-190				

Table A2: The Renewable Generation Plan for the TDP 2015 to 2024

RENEWABLE GENERATION SCHEDULE FOR THE TDP PERIOD 2015 TO 2024

2010 IRP Calender Year	PSS/E Casefile Year	Wind Unit ID	Wind Unit	Wind Location	Wind MW	CSP Unit ID	CSP Unit	CSP Location	CSP MW	PV Unit ID	PV Unit	PV Location	PV MW	Other RE Unit	Unit	Other RE Location	Other RE MW
2015	2015	I202W	1	Aurora	65	I798C	1	Garona	50	I163P	1	Aries	10	I00298	1	Etna	18
		I123W	1	Bacchus	26	I118C	1	Paulputs	100	I164P	3	Aurora	5				
		I043W	1	Delphi	97					I037P	1	Bacchus	36				
		I186W	2	Grassridge	134					I135P	1	Bighorn	7				
		I138W	3	Grassridge	26					I572P	1	Boundary	48				
		I148W	4	Grassridge	78					I443P	1	Douglas	10				
		I036W	3	Hydra	73					I696P	2	Douglas	20				
		I225W	1	Poseidon	135					I444P	1	Ferrum	75				
		Eskom	1	Juno (Sere)	100					I031P	1	Harvard	64				
										I182P	1	Hydra	48				
										I064P	2	Hydra	10				
										I159P	5	Hydra	73				
										I564P	6	Hydra	75				
										I065P	1	Kronos	20				
										I032P	2	Olien	64				
										I118P	1	Paulputs	100				
										I128P	2	Paulputs	10				
										I052P	1	Tabor	28				
										I035P	1	Witkop	30				
2016	2016	I00092W	7	Hydra	139					I00771P	4	Aurora	75	I01498	1	Impala	16.5
		I00093W	8	Hydra	96.5					I02692P	2	Kronos	75				
		I00242	4	Poseidon	86.6					I02693P	3	Kronos	75				
										I0338P	1	Malimba	60				
2017	2017	I309W	4	Aurora	91	I002C	2	Garona	50	I373P	2	Aurora	9	I815H	3	Paulputs	10
		I364W	1	Grassridge	60	I0056C	2	Paulputs	100	I207P	2	Ferrum	74	I490H	1	Tugela	4.3
		I303W	5	Grassridge	95	I0040C	1	Upington	100	I764P	3	Garona	9				
		I014W	1	Mulderssvlei	135					I523P	4	Hydra	37				
		I372W	1	Pembroke	21					I168P	7	Hydra	75				
		I240W	2	Poseidon	138					I375P	1	Juno	9				
		I362W	3	Poseidon	23					I562P	1	Olien	75				
		I00281W	1	Helios	138					I750P	1	Perseus	60				
		I00284	9	Hydra	79					I527P	1	Ruigtevallei	70				
		I002817W	2	Helios	128					I00064P	3	Ferrum	75				
		I01361W	6	Grassridge	110					I03461P	2	Boundary	75				
2018	2018		10	Hydra	100		2	Upington	100								
			1	Delphi	100												
			1	Nama	100												
			1	Gromis	100												
2019	2019		1	Droerivier	100		3	Upington	100								
			2	Delphi	100												
			3	Delphi	100												
			1	Bacchus	100												
2020	2020		2	Nama	100		4	Upington	100								
			2	Bacchus	100												
			2	Droerivier	100												
			1	Neptune	100												
2021	2021		3	Nama	100		5	Upington	100								
			3	Bacchus	100												
			3	Droerivier	100												
			2	Neptune	100												
2022	2022		4	Delphi	100		6	Upington	100								
			4	Droerivier	100												
			7	Grassridge	100												
			4	Nama	100												
2023	2023		5	Poseidon	100		7	Upington	100								
			5	Droerivier	100												
			8	Grassridge	100												
			5	Nama	100												
2024	2024		3	Helios	100		8	Upington	100								
			4	Helios	100												
			1	Gromis	100												
			6	Poseidon	100												
			5	Delphi	100												
			6	Delphi	100												
			7	Delphi	100												
			8	Delphi	100												

Appendix B: Costing for transmission projects

Appendix B1: Costing for Gauteng projects

EXPANSION	**R 18 468 922 980**
Benburg MTS Install 3rd 250 MVA 275/132 kV Transformer	R 54 424 455
Craighall B Integration	R 1 358 553 369
Craighall SS: 88 kV Randburg Strengthening	R 485 000
Demeter 400/132 kV SS Establish and Integrate	R 940 931 418
JHB East Strengthening Phase 3C (Jupiter B + Matla-Jupiter Lines)	R 1 509 692 405
JHB North Phase 2a: Lepini Ext. 275 kV 2 x 150 MVAr Capacitors	R 78 549 198
JHB North Phase 2b: Apollo-Lepini 275 kV Line	R 399 426 988
JHB Reactive Power Project	R 686 171
Johannesburg East Strengthening – Phase 1B to 3A – North Rand Integration	R 1 204 818 048
Johannesburg East Strengthening Phase 3C to D: Jupiter B and Loop-ins	R 1 327 915 262
Kookfontein MTS 3rd 275/88 kV Transformer and 3rd Glockner-Kookfontein 275 kV Line	R 205 687 967
Kyalami 400 kV SS Establish and Integrate	R 1 616 487 439
Pelly 132/22 kV Transformer Upgrade	R 4 639 037
Siluma 275 kV SS Establish and Integrate	R 380 546 204
Simmerpan MTS Phase 1: 275/88 kV	R 706 914 463
Simmerpan MTS Phase 2: 275/132 kV	R 319 981 720
Soweto Strengthening Phase 1: New Quattro SS 275/88 kV + Quattro-Etna 1 and 2 400 kV Lines (at 275 kV)	R 905 004 506
Soweto Strengthening Phase 2: Quattro SS 275/132 kV + 2 x 500 MVA Transformer	R 711 037 318
Tshwane Metro-Wildebees Integration	R 400 375 275
Tshwane Metro Power Supply Tx Development Plan	R 769 676 591
Tshwane Metropolitan Strengthening	R 195 602 904
Tshwane Reinforcement – Phoebus Phase 1	R 1 634 554 390
Vaal South Strengthening Phase 1	R 56 043 143
Vaal South Strengthening Phase 2	R 3 449 980
Vaal Strengthening (Phase 2b): Glockner-Etna 1st and 2nd 400 kV Line (Operate at 275 kV)	R 358 740 653
West Rand Strengthening – Westgate 400 kV	R 1 149 699 941
West Rand Strengthening – Etna 400 kV	R 658 678 983
West Rand Strengthening – Taunus 400 kV	R 303 059 673
Johannesburg East Strengthening Phase 3E to F: Sebenza MTS and North Rand-Sebenza 400 kV Lines	R 1 213 260 480
REFURBISHMENT	**R 253 510 777**
OTHER	**R 185 719 451**
DIRECT CUSTOMER CONNECTIONS	**R 31 103 228**
Grand total	**R 18 939 256 436**

Appendix B2: Costing for KZN projects

EXPANSION	**R 21 470 828 345**
Ariadne-Eros 2nd 400 kV Line	R 1 781 747 089
Ariadne-Venus 2nd 400kV Line (TS189)	R 1 278 676 787
Avon MTS 3rd 275/132 kV 250 MVA Transformer Scope Definition and Execution	R 19 871 736
Candover 400/132 kV Substation	R 2 100 856 680
eThekwini Strengthening – Inyaninga	R 24 668 878
eThekwini Strengthening – Shongweni	R 2 114 978 664
Ingula Pumped-storage Scheme Integration	R 39 067 335
Invubu-Theta (Mbewu) 2nd 400 kV Line	R 1 185 238 988
KZN 765 kV Integration – Lambda 400 kV Substation	R 2 180 781 860
Lambda-Sigma (Isundu) 1st 765 kV Line	R 3 311 455 725
Loop in Ariadne-Hector 2 400 kV (De-energised) Circuit into Isundu	R 647 854 282
Majuba-Lambda 1 400 kV Line and Tutuka-Lambda 1 400 kV line	R 135 908 258
Mbewu 1 x 765/400 kV 2 000 MVA Substation	R 2 464 596 983
Mersey Ext. 3rd 250 MVA 275/132 kV Transformer	R 29 866 382
Sigma (Isundu) 1 x 765/400 kV 2 000 MVA Substation	R 1 733 267 041
South Coast Strengthening – St Faiths Integration	R 966 191 295
Theta (Mbewu) 400 kV Loop-ins (Athene-Umfolozi 1st 400 kV and Invubu-Umfolozi 1st 400 kV Line)	R 181 704 854
Umfolozi-Theta (Mbewu) 765 kV Line (Extension of the Majuba-Umfolozi 1 765 kV Line)	R 1 187 551 131
Incandu MTS: 3rd 400/132 kV 500 MVA Transformer	R 86 093 737
Mersey Ext. 3rd 250 MVA 275/132 kV Transformer	R 450 640
DIRECT CUSTOMER CONNECTIONS	R 1 421 135 561
REFURBISHMENT	R 231 085 276
OTHER	R 52 166 517
Grand total	**R 23 175 215 699**

Appendix B3: Costing for Limpopo projects

EXPANSION	**R 15 530 991 547**
Borutho 2 x 500 MVA 400/132 kV Substation	R 259 334 875
Dwaalboom Strengthening Tx	R 170 454 248
Foskor 275/132 kV Transformation Upgrades (Phase 2)	R 702 149 395
Foskor-Acornhoek	R 336 075 210
Medupi Power Station Transmission Integration	R 6 039 154 477
Medupi Stability Integration 400 kV – Remote-end Reactors	R 592 970 988
Medupi Stability Integration 400 kV – Witkop-Senakangwedi B 400 kV Line	R 896 690 959
Medupi Stability Integration 400 kV – Borutho-Marble Hall 400 kV Line	R 738 489 086
Medupi Stability Integration 400 kV – Medupi-Phokoje 1st 400 kV Line	R 109 175 618
Medupi Stability Integration 400 kV – Medupi-Witkop 1st 400 kV Line	R 1 257 499 478
Nzhelele Integration 2 x 250 MVA 400/132 kV MTS	R 2 965 489 775
Tubatse Strengthening Phase 1: Senakangwedi 400/275 kV SS + Arn-Mer Loop-in + 1st 500 MVA Transformer	R 1 380 721 027
Waterberg Gx Integration Fault Level Management Plan Phase 1 – Spitskop Substation	R 51 271 173
Witkop Tabor 400 kV Line and 400/132 kV Transformer	R 2 301 329
Spitskop 2 x 500 MVA 400/132 kV Transformer Upgrade	R 28 935 444
Spitskop 2 x 500 MVA 400/132 kV Transformer Upgrade (Dev.)	R 278 466
REFURBISHMENT	**R 100 366 384**
DIRECT CUSTOMER CONNECTIONS	**R 24 670 989**
Grand total	**R 15 656 028 920**

Appendix B4: Costing for Mpumalanga projects

EXPANSION	**R 8 968 823 251**
Highveld Northwest and Lowveld North Reinforcement Phase 1	R 689 174 026
Highveld Northwest and Lowveld North Reinforcement Phase 2	R 2 137 908 775
Highveld Northwest and Lowveld North Reinforcement Phase 3	R 130 529 624
Highveld South Reinforcement: New Sol B 400/132 kV SS + Loop-/Turn-ins + 8 x 132 kV Feeders	R 1 293 152 684
Kusile Power Station Transmission Integration	R 2 185 476 430
Lowveld 400 kV Strengthening – Phase 2: Marathon 400 kV Yard (New) + Marathon-Gumeni 1st 400 kV Line	R 917 056 758
Lowveld 400 kV Strengthening – Phase 3: Arnot-Gumeni-Marathon 400 kV Line, Including Transformer	R 567 930 783
Lowveld Strengthening Phase 1 (Hendrina-Gumeni)	R 514 364 786
Lowveld Transformation Capacity Expansion	R 1 688 455
Mpumalanga Underrated Equipment Upgrade (Apollo-Kendal 1 and 2, Duvha-Minerva, Duvha-Matla, Kendal-Minerva, and Kriel-Zeus)	R 483 464 463
Kruispunt Strengthening: Komati-Matla 275 kV Loop-in	R 33 390 371
Normandie MTS 2nd 400/132 kV Transformer	R 14 686 097
DIRECT CUSTOMER CONNECTIONS	R 519 591 285
REFURBISHMENT	R 268 376 736
OTHER	R 17 237 605
Grand total	**R 9 774 028 877**

Appendix B5: Costing for North West projects

EXPANSION	**R 4 857 007 451**
Bighorn 2nd 400/275kV 800MVA Transformer	R 219 841
Bighorn 400/132 kV 2 x 500 MVA Substation Extension	R 251 180 089
Dinaledi 3rd 500 MVA 400/132 kV Transformer	R 66 479 169
Kimberley Strengthening Phase 3a: Hermes-Mookodi 1st and Ferrum-Mookodi 2nd 400 kV Lines	R 2 756 777 695
Ngwedi 2 x 500 MVA 400/132 kV Substation	R 588 070 958
Rustenburg Strengthening Phase 2 (Marang B)	R 779 430 171
Waterberg Gx Integration Fault Level Management Plan Phase 1 – Ararat Substation	R 59 471 294
Waterberg Gx Integration Fault Level Management Plan Phase 1 – Bighorn Substation	R 10 184 061
Waterberg Gx Integration Fault Level Management Plan Phase 1 – Marang Substation	R 104 145 752
Waterberg Gx Integration Fault Level Management Plan Phase 1 – Trident Substation	R 59 751 135
Dinaledi 3rd 500 MVA 400/132 kV Transformer	R 44 005 621
Watershed Strengthening	R 136 291 664
REFURBISHMENT	**R 43 239 414**
OTHER	**R 29 247 351**
DIRECT CUSTOMER CONNECTIONS	**R 18 032 781**
Grand total	**R 4 947 526 997**

Appendix B6: Costing for Free State projects

EXPANSION	**R 2 802 308 981**
Bloemfontein Strengthening Phase 2	R 1 069 194 746
Bloemfontein Strengthening: Everest-Merapi 275 kV Line	R 716 250 162
Harrismith Strengthening Phase 1a – Sorata	R 327 198 591
Makalu B Strengthening	R 689 644 763
Zeus-Hydra Scheme	R 20 720
REFURBISHMENT	R 111 503 819
OTHER	R 5 520 181
DIRECT CUSTOMER CONNECTIONS	R 1 128 885
CAPITAL SPARES	R 570 273
Grand total	**R 2 921 032 139**

Appendix B7: Costing for Northern Cape projects

EXPANSION	**R 21 362 772 433**
Aggeneis-Paulputs 220 kV Line	R 559 163 857
Aries-Nieuwehoop 400 kV Line	R 689 891 795
Garona SS Strengthening: Kronos SS 400/132 kV + 1 x 250 MVA Transformer + Kro-Cup 1 and 2 132 kV Lines	R 213 560 487
Hotazel 400 kV Loop-in (Ferrum-Mookodi (Vryburg) 2nd 400 kV Line)	R 719 183 955
Hydra-Aries 400 kV Lines	R 1 926 208 313
Hydra-Gamma 1	R 17 456 269
Juno-Gromis 400 kV and 2nd Gromis-Oranjemond 220 kV Lines	R 1 969 357 679
Kimberley Strengthening Phase 4A	R 5 561 708 162
Kimberley Strengthening	R 25 194 773
Kimberley Strengthening Phase 4B	R 715 665 526
Kimberley Strengthening Phase 4C	R 722 692 074
Northern Cape Strengthening: Aries 300 MVAr SVC Reactor	R 603 670 957
Northern Cape Strengthening: Ferrum-Nieuwehoop 1st 400 kV Line	R 1 279 344 876
Sishen Saldanha	R 2 690 242
Sishen Saldanha Phase 2: 4 x 400/50 kV SSs + 3 x Series Capacitors + Aries-Nieuwehoop 400 kV Line	R 1 835 891 321
Upington Strengthening Phase 1a	R 973 534 504
Upington Strengthening Phase 1b	R 1 842 871 956
Upington Strengthening Phase 1c	R 1 497 751 823
Nama MTS Transformers Upgrade – 250 MVA 66/22 kV	R 48 003 737
Paulputs 250 MVA 220/132 kV Transformer (Replacement of 125 MVA)	R 157 936 562
Paulputs 2nd 250 MVA 220/132 kV Transformers	R 993 176
DIRECT CUSTOMER CONNECTIONS	**R 870 420 531**
REFURBISHMENT	**R 119 971 220**
CAPITAL SPARES	**R 548 592**
Grand total	**R 22 353 712 776**
Grand total	**R 15 656 028 920**

Appendix B8: Costing for Eastern Cape projects

EXPANSION	**R 15 874 716 783**
East London Strengthening: Total	R 110 005 012
East Londeon/Umtata Phase 3: Poseidon-Neptune 1st 400 kV Line	R 1 195 473 822
East London/Umtata Phase 4: Pembroke 400/132 kV SS	R 580 554 648
Grassridge-Dedisa Strengthening	R 67 843 639
Nuclear 1 Integration: Thyspunt	R 5 638 985 604
Port Elizabeth Strengthening	R 163 672 515
Port Elizaberth Strengthening Phase 4: 3 x 100 MVAr Capacitor Banks	R 193 695 157
Port Elizabeth SS Integration	R 968 628 505
Southern Grid Phase 3: 1st Gamma-Grassridge 765 kV Line	R 5 344 781 757
Southern Grid Phase 4: 2nd Gamma-Grassridge 765 kV Line	R 1 586 163 171
Southern Grid Tx Transformer Normalisation	R 24 912 954
DIRECT CUSTOMER CONNECTIONS	R218 361 409
REFURBISHMENT	R71 323 719
OTHER	R18 907 991
Grand total	**R16 183 309 903**

Appendix B9: Costing for Western Cape projects

EXPANSION	**R 10 258 853 769**
Acacia 3rd Transformer	R 24 291
Acacia-Koeberg 2nd 400 kV Line	R 148 941 457
Ankerlig-Sterrekus 400 kV Lines	R 511 306 457
Ankerlig Transmission Koeberg 2nd Supply	R 70 231 406
Blanco MTS Integration	R 909 050 045
Blouwater 400/132 kV Substation (1st and 2nd 500 MVA Transformers)	R 481 949 114
Cape Corridor 132 kV 72 MVAr Shunt Capacitor	R 2 662 653
Droërivier-Narina-Gourikwa 400 kV Line	R 1 429 743 066
Erica MTS Integration	R 902 280 921
Gas 1 (Ankerlig-Gourikwa)	R 8 530 691
Houhoek Network Strengthening: Asteria MTS and Lines	R 647 992 584
Hydra-Omega Scheme	R 1 510 911 311
Koeberg 400 kV Busbar Reconfiguration	R 1 131 778 871
Philippi 3rd 400/132 kV 500 MVA Transformer	R 388 864 152
Philippi-Mitchell's Plain (Erica) 400 kV Line	R 116 886 699
Pinotage MTS Integration	R 570 388 668
Stikland MTS Install FCLRs	R 26 865 882
Vryheid Network Strengthening: Agulhas MTS and Lines	R 685 015 711
Windmill 400/132 kV Substation (1st and 2nd 500 MVA Transformers)	R 672 284 395
Muldersvlei Ext. 3rd 500 MVA 400/132 kV Transformer and 132 kV Series Reactors	R 43 145 395
REFURBISHMENT	**R 168 026 850**
DIRECT CUSTOMER CONNECTIONS	**R 66 771 687**
OTHER	**R 12 686 390**
CAPITAL SPARES	**R 5 050 365**
Grand total	**R 10 511 389 061**

Appendix B10: Costing for national projects

EXPANSION	**R 22 754 266 120**
CAPITAL SPARES	R 606 139 288
REFURBISHMENT	R 400 930 683
TELECOMMS	R 160 015 719
PRODUCTION EQUIPMENT	R 152 000 000
OTHER	R 51 660 996
Grand total	**R 24 125 012 806**

Appendix C: Publication team

Although the publication of the document did not comprise a formal team, the following people were instrumental in bringing the document to life. Credit is also given to all the Grid Planning staff, who are responsible for formulating the Strategic Grid Plan as well as the Regional Grid Plans.

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Notes

Notes

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