Transmission development plan 2016-2025

Eskom

Foreword by Group Executive

A reliable electricity supply of acceptable quality is essential for the enjoyment of the 21st-century lifestyle that so many of us take for granted. Electricity transforms the lives of people in newly electrified areas when the supply is switched on for the first time, giving them access to opportunities they could previously only dream about.

Electricity is generated in power stations distributed around South Africa. The bulk of South Africa's electricity is generated in coal-fired power stations located mainly on the Mpumalanga Highveld. 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 not only requires maintenance to deliver a reliable supply of electricity, but also needs to be strengthened to meet changing customer needs and connect new loads and generating capacity.

Our plans for the transmission system 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 developed by Eskom and Independent Power Producers (IPPs) must be connected to the network. This includes additional IPP baseload and cogeneration plant. Additional large-scale renewable generation (wind and solar energy) is also still being connected to the grid, which will further diversify the country's energy mix and reduce our 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 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.

Regards

Thava Govender

GROUP EXECUTIVE
(TRANSMISSION AND SUSTAINABILITY)

October 2015

Disclaimer

The purpose of publishing the TDP is to inform stakeholders about the proposed developments in the Eskom transmission network. These plans are subject to change as and when better technical solutions are identified or when more accurate developmental information becomes available. The information contained in the TDP should, therefore, not be used for any purpose other than for sharing this information.

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Executive summary

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.

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The projects covered in this document include the generation integration projects required to ensure that the network is adequate to evacuate and dispatch power to the load centres from the new power stations (conventional and renewable) connecting to the grid. 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 is those needed to connect new and growing loads and load centres to the network.

Eskom's current liquidity position will impact the execution of the Transmission Development Plan and is likely to remain in force at least until the first quarter of 2018, when Nersa is due to review Eskom's funding and revenue requirements and announce the Eskom tariff determination for the MYPD4 (fourth multi-year price determination) period, commencing 1 April 2018. Until then, the plan will have to be revised each year to fit within the available budget by reprioritising projects to minimise the impact on customers and the national economy of any delays arising from a shortage of funding or delays in obtaining sites and servitudes and environmental and other statutory approvals.

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.

The financial year ended in March 2015 was the first year in which customers (load and generation) were offered the self-build option, in terms of which they could elect to design, procure and construct their own connection to the transmission system instead of Eskom providing the network connection and charging the customer a connection charge. The self-build option was introduced by Eskom Transmission in order to give customers greater control over risk factors affecting their network connection. The self-build option has since been expanded to allow customers to also self-build associated works that will be shared with other customers, subject to approval by Eskom based on an assessment of associated risks to the system and other customers. The option of Eskom constructing the customer's network connection and the customer paying a connection charge remains available to the customer as before, since the self-build option is purely voluntary.

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. Acquisition of sites and servitudes and associated EIAs (environmental impact assessments) and other statutory approvals for the construction of transmission infrastructure are also defined in the Grid Code as strategic projects. Facilities consist of buildings and associated works 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.

Contents

Contents

Table of figures

List of tables

Abbreviations

BQ – budget quote
Quotation giving customers costs and scope at an 85% accuracy level.

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.

CoCT – City of Cape Town

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 Central Grid.

DEA – Department of Environmental Affairs

DoE – Department of Energy

EHV – extra high voltage

EIA – environmental impact assessment

GAU – grid access unit

GCCA – Grid Connection Capacity Assessment

GDP – gross domestic product

GUMP – Gas Utilisation Master Plan

HVDC – high-voltage direct current

ICE – indicative cost estimate
Cost estimate giving a non-binding indication of the order of magnitude costs.

IDZ – industrial development zone

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

IRP – Integrated Resource Plan
MTPPP – Medium Term Power Purchase Programme

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.

MYPD4 – Multi-year Price Determination 4
The fourth multi-year price determination for tariff increases awarded to Eskom by Nersa. The annual price increase and period duration will be decided by Nersa by 31 March 2018 and will come into effect from 1 April 2018.

MTS – main transmission substation
These are substations owned and operated by a TNSP.

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.

OCGT – open-cycle gas turbine
Combustion turbine fuelled by liquid fuel or gas, used to drive a generator.

PPA – power purchase agreement

RTS – return to service
A previously mothballed power station undergoing recommissioning.

REIPPPP – Renewable Energy Independent Power Producers Procurement Programme

REBID – Renewable Energy Bids Programme

REDZ – renewable energy development zones

SEA – strategic environmental assessment

STE – Sociedade Nacional de Transporte de Energia (Mozambique Regional Transmission Backbone Project)

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.

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

TOSP – time of system peak

TS – transmission system

Chapter 1
Introduction

1.1 Context of the TDP

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 sixth TDP was published early in October 2014; this is the seventh publication based on the TDP for 2016 to 2025.

1.2 Major factor changes from the 2014 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 2014. The two main factors include the capital constraints followed by the potential generation scenarios. 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.

1.2.1 Capital constraints

Due to capital constraints being experienced Eskom has had 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 available capital, while minimising the risks to security and reliability of supply.

1.2.2 Generation assumptions

A number of generation projects that were assumed to be in place for the TDP studies for the period 2015 to 2024, have been changed in the generation assumptions for this TDP update period. These are discussed in section 3.2.

1.3 Structure of the document

The document is structured in the following manner:

Chapter 2, IPPS: connections and strategic plans, deals with the strategic plans associated with connecting IPPS in the different provinces and sets the scene for the assumptions used in this plan.

Chapter 3, Load demand forecast and generation assumptions, 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 4, Project updates. This chapter 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 changes from the previous generation assumptions to the ones informing this plan, changes in the load forecast advancing or 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.

This chapter also focuses on the completed projects and projects nearing completion as well as grid connection applications processed by Transmission.

Chapter 5, National overview, 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, Breakdown of the tdp projects by province, 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, Grid access, deals with the strategic plan to integrate future generation onto the grid.

Chapter 8, Impact of the doe generation scenarios, deals with the different scenarios that can be expected for future generation in the different provinces and the planned corridors.

Chapter 9, Capital expenditure plan, deals with the forecasted costs of implementing the TDP.

Chapter 10, Conclusion, deals with various conclusions based on the content of this document.

Chapter 2
IPPS: Connections and strategic plans

There has been a significant change in the approach to the planning and implementation of the development of the future transmission grid, which has been driven by the new generation to be connected. The 2010 IRP calls for the connection of new types of generation, particularly renewable energy, which will be spread across wider areas of the country. Traditionally, Eskom integrated large centralised generation plant under its direction and new connections to the grid were primarily load customers. However, the future generation will largely be IPP developments, which are now also connection customers.

Major transmission infrastructure projects could take up to ten years to implement, moving from planning, environmental authorisation, procurement and construction to final commissioning. The IPP developments are of smaller sizes and can be delivered in relatively short periods, but as a result of a competitive process, the location of the successful bidders is only known at a late stage. If new transmission projects are required for the IPPs, it is difficult for them to be delivered within the desired target dates, which provides challenges for the future.

Eskom, especially its Transmission and Distribution Divisions, has been fully committed to meeting these challenges and enabling the integration and connection of the 2010 IRP generation, specifically the REIPPPP. A number of initiatives have been undertaken to facilitate the IPP programmes of the DoE.

These include:

- establishment of the Grid Access Unit (GAU) and the Single Buyer Office to facilitate the connection requests of IPP developers and buy the energy, respectively;
- creation of a simpler, faster connection application process, specifically for all new generation plant, which is applicable to both IPPs and new Eskom power plants;
- update of the applicable Grid Codes and connection agreements to encompass renewable generation plant;
- publication of the Grid Connection Capacity Assessment (GCCA) document to guide stakeholders to available network capacity in relation to the renewable energy resources and across the country for any type of IPP project;
- commitment of resources to work closely with the DoE IPP Office, with the intention of aligning the IPP programme with feasible network expansion plans;
- introduction of a Self-Build Procedure document that provides IPPs with the option to "self-build" their own dedicated connection infrastructure as well as shared network in exceptional cases;
- identification of strategic transmission line routes to unlock network capacity to connect future IPPs and collaborating with the Department of Environmental Affairs (DEA) to complete strategic environmental impact assessments (SEAs) of these routes; and
- participation in several external independent studies to identify the best resource areas for development such as renewable energy development zones (REDZs) and the impact of the integration of large volumes of renewable energy generation.

2.1 Connecting the IPPS

Eskom has enabled the network to successfully connect and integrate the successful bidders from the REIPPPP bid Windows 1 to 3 at a cost of R2.4 billion. The current status as at the end of August 2015 of the REIPPPP is shown in Table 2.1.

The budget quote requests for the Bid Window 4 (2 205 MW) are currently being processed to meet the required target dates. Requests for connection cost estimate letters by potential bidders for the Ministerial expedited bid window for an allocation of 1 800 MW are being processed to meet the submission deadline.

Workshop discussions are being held with the DoE IPP Office on how to accommodate the proposed IPP coal programme of 2 500 MW and the IPP gas generation programme of up to 3 000 MW. Further discussions are taking place on how best to structure the REIPPPP bid windows beyond 2019 to 2025 for up to 7 700 MW as per the 2010 IRP. Proposals on how to expand the transmission grid to accommodate these programmes are discussed in some detail under Chapter 7, GRID ACCESS.

Table 2.1: REIPPPP status

REIPPP programme	No. of projects	MW contribution	Status
Bid Window 1	*28*	*1 436 MW*	*All 28 projects connected*
Bid Window 2	*19*	*1 054 MW*	*14 projects connected* *Five projects in execution*
Bid Window 3	*21*	*1 856 MW*	*19 budget quotes issued. Two in progress*

2.2 Strategic plans for IPPS

The development plans for the transmission network must be able to adapt to the uncertainty of future load and generation locations. They should identify the critical power corridors and constraints on the transmission network and develop strategies to unlock and create a flexible and robust grid to be able to respond to the changing future needs of the country.

The 2040 Transmission Network Study was undertaken for this purpose in order to determine the development requirements of the future transmission grid to accommodate the expected load demand needs and the potential impact of future generation scenarios using the 2010 Integrated Resource Plan (IRP) as a baseline. The study identified five main power corridors that would need to be developed under all the potential generation scenarios.

The study findings were used as input into a number of internal and independent external studies on the location and integration of renewable energy resources, IPP coal projects and large volumes of natural gas generation. One of the more significant is the CSIR study on behalf of the DEA to identify suitable zones for the efficient and effective roll-out of wind and solar PV energy as part of the government SIP 8 initiative. These are referred to as renewable energy development zones (REDZs) and the selection criteria included, among others, the environmental suitability of the land, the resource potential, as well as exclusion areas. A total of eight REDZs have been identified, which are being prepared for gazetting by the government.

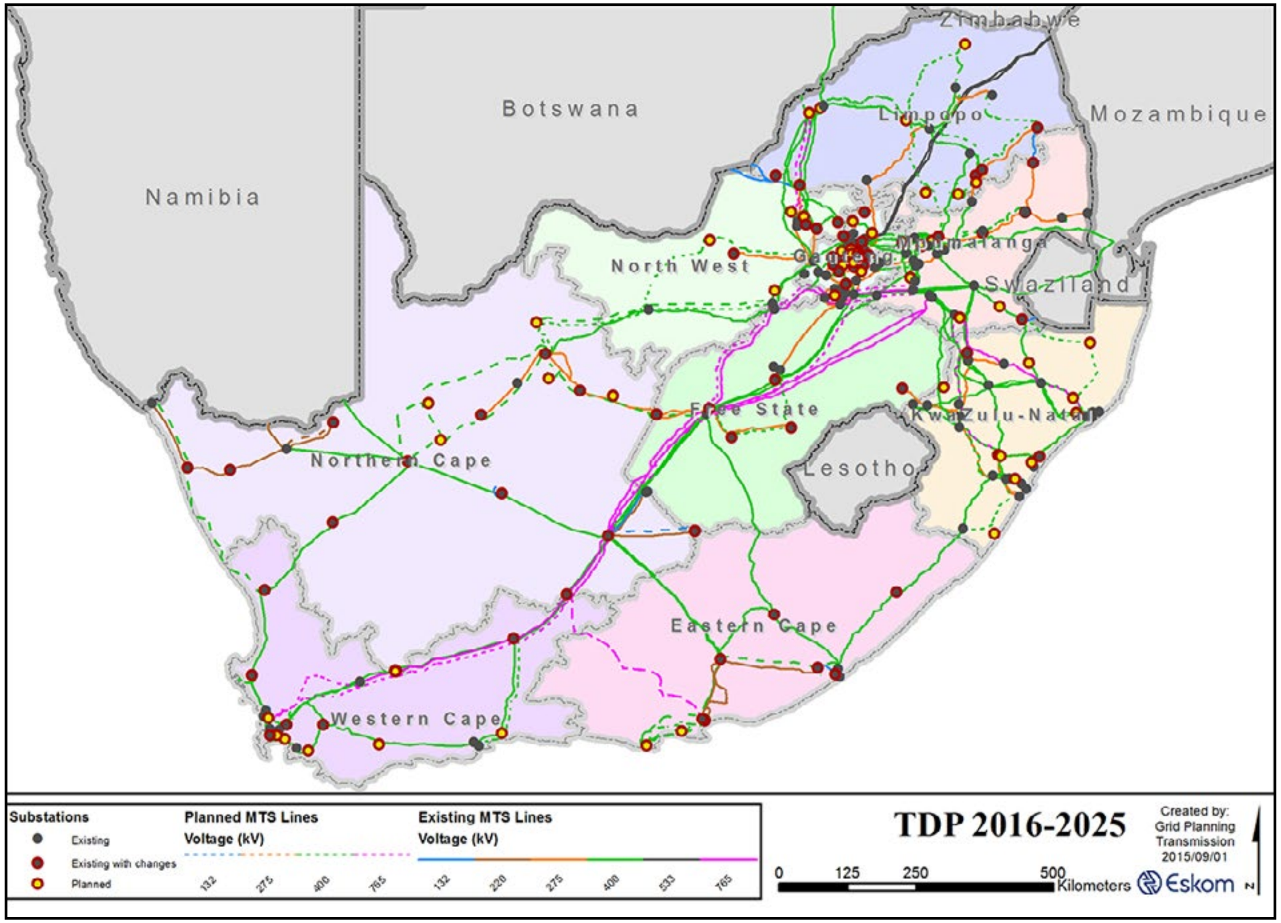
Eskom has taken a twofold approach to strategically prepare the transmission grid for the creation of additional generation connection capacity. The first is proposals for the immediate to medium-term period and the second is the securing of power corridors for the longer term to enable a faster response to changing IPP generation programmes.

2.2.1 The immediate to medium-term period

This consists of the GCCA-2022 document, which indicates where there is available connection capacity across the entire transmission grid and a set of transmission projects outside the TDP list that could be implemented within a relatively short period over a number of phases. The proposals include transmission works at existing and new substations that can be implemented as Phase 1 (less than two years), Phase 2 (three to four years), Phase 3 (five to six years), or Phase 4 (seven to eight years) projects, as required.

The location and phasing of these projects are indicated on the map in Figure 2.1. This includes a Phase 5 (eight to 10 years) project, which requires an HVDC scheme to unlock the Lephalale area for IPP coal project developers.

Figure 2.1: Generation connection capacity for the immediate to medium term



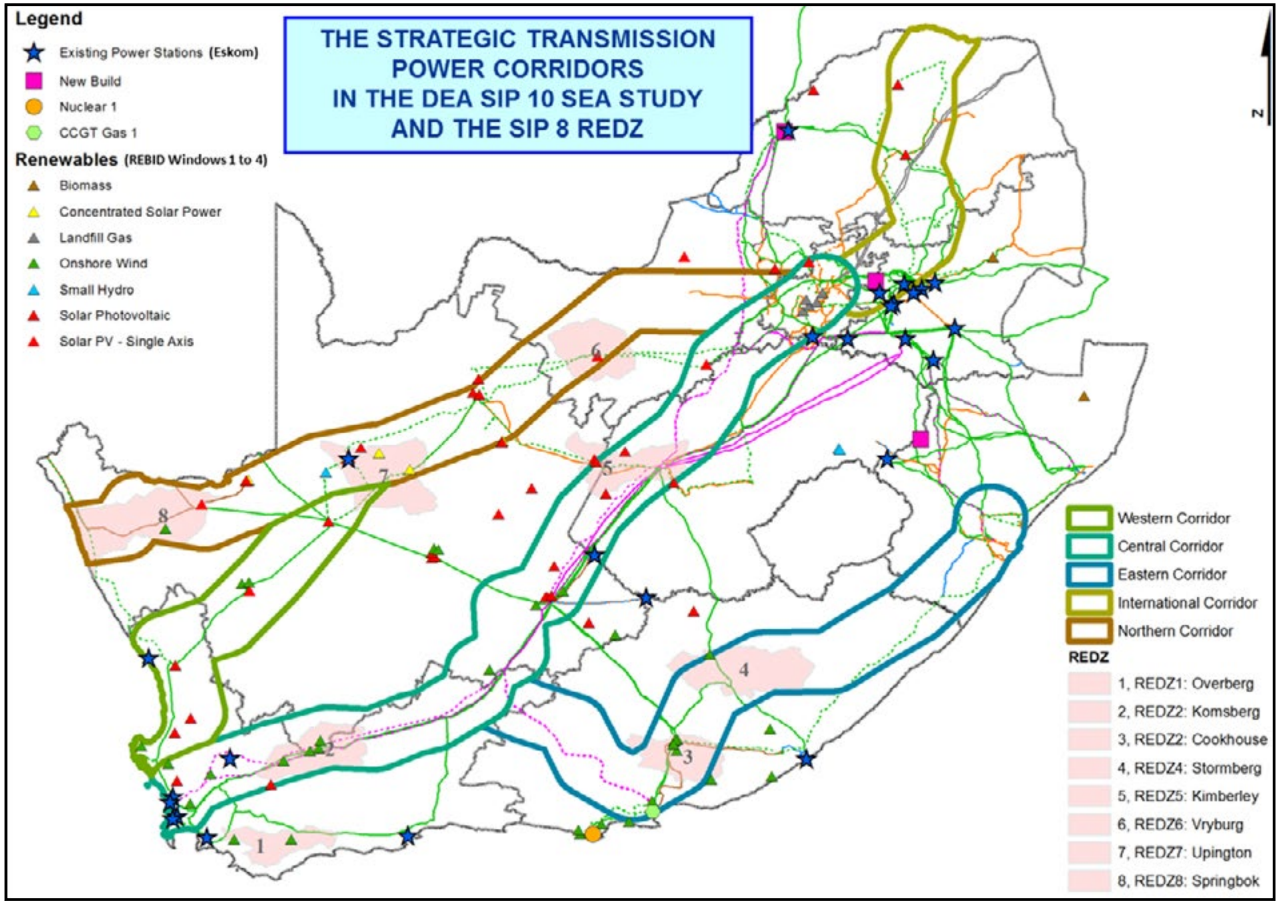
2.2.2 Power corridors for the longer term

The key to a flexible and robust transmission grid is to secure power corridor routes with most of the rights and approvals in place, so that new transmission lines can be constructed quickly as required when the actual generation is selected and confirmed for integration. To this end, Eskom has been working closely with the DEA on a national SEA study project that is part of the SIP 10 initiative from the National Development Plan of the government.

The objective is to complete all the environmental studies and secure all the required environmental and related approvals for transmission lines and substations within the five identified corridors. The corridors will be 100 km wide and the secured approvals will be valid for extended periods in order to allow the acquisition of line servitudes and substation sites for strategic purposes. The intention is to have these power corridors gazetted in early 2016.

The five transmission power corridors are shown on the map in Figure 2.2.

Figure 2.2: Power corridors for the longer term



Chapter 3
Load demand forecast and generation assumptions

The 10-year 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 TDP for the defined period.

3.1 Load forecast

Load forecasting is a fundamental requirement in the 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 model.

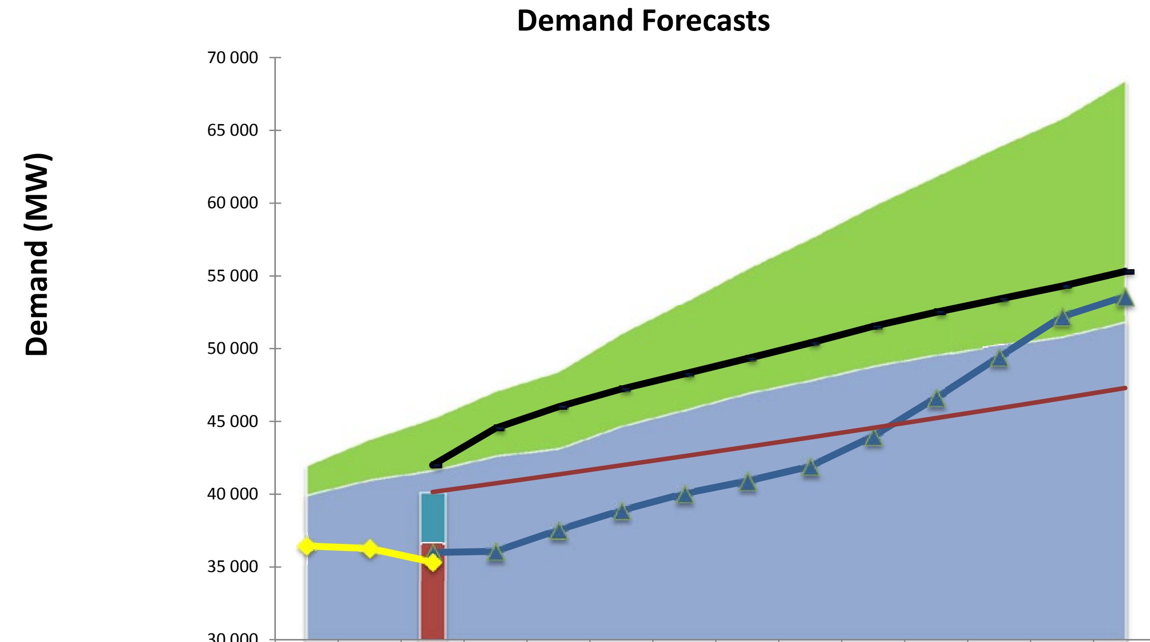
At the Combined Forecasting Forum, the forecasts were discussed with all parties and two Transmission load forecast curves were determined, namely, an "unconstrained" forecast and a "constrained" forecast.

The unconstrained load forecast uses the contracted NMD (nominated maximum demand) values for the top and mid-size customers that Eskom has contractually agreed to supply as the base on which the projected load growth is added. The constrained forecast uses the actual peak demand from the previous year as the base on which the projected load growth is added, but also takes into account the suppressed load of the NMD. Thus, the constrained forecast increases at a higher growth rate to meet the unconstrained forecast by 2022.

These load forecasts, including the projected 2010 IRP load forecast, can be seen in the graph in Figure 3.1. The NMD value for 2014 is indicated as a bar graph of the top and mid-size customers, where the red line indicates the increase of the NMD value at a 1.5% growth rate.

While the actual peak demand (indicated by the yellow line) has been on the decline over the past few years due mainly to generation constraints, the Transmission development planning is based on meeting the unconstrained forecast, but project releases are motivated using the constrained forecast.

Figure 3.1: The Eskom transmission system demand forecast



	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
2010 IRP High Demand (MW)	42027	43839	45 255	47 124	48 479	51 090	53 276	55 573	57 649	59 885	61 932	63 955	65 870	68 458
2010 IRP Low Demand (MW)	40002	41040	41 669	42 666	43 157	44 710	45 815	46 952	47 848	48 828	49 596	50 299	50 872	51 903
Mid Size Customer NMD (MW)			3 472											
Top Customer NMD (MW)			36 676											
2015 TDP Demand (MW) - Constrained			36 000	36 065	37 536	38 885	40 036	40 904	41 921	43 990	46 629	49 427	52 193	53 600
2015 TDP Demand (MW) - Unconstrained			42 000	44 536	45 998	47 220	48 271	49 328	50 398	51 528	52 501	53 403	54 296	55 310
Actual Peak Demand (MW)	36437	36276	35 343											
NMD growth at 1.5%			40 148	40 750	41 361	41 982	42 612	43 251	43 900	44 558	45 226	45 905	46 593	47 292

3.2 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 still 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 draft updated IRP version was released in December 2013 for comment and the generation assumptions have taken cognisance of this draft but are still primarily based on the official 2010 IRP document. Consideration has also been given to the proposed IPP programmes of the DoE, such as future REIPPPP bid windows for renewables, a coal IPP programme and a gas generation programme (to be based on the Gas Utilisation Master Plan (GUMP) proposals).

This has produced a "baseline" TDP generation scenario assumption, which is presented below. In addition, discussions were held with the DoE regarding possible different IPP generation scenarios to be considered for the TDP period. However, the inclusion of different generation scenarios produces a number of transmission infrastructure projects. Thus, such a TDP will have to contain a large number of potential projects in the last part of the planning period.

The final proposals for generation scenarios from the DoE were tabled close to the end of the planning study cycle for this TDP period. It was therefore agreed that only the potential impact of these possible generation scenarios on the TDP would be identified at a high level.

The generation assumptions for the TDP would therefore be considered as the "baseline" scenario, which was a reasonable representation of the expected future generation for the TDP period. The assumptions for the additional generation scenarios and their potential impact on the TDP project requirements are discussed in Section 8: Impact of the DoE Generation Scenarios.

The generation assumptions for the TDP period were fixed in January 2015 based on what was known and expected at the time, guided by the IRP and are discussed below.

3.2.1 Existing and approved power stations

The existing generation plant is assumed to be available over the 2016 to 2025 period, except for the units expected to be decommissioned at three power stations by 2025 in line with their decommissioning schedules. New generation will be added to the network over this period, which contains both approved new power stations and proposed "New Build" power stations.

The currently approved new Eskom major power stations are as follows:

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

In order to achieve the proposed plan, a number of assumptions regarding size and location of the future planned generation plant had to be made. These assumptions are discussed below and are shown in Tables A1 and A2 in Appendix A.

3.2.2 DoE OCGT power stations

The Department of Energy (DoE) should have implemented the two OCGT power stations, located at the Dedisa and Avon substations, by 2013 but are assumed to be completed in 2015 in time for the 2016 system peak and. They have been based on 147 MW units; however, the generators to be installed are understood to be 170 MW units. For the TDP studies, they have been modelled as follows:

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

3.2.3 Ingula Pumped-storage

The Ingula Pumped-storage Power Station is an approved project. The project has been rescheduled, with further delays and has been assumed to only have Units 1 and 2 completed in time for the 2016 system peak, with Unit 3 completed late in 2016 and Unit 4 completed in 2017 in time for the 2017 system peak.

3.2.4 Coal generation

Baseload coal (Medupi and Kusile)

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

The first Medupi unit (unit 6) has been delayed from 2013 to late 2015, with the first unit only available for the 2016 system peak; the last unit will be completed before the 2019 system peak. The first unit at Kusile has been brought forward from 2017 to 2016 and will assist with system peak. The roll-out will be slower than Medupi, with the last unit in place for the 2020 system peak.

No further large Eskom-built base load coal-fired power stations are expected for the ten year period of 2016 to 2025.

New build 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 base load coal power stations and it has been assumed that these would be IPP coal power 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 with a maximum power station size of 600 MW. In order to model the potential integration for this programme, a number of separate IPP coal power stations have been 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, except reduced to 400 MW each (2 x 200 MW units each). Coal IPP 1 will be in the Witbank area in 2019 and Coal IPP 3 is modelled as a 400 MW power station in 2020, also in the greater Witbank area.

The other two power stations, Coal IPP 2 and Coal IPP 4, represent the balance of the proposed coal IPP programme. Coal IPP 2 has been allocated as a 1 000 MW power station (4 x 250 MW units) and Coal IPP 4 is a new 1 250 MW (5 x 250 MW) power station, both from 2022. Both are in the Lephalale area and are assumed to be connected to the Massa substation via the 400 kV busbar.

Coal IPP 1 and Coal IPP 3 represent the coal power stations not in Lephalale that can be connected before 2022. Coal IPP 2 and Coal IPP 4 represent the coal power stations that can be connected in the Lephalale area, but only from 2022. This is because the integration of Medupi does not allow for the connection of any new significant generation due to the lack of transmission infrastructure. In order to allow the connection of new generation in the Lephalale area, it is proposed to establish a new HVDC scheme to connect this area into Johannesburg. This will be achieved by having the sending HVDC terminal at the Massa substation and two HVDC terminals at the Juno B and Etna substations. The HVDC capacity will be 3 000 MW, with 2 000 MW under normal operation from 2022 to 2025.

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 units will start to be decommissioned at Camden and Hendrina from 2020. In 2022, units will start to be decommissioned at Arnot.

For the purposes of the TDP studies, the proposed Eskom decommissioning has been modelled one year later than what was assumed in the previous TDP period, namely, starting from 2021 instead of 2020, to determine the impact on the transmission grid. The schedule is shown in Table A1 in Appendix A.

3.2.5 Nuclear generation

For this TDP update, the Nuclear 1 Power Station has been included from 2023. It has been assumed to be established at the Thyspunt site near Port Elizabeth. The integration is as modelled in earlier TDP studies, with five 400 kV lines. Three units of 1 600 MW each are assumed.

3.2.6 Open and combined-cycle gas generation (OCGT and CCGT)

There are a number of open-cycle gas turbine (OCGT) and combined-cycle gas turbine (CCGT) generation plants proposed as New Build options, giving a total of 711 MW OCGT and 1 614 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 near Coega.

The unit sizes at Dedisa have been assumed as follows:

- OCGT (2 x 237 MW) from 2019 to 2021
- CCGT (3 x 269 MW) in 2022
- CCGT (3 x 269 MW) in 2025

3.2.7 Imported hydropower

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 from which this hydro will come is Northern Mozambique. This will be transported down to the Maputo area via the proposed Mozambique transmission backbone project (referred to as the STE project). This will effectivley relocate the power to Maputo. For the purposes of the TDP studies, this will relieve the Mozal load in Maputo, which Eskom is required to supply. Therefore, the hydro import can be modelled as four 570 MW generators placed at the Maputo 400 kV substation.

3.2.8 Cogeneration projects and MTPPP

A total of 390 MW of cogeneration plant was included in the 2010 IRP by 2013. The MTPPP programme, which 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.

3.2.9 Renewable energy IPP generation

The REIPPPP (also referred to as the REBID programme) has gone out for procurement, with Windows 1 and 2 already completed, Window 3 close to financial close and the Bid Window 4 shortlist about to be announced at the time the TDP studies were started. The REIPPPP allows IPPs to bid tariffs, with maximum tariff limits for the following renewables:

- Wind
- Small hydro
- Landfill gas
- Concentrated solar
- Photovoltaic (PV)

Windows 1 and 2 of the REIPPPP allow for the renewable generation to be connected by the end of 2014 and the end of 2016, respectively. It has been assumed that the successful IPPs for Windows 1 and 2 will be in place for the system peaks of 2015 and 2017, respectively. The Window 3 shortlisted projects have been assumed to be in service as per their bid submission dates between 2016 and 2017. The two CSP plants from Bid Window 3 of 100 MW each are connected at the Ferrum and Olien substations. The best estimate of the potential Bid Window 4 shortlist was made in January 2015.

The IPP renewable generators have been assumed to be connected to the transmission substation that either supplies the distribution network to which they are connected or is the point of connection. The REIPPPP projects and future IPP assumed projects are indicated in the renewable energy generation schedule in Table A2 in Appendix A.

Wind generation

From 2019 onwards to 2025, wind generation has been allocated as 100 MW or 200 MW units to various transmission substations per year to determine the overall impact on the transmission power flows. By 2025, the locations are aligned overall with the expected "wind area" allocation assumed in the "Assumptions Paper for the 2040 Transmission Network Study", dated August 2011. In addition, the substation allocations have taken the following study and grid capacity increase proposals into account:

- The proposed REDZ areas from the government SIP 8 project
- The Eskom study to map and quantify RE developer interest
- The Eskom proposals to the DoE for phased transmission projects to increase grid connection capacity for RE generators

The units are connected to the 66 kV or 132 kV busbars of the transmission substations, as appropriate, which are listed in Table A2 in Appendix A.

PV solar generation

A significant amount of PV has been allocated under New Build options in the 2010 IRP, with over 4 900 MW by 2025. The government REIPPPP programme has resulted in a large number 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 the energy supplied during daylight hours and a reduction in South Africa's carbon footprint. This in turn will start to have an impact on the transmission grid performance during the day and is the subject of a number of impact studies under way separate from the TDP studies.

Concentrated solar power (CSP) generation

The concentrated solar power (CSP) generation has been set at 1 000 MW. The five successful CSP projects from the REIPPPP windows have been allocated to Upington, Garona, Paulputs, Ferrum and Olien.

The balance of the CSP generation is modelled as 100 MW units at Upington, Garona and Ferrum substations. These units will be run at maximum output during both the system peak and the local peak. They will not be run during the low load conditions at night.

3.2.10 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. Table A1 indicates the dispatchable generation and Table A2 the renewable energy generation. These generation units have been assumed to be in service at the expected dates. This is graphically illustrated in Figure 3.2 and Figure 3.3.

Figure 3.2: Power station capacity introduction by year

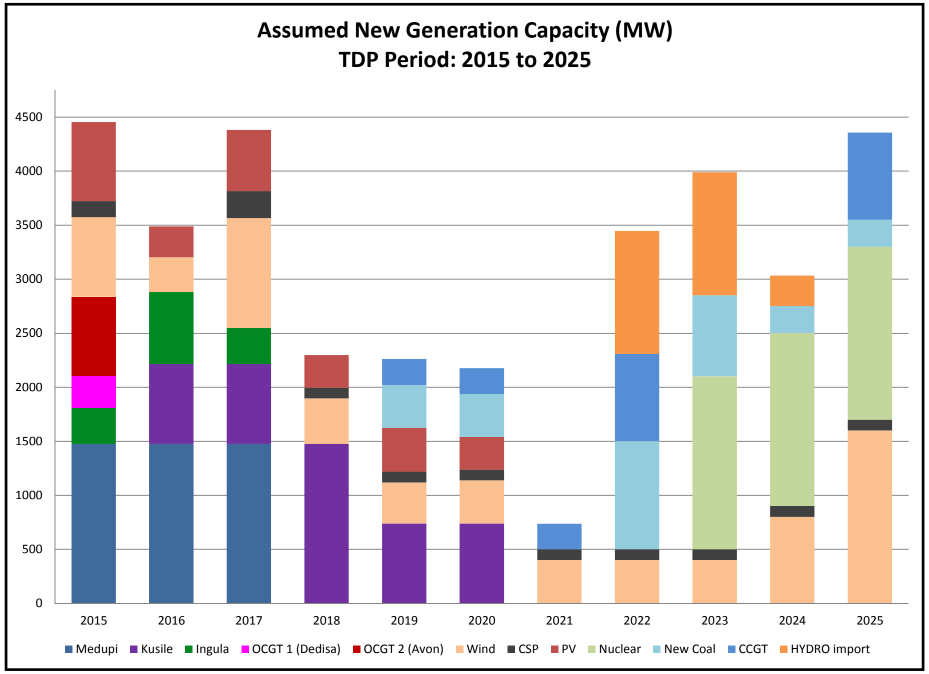
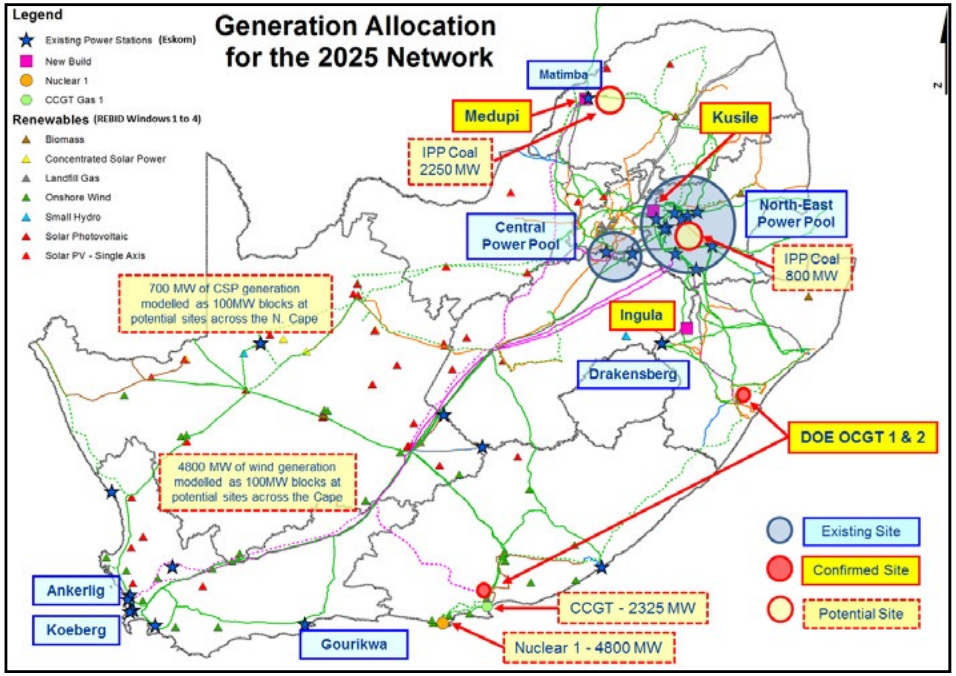


Figure 3.3: Planned power station capacity by 2025



Chapter 4
Project updates

4.1 Transmission reliability projects

This section shows the projects completed and nearing completion since the previous TDP publication in 2014. The project lists exclude feeder bay projects resulting from connection applications received.

Table 4.1: Completed projects FY2014/2015 and 2015/16

PROVINCE	PROJECT NAME
Eastern Cape	*Neptune-Vuyani 1st 400 kV line*
	Vuyani (Mthatha) 400/132 kV substation (1st and 2nd 250 MVA transformers)
	Eros-Vuyani 1st 400 kV line
Free State	*Merapi Ext. 3rd 250 MVA 275/132 kV transformer*
Gauteng	*Apollo-Pluto 400 kV loop-in-out Thuso*
	Thuso 400/132 kV substation (1st and 2nd 250 MVA transformers)
Limpopo	*Dinaledi-Spitskop 1st 400 kV line*
	Dinaledi-Spitskop 2nd 400 kV line
	Medupi-Spitskop 1st 400 kV line
	Medupi-Marang 1st 400 kV
	Medupi 400/132 kV 2 x 250 MVA substation
Mpumalanga	*Kusile 400 kV loop-in (Apollo-Kendal 1st 400 kV line)*
Northern Cape	*Mercury-Mookodi (Vryburg) 1st 400 kV line*
	Ferrum Ext. 1st and 2nd 500 MVA 400/132 kV transformers
	Ferrum-Mookodi (Vryburg) 1st 400 kV line
Western Cape	*Gamma Ext. 765 kV busbar establishment*
	Kappa 400 kV loop-ins (Droërivier-Bacchus and Droërivier-Muldersvlei 400 kV lines)
	Kappa 765/400 kV substation
	Kappa Ext. 400 kV 100 MVar shunt reactor
	Gamma-Kappa 1st 765 kV line

Table 4.2: Projects planned to be completed by FY2015/2016

PROVINCE	PROJECT NAME
Gauteng	*Kookfontein Ext. 3rd 315 MVA 275/88 kV transformer and 3rd Glockner-Kookfontein 275 kV line*
Mpumalanga	*Vulcan 400 kV bypass and reconfiguration*
	Gumeni 400/132 kV substation (1st 500 MVA 400/132 kV transformer)
	Hendrina-Gumeni 1st 400 kV line
Northern Cape	*Kronos-Cuprum 1st and 2nd 132 kV*
Western Cape	*Kappa-Sterrekus (Omega) 1st 765 kV line*
	Sterrekus (Omega) 400 kV loop-in (Koeberg-Muldersvlei 400 kV line)
	Sterrekus (Omega) 765/400 kV substation

4.2 Grid connection applications

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 4.3: Connection applications quoted and accepted

INDICATIVE COST ESTIMATES		BUDGET QUOTATIONS	
Issued	Accepted	Issued	Accepted
113	*13 (12%)*	*28*	*9 (32%)*

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

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 Units 5, 4, 3, 2 and 1 of the new Medupi Power Station in the developing Limpopo West Power Pool requires significant additional lengths of transmission line. The HVDC lines/system required for further generation developments in the Limpopo province are not included, since they will only be required after 2025 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.

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 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.

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

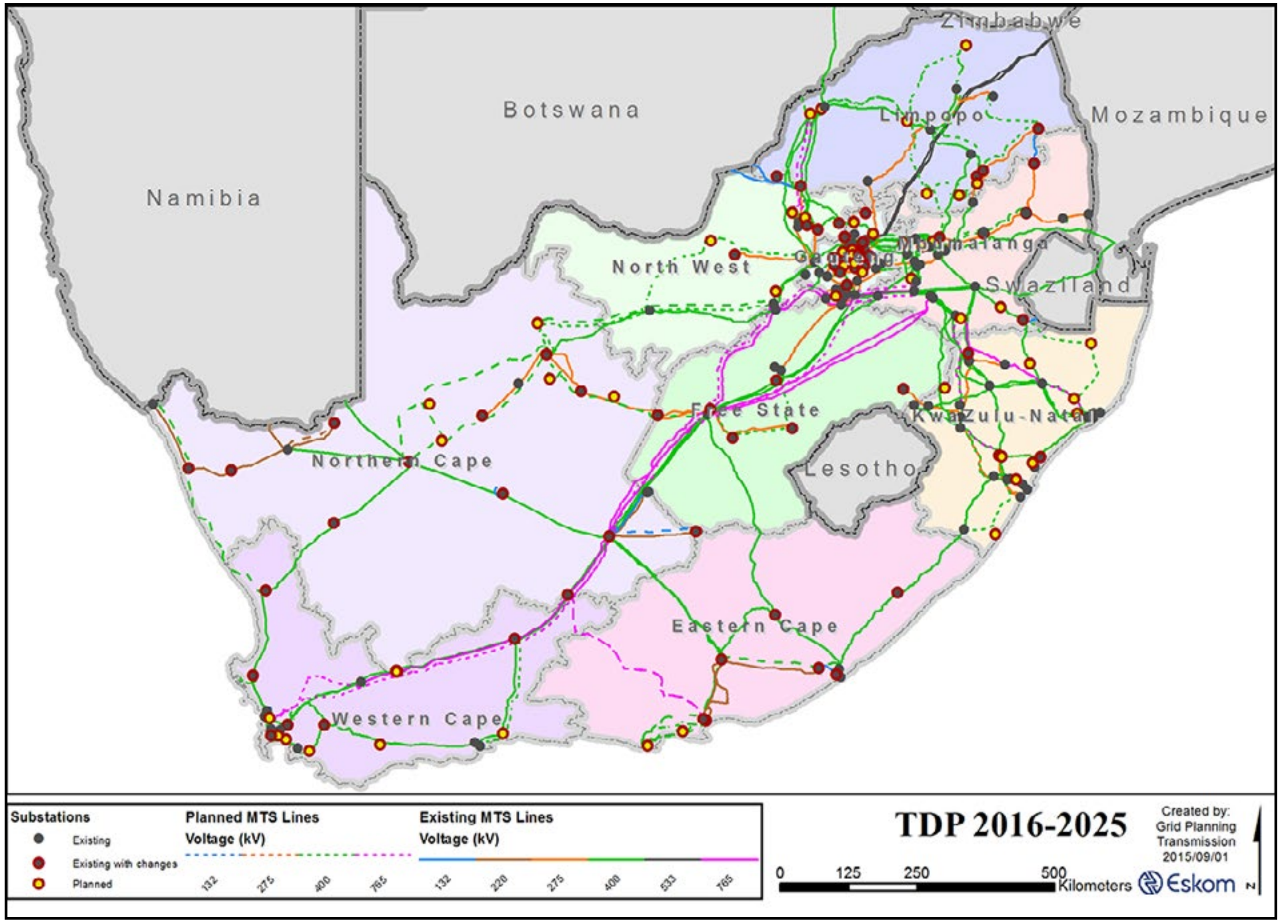


Table 5.1: Major TDP transmission assets expected to be installed

NATIONAL TRANSMISSION ASSETS	NEW ASSETS EXPECTED IN 2016 - 2020	NEW ASSETS EXPECTED IN 2021 - 2025	TOTAL NEW ASSETS
POWER LINES (KM)			
765 kV	*350*	*1 760*	*2 110*
400 kV	*2 589*	*4 915*	*7 504*
275 kV	*19*	*336*	*355*
Total length (km)	*2 958*	*7 011*	*9 969*
TRANSFORMERS			
Number of units	*71*	*94*	*165*
Total capacity (MVA)	*29 240*	*46 155*	*75 395*
Capacitors			
Number of banks	*15*	*6*	*21*
Total capacity (MVar)	*1 308*	*676*	*1 984*
Reactors			
Number of banks	*6*	*15*	*21*
Total capacity (MVar)	*667.5*	*3 100*	*3 767.5*

Chapter 6
Breakdown of the TDP projects by province

6.1 Gauteng province

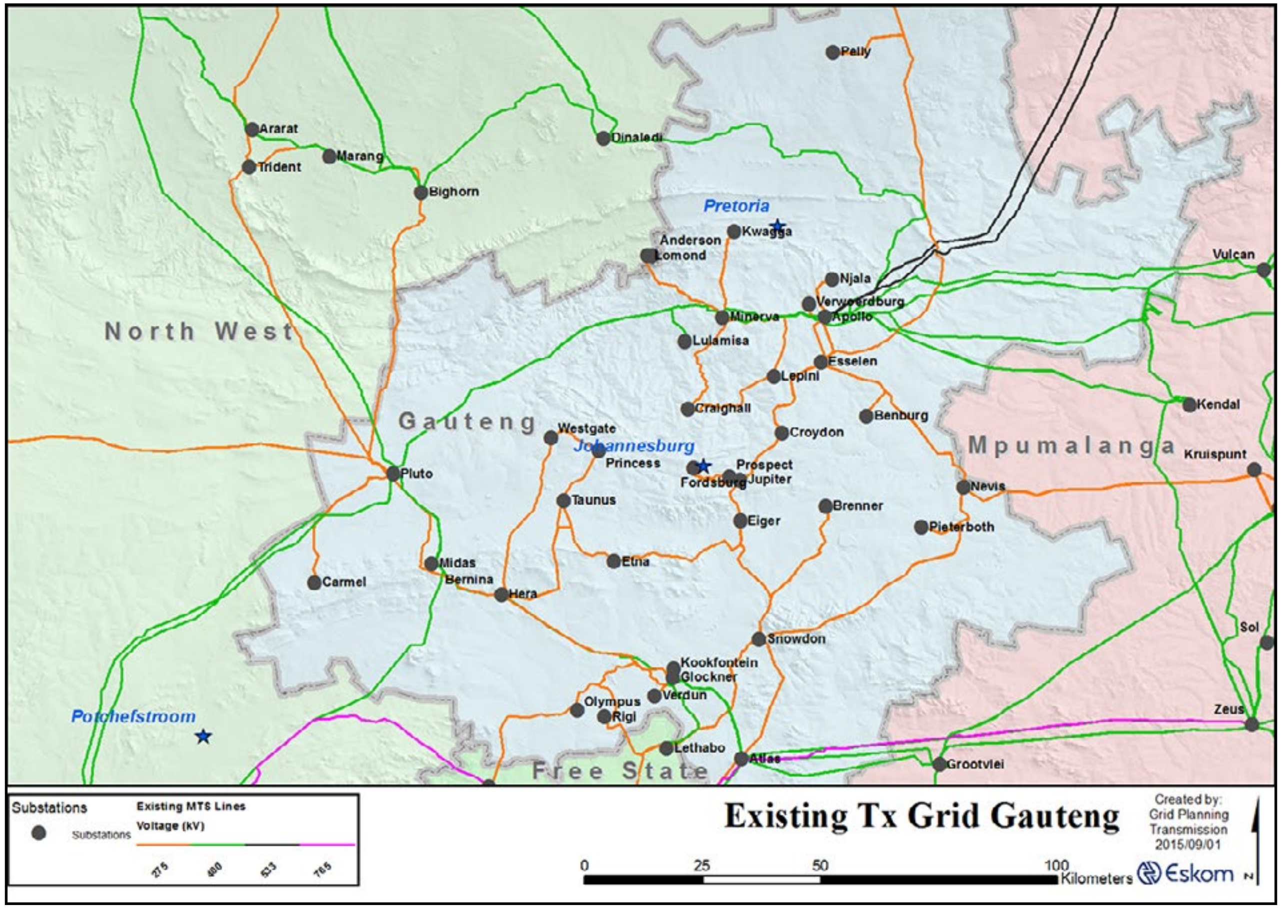
The Gauteng province is the hub of economic activity in South Africa and accounts for about 27% of electricity consumption in the country. The province is home to the Johannesburg Stock Exchange (JSE), other major financial institutions and large commercial and industrial establishments. Large municipalities (redistributors) are the dominant players, accounting for about 75% of electricity consumption in the province.

The Gauteng transmission network is predominantly connected at 275 kV voltage level, with a few transmission stations connected at 400 kV. Gauteng is primarily supplied by various power stations in the Mpumalanga Power Pool with additional support from Lethabo Power Station in the Free State province and the Songo-Apollo HVDC link that imports power from Mozambique. There are independent power stations, named Kelvin and Rooiwal, in the Johannesburg and Tshwane Municipalities, respectively.

Major transmission network development schemes planned include the Johannesburg East Strengthening, Johannesburg North Strengthening, Tshwane Strengthening, West Rand Strengthening and Vaal Strengthening. The current transmission network is shown in Figure 6.1.

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

Figure 6.1: Current Gauteng province network diagram



6.1.1 Major schemes

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

Johannesburg North Strengthening

The scheme is required to resolve the thermal and low-voltage constraints in the Johannesburg North CLN and to support future loads in the CLN. 2 x 150 MVar capacitor banks will be installed at Lepini 275 kV and the Apollo-Lepini 275 kV line will be built to strengthen supply into Lepini substation. Demeter and Kyalami 400 kV substations will be established south of Lenasia and Kyalami respectively.

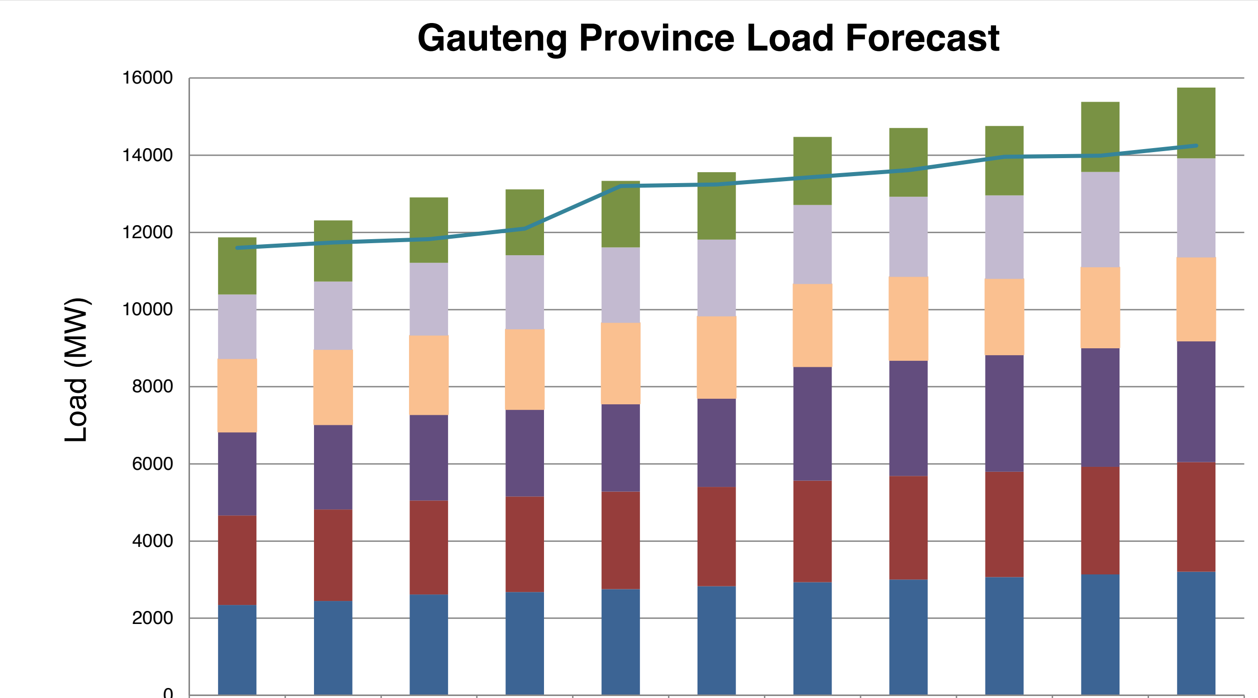
Vaal Strengthening

The scheme proposes the construction of 2 x Glockner-Etna 400 kV lines and uprating of underrated terminal equipment in order to deload the overloaded lines in the Vaal and West Rand CLN. Phase 1 of the project, that was completed in 2014 entailed; closing the Hera-Bernina 275 kV link, was completed in 2014. These lines will be energised at 275 kV until the introduction of the 400 kV voltage level at Etna substation.

Simmerpan 275 kV Integration

Simmerpan Strengthening will address unfirm transformation at Jupiter substation and alleviate thermal constraints at the Simmerpan 88 kV distribution substation due to load increases in the Ekurhuleni area. The scope of work includes establishing a 275 kV transmission substation adjacent to the Simmerpan distribution substation and installing 2 x 160 MVA 275/88 kV transformers. Simmerpan 275 kV substation will be energised from the planned Jupiter B substation via the existing Jupiter–Simmerpan 275 kV lines (currently energised at 88 kV). The substation will be extended further to accommodate 2 x 250 MVA 275/132 kV transformers.

Figure 6.2: Gauteng province load forecast



	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
VAAL	1486	1584	1693	1708	1723	1743	1763	1782	1801	1820	1833
JHB NORTH	1670	1772	1888	1924	1956	1991	2047	2075	2160	2465	2569
EAST RAND	1885	1933	2043	2067	2096	2116	2137	2158	1964	2087	2157
WEST RAND	2170	2201	2233	2263	2282	2304	2960	3003	3035	3086	3148
TSHWANE	2321	2376	2432	2478	2525	2573	2632	2688	2732	2788	2844
JHB SOUTH	2342	2445	2616	2678	2755	2831	2934	3001	3067	3139	3203
TOSP	11598	11736	11823	12094	13201	13243	13436	13612	13957	13986	14248

Soweto Strengthening

The focus of this scheme is to ensure Grid Code compliance for Taunus and Fordsburg substations and address the expected thermal constraints in the Soweto distribution network. The scope of work includes establishing the new Quattro substation that will be equipped with 2 x 315 MVA 275/88 kV transformers belonging to City Power and 2 x 500 MVA 275/132 kV transformers belonging to Eskom. Two 400 kV lines (energised at 275 kV) will be built from Etna, south of Lenasia to Quattro, in the Soweto supply area.

Johannesburg East Strengthening

This scheme will address network constraints in the East Rand and Johannesburg South CLNs. The planned construction of 2 x Apollo-North Rand 400 kV lines (energised at 275 kV) and two Matla-Jupiter B 400 kV lines (energised at 275 kV) will result in an increase in transfer limits in the East Rand and Johannesburg South CLNs. Furthermore, the Sebenza 275/88 kV substation (400/88 kV construction) that City Power is building will deload Prospect Substation and create more capacity in the East Rand.

West Rand Strengthening

This scheme addresses future thermal, substation compliance and distribution network constraints in the West Rand CLN.

- Westgate 400 kV Integration

  The project entails establishing 400 kV at Westgate, building the Hera-Westgate 400 kV line and installing a 500 MVA 400/132 kV transformer at Westgate.

- Etna 400 kV Integration

The scope of work includes establishing 400 kV at Etna and installing 2 x 800 MVA 400/275 kV and 1 x 315 MVA 400/88 kV transformers. The Etna-Glockner lines will then be operated at 400 kV.

- Taunus 400 kV Integration

  The project entails establishing 400 kV at Taunus, building the Etna-Taunus 400 kV line and installing a 500 MVA 400/132 kV transformer at Taunus.

Tshwane Strengthening

The Tshwane strengthening scheme addresses transformation unfirmness due to load increases at substations in the Tshwane CLN. Diphororo (Phoebus) 400/132 kV substation to be equipped with 2 x 500 MVA transformers will cater for load growth in the Garankuwa and Soshanguve areas. Wildebees 400/132 kV substation, to be built in the Mmamelodi area will be equipped with 2 x 315 MVA transformers.

6.1.2 Generation capacity

There is no new baseload generation planned in Gauteng, but Kusile Power Station (located in Mpumalanga province), which is under construction, will serve as an important power source into the province.

6.1.3 Substation firm capacity

The following transmission substation projects are proposed to mitigate the foreseen transformation constraints within the 2015 TDP period:

- A 3rd 250 MVA 275/132 kV transformer will be installed at Benburg substation to alleviate existing N-1 transformation constraints and cater for future load growth.
- A 3rd 315 MVA 275/88 kV transformer will be installed at Kookfontein substation to alleviate the N-1 transformation constraints.
- The second phase of strengthening at Thuso (Verwoerdburg) substation will entail installing a 3rd 250 MVA 275/132 kV transformer.
- The expected N-1 unfirmness at Taunus 275/132 kV substation will be alleviated by the establishment of the new Quattro substation, to be equipped with 2 x 500 MVA 275/132 kV transformers. City Power will also establish the Quattro 2 x 315 MVA 275/88 kV transformers to deload Fordsburg substation.
- The existing Simmerpan distribution substation will be upgraded to a transmission substation equipped with 2 x 160 MVA 275/88 kV transformers. The upgrade will alleviate the N-1 transformation constraints at Jupiter substation. The Simmerpan substation will be further extended to accommodate 2 x 250 MVA 275/132 kV transformers.
- North Rand distribution station will be upgraded to a transmission substation equipped with 2 x 500 MVA 275/132 kV transformers which will in-turn de-load the Esselen substation.
- The N-1 firmness at Westgate 275/132 kV substation will be mitigated by the establishment of the Westgate 400/132 kV 500 MVA transformer.

6.1.4 Reactive power compensation

The following capacitor banks will be installed in the West Rand:

- 2 x 48 MVar capacitor bank at Etna 88 kV
- 1 x 72 MVar capacitor bank at Taunus 132 kV
- 1 x 72 MVar capacitor bank at Quattro 132 kV
- 2 x 48 MVar capacitor bank at Brenner 88 kV

6.1.5 Underrated equipment

Gauteng province has high fault levels, particularly in the East Rand Customer Load Network (CLN). The Johannesburg East fault level management plan and proposed strengthening projects will address these fault level exceedances.

6.1.6 Provincial summary

The increase in transmission assets by the end of 2020 and the end of 2025 and cumulative 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 IN 2016 - 2020	NEW ASSETS EXPECTED IN 2021 - 2025	TOTAL NEW ASSETS
POWER LINES (KM)			
765 kV	*0*	*0*	*0*
400 kV	*104*	*775*	*879*
275 kV	*4*	*78*	*82*
Total length (km)	*108*	*853*	*561*
TRANSFORMERS			
Number of units	*12*	*21*	*33*
Total capacity (MVA)	*4 355*	*7 635*	*11 990*
CAPACITORS			
Number of banks	*4*	*4*	*8*
Total capacity (MVar)	*396*	*240*	*636*
REACTORS			
Number of banks	*0*	*0*	*0*
Total capacity (MVar)	*0*	*0*	*0*

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*	*2016*
Johannesburg North Strengthening Phase 1	*Lepini Ext. 275 kV 2 x 150 MVar capacitor banks*	*2017*
Kookfontein Strengthening	*Kookfontein Ext. 3rd 315 MVA 275/88 kV transformer and 3rd Glockner-Kookfontein 275 kV line establishment*	*2017*
Tshwane Reinforcement: Verwoerdburg Phase 2	*Verwoerdburg(Thuso) 400/132 kV substation (3rd 250 MVA transformer)*	*2018*
Vaal Strengthening Phase 2	*Glockner-Etna 1st and 2nd 400 kV line (operate at 275 kV)*	*2018*
Brenner Strengthening Phase 1	*Brenner 2 x 88 kV 48 MVar capacitor banks*	*2018*
Tshwane Reinforcement – Wildebees Phase 1	*Wildebees 400/132 kV substation (2 x 315 MVA customer transformers)* *Wildebees 400 kV loop-in-out (Apollo-Dinaledi 400 kV line)*	*2020*
Soweto Strengthening	*Etna-Quattro 1st and 2nd 400 kV lines (energised at 275 kV)* *Quattro 275/88 kV substation (400/88 kV construction) (City Power 3 x 315 MVA transformers)* *Quattro 275/132 kV substation (400/132 kV construction) (1st and 2nd 500 MVA transformers)*	*2020*
Tshwane Reinforcement: Phoebus Phase 1	*Diphororo (Phoebus) Ext. 400/132 kV substation (1st and 2nd 500 MVA transformers)* *Diphororo (Phoebus) 400 kV loop-in (Apollo-Dinaledi 400 kV line)*	*2020*
Johannesburg East Strengthening: Sebenza Integration	*Integrate Sebenza 400 kV substation by connecting to Jupiter B and North Rand substations*	*2021*
West Rand Reactive Power Project	*2 x 48 MVar capacitor banks at Etna 88 kV* *1 x 72 MVar capacitor bank at Taunus 132 kV* *1 x 72 MVar capacitor bank at Quattro 132 kV*	*2021*
West Rand Strengthening: Westgate 400 kV Integration	*Westgate 400/132 kV substation (1st 500 MVA transformer)* *Hera-Westgate 1st 400 kV line*	*2021*

Table 6.2: Gauteng province – summary of projects and timelines

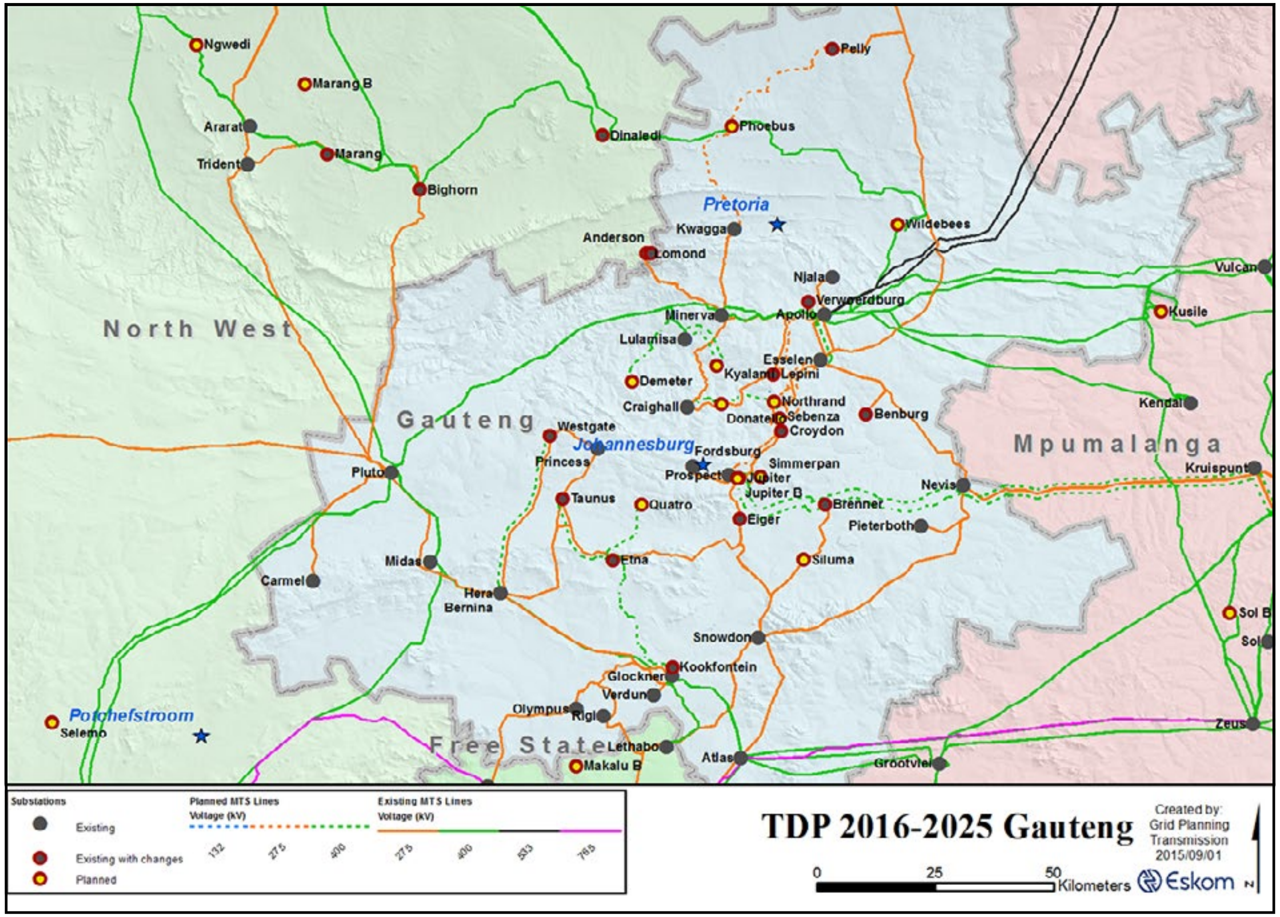
SCHEME NAME	PROJECT NAME	EXPECTED YEAR
Johannesburg North Strengthening Phase 2	*Apollo-Lepini 1st 275 kV line*	*2021*
Simmerpan 275 kV Integration Phase 1	*Jupiter B-Simmerpan 1st and 2nd 275 kV lines (uprate of 88 kV lines)*	*2022*
	Simmerpan 275/88 kV substation (expand existing Dx station) (2 x 160 MVA transformers)	
Johannesburg North Strengthening: Demeter 400 kV Integration	*Loop-in Pluto-Thuso 400 kV line into Sesiu(Demeter)*	*2022*
	Establish Sesiu(Demeter) 400/88 kV substation (1st, 2nd and 3rd 315 MVA transformers)	
Johannesburg East Strengthening: North Rand Integration	*North Rand Ext. 1st and 2nd 500 MVA 275/132 kV transformers*	*2022*
	Connect Esselen-North Rand 1st 275 kV line (currently operated at 132 kV) to North Rand 275 kV busbar	
	Bypass Chloorkop substation with Esselen-Chloorkop 132 kV and Chloorkop-North Rand 132 kV to form Esselen-North Rand 2nd 275 kV line (currently operated at 132 kV)	
	Construct a 15 km double-circuit 400 kV line (to be energised at 275 kV) from Apollo towards Esselen and bypass Esselen by connecting the double-circuit line to the Esselen-North Rand 1 and 2 275 kV lines to form 2 x Apollo-North Rand 275 kV lines	
	North Rand-Chloorkop 1st and 2nd 132 kV lines	
	North Rand-Sebenza 1st and 2nd 400 kV lines (to be energised at 275 kV)	
Johannesburg East Strengthening: Jupiter B Integration	*Jupiter B 275 kV switching station*	*2022*
	Matla-Jupiter B 1st and 2nd 400 kV line (operated at 275 kV)	*2022*
	Jupiter B 275 kV loop-ins (Prospect-Sebenza 1 and 2, Jupiter-Prospect 1, Jupiter-Fordsburg 1)	*2023*
Johannesburg North Strengthening: Kyalami 400 kV Integration	*Kyalami 400 kV loop-in (Kusile-Lulamisa 1st 400 kV line)*	*2023*
	Kyalami 400/132 kV substation (1st and 2nd 500 MVA transformers) (all bays are GIS)	

Table 6.2: Gauteng province – summary of projects and timelines

SCHEME NAME	PROJECT NAME	EXPECTED YEAR
Brenner Strengthening Phase 2	*Siluma (Brenner B) 275/88 kV (built at 400 kV) 2 x 315 MVA transformers*	*2023*
	Loop in and out Snowdon-Brenner, Lethabo-Eiger and Brenner-Eiger 275 kV lines into Siluma	
Tshwane Reinforcement: Phoebus Phase 2	*Diphororo (Phoebus) 400/275 kV substation (1st and 2nd 400 MVA 400/275 kV transformers)*	*2023*
	Diphororo (Phoebus)-Kwagga 1st 275 kV line	
Johannesburg North Strengthening: Demeter 400 kV Integration	*Pelly-Diphororo (Phoebus) 1st 275 kV line utilising the Hangklip-Pelly line currently energised at 132kV*	*2024*
Johannesburg North Strengthening: Craighall Integration	*Craighall B/Donatello 400/88 kV GIS substation*	*2024*
	Craighall B/Donatello-Sebenza 1st 400 kV line (operated at 275 kV) (reuse existing Delta-Kelvin 88 kV servitude)	
	Lepini-Craighall 275 kV line loop-in-and-out of Craighall B/Donatello)	
West Rand Strengthening: Etna 400 kV Integration	*Etna Ext. 400/275 kV transformation (2 x 800 MVA transformers)*	*2024*
	Etna Ext. 400/88 kV transformation (1 x 315 MVA transformer)	
	Glockner-Etna 1st and 2nd 400 kV lines (operate at 400 kV)	
West Rand Strengthening: Taunus 400 kV Integration	*Etna-Taunus 400 kV line (energised at 275 kV)*	*2024*
	Taunus Ext. 400/132 kV transformation (1 x 500 MVA transformer)	
Simmerpan 275 kV Integration Phase 2	*Simmerpan Ext. 275/132 kV transformation (2 x 250 MVA transformers)*	*2025*

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

Figure 6.3: Future Gauteng province network diagram



6.2 Kwazulu-Natal (KZN) province

The KwaZulu-Natal province is situated on the eastern seaboard of South Africa. Economic activities in the province are mainly concentrated around the Port of Durban and the capital, Pietermaritzburg, with significant contributions in the Richards Bay-Empangeni area, the Ladysmith-Ezakheni area and the Newcastle-Madadeni regions.

The province has a number of development proposals, which include the Dube Trade Port at La Mercy, the bolstering of the Ermelo-Richards Bay Coal Link, Richards Bay Industrial Development Zone and investment opportunities in tourism in the iSimangaliso (Greater St Lucia) Wetland Park.

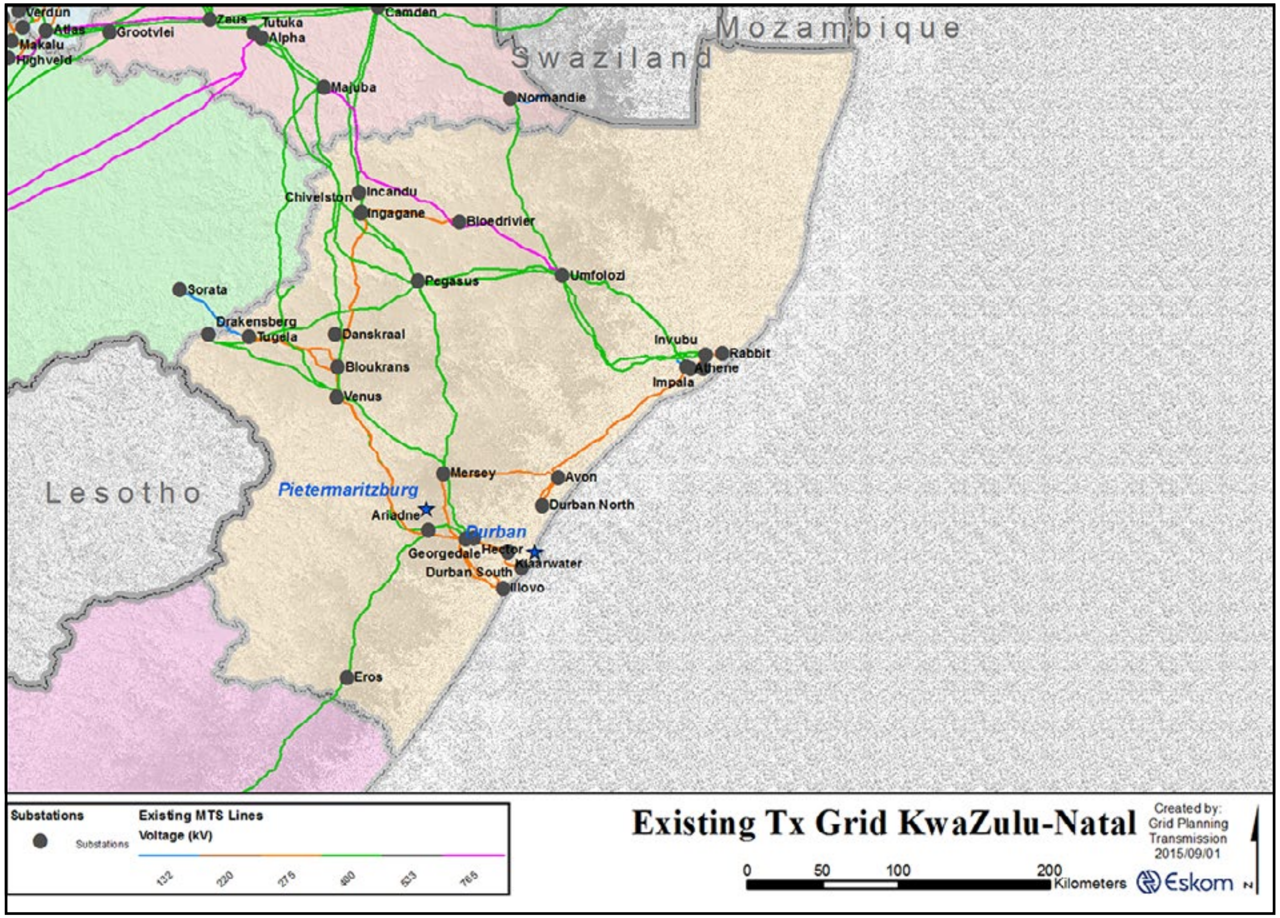
The KwaZulu-Natal plans include various projects for much-needed public infrastructure delivery, including household electrification, housing, schools, health facilities and water. These programmes will not only improve services, but will benefit local suppliers and boost the construction sector enormously.

The power supply into the province is mainly from Mpumalanga Power Pool and Drakensberg Pumped-storage Scheme via 400 kV lines. As the demand for electricity in the province increases, the existing transmission infrastructure is becoming heavily loaded and will eventually reach its full capacity. In order to cater for the anticipated growth over the next 10 years, a number of transmission network reinforcements have to be implemented. Major transmission development plans in the province consist of the following projects:

- The main power corridor from the Mpumalanga Power Pool into KwaZulu-Natal must be strengthened. This strengthening entails phased construction of 765 kV and 400 kV transmission lines and substations into the

The current transmission network is shown in Figure 6.4.

Figure 6.4: Current KZN province network diagram

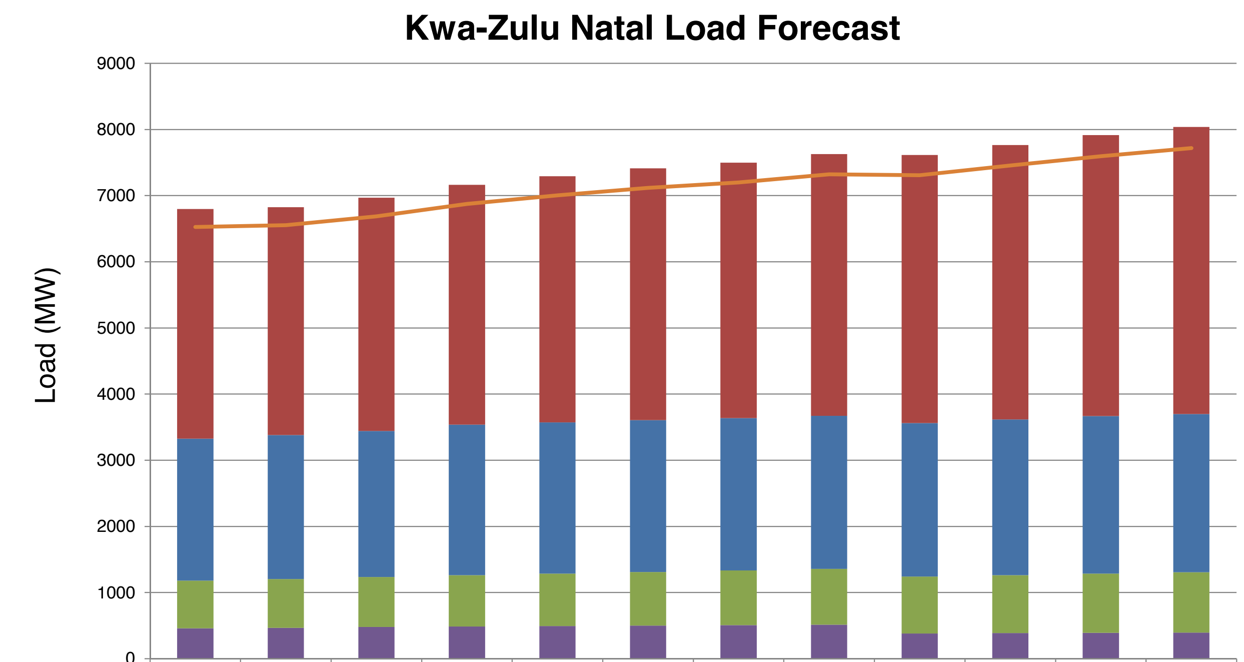


Empangeni/Richards Bay and Pietermaritzburg/Cato Ridge regions.

- The strengthening of the transmission network supplying the South Coast. It entails construction of new 400 kV and 132 kV lines and a 400/132 kV substation near Port Shepstone.
- A new transmission substation along the North Coast to address supply constraints around Pongola, Makhatini Flats and iSimangaliso (Greater St Lucia) Wetland Park
- Reinforcement of the bulk transmission supply into eThekwini Metropolitan Municipality, which consists of the establishment of two 400/132 kV transmission substations, one around the Dube Trade Port and the other around Shongweni/Hillcrest
- The integration of 680 MW Avon IPP OCGT situated in KwaDukuza Municipality and 1 320 MW Ingula Pumped-storage Scheme situated around the Drakensberg

The load forecast for the KZN province is shown in Figure 6.5.

Figure 6.5: KZN province network diagram



	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Pinetown	3472	3446	3523	3623	3721	3807	3861	3959	4052	4149	4246	4341
Empangeni	2147	2175	2207	2278	2287	2296	2305	2313	2320	2353	2383	2393
Newcastle	720	738	756	774	791	809	826	844	861	877	894	910
Ladysmith	460	467	482	488	495	502	508	514	381	387	392	396
TOSP	6527	6553	6689	6877	7003	7118	7200	7324	7310	7455	7598	7718

6.2.1 Major schemes

The current transmission network is shown in Figure 6.4 below.

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 KwaZulu-Natal to the Eastern Cape. 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. Vuyani-Neptune and Eros-Vuyani were commissioned in 2014 and 2015, respectively.

eThekwini Electricity Network Strengthening

- The establishment of Shongweni 2 x 500 MVA 400/132 kV substation and the construction of two 400 kV lines from Hector to the proposed Shongweni substation to deload Hector-Klaarwater 275 kV lines and Klaarwater substation.
- The establishment of Inyaninga 2 x 500 MVA 400/132 kV substation by looping into one of the planned Isundu Mbewu 400 kV lines to form Isundu-Inyaninga 400 kV line and Inyaninga-Mbewu 400 kV line.

NKZN Strengthening (Candover 400/132 kV substation – 2 x 500 MVA transformers)

This project involves the establishment of a 400/132 kV substation around Candover/Mkuze in order to address supply constraints around Pongola, Makhatini Flats and iSimangaliso (Greater St Lucia) Wetland Park. The planned Candover 400/132 kV substation will be integrated into the 400 kV network via two 400 kV lines, namely, Normandie-Candover and Duma-Candover 400 kV lines.

Duma substation is part of the proposed Ermelo-Richards Bay Coal Link Upgrade.

6.2.2 Generation capacity

- Integration of Ingula Pumped-storage Scheme – Ingula Power Station is a pumped-storage scheme that is under construction, spanning the escarpment of the Little Drakensberg, straddling the provincial boundary of the Free State and KwaZulu-Natal within the Ladysmith Customer Load Network (CLN). Ingula will consist of four units with a total generating capacity of 1 320 MW.
- Avon OCGT Integration – Avon Power Station is an independent power producer (IPP) OCGT plant situated in KwaDukuza Municipality. The plant will consist of four units, with a total generating capacity of 680 MW.

6.2.3 Substation firm capacity

- Transmission Transformer Capacity Study: East Grid – a 3rd 250 MVA 275/132 kV transformer is planned for Avon substation.
- Transmission Transformer Capacity Study: East Grid – a 3rd 400/132 kV transformer, 500 MVA unit, is planned for Incandu substation.
- Mersey Substation Transformation Analysis – a 3rd 250 MVA 275/132 kV transformer is planned for Mersey substation.
- Harrismith Strengthening Phase 1 – Sorata 132 kV switching station will be extended to a 275/132 kV substation in order to address the loading at Tugela substation. Sorata substation will be supplied by the existing Tugela-Sorata 275 kV line, which is currently operated at 132 kV.
- Georgedale 275/132 kV Transformer Refurbishment – as part of the 40-year-old transformer refurbishment project, the 2 x 150 MVA 275/132 kV transformers at Georgedale substation will be replaced with 2 x 250 MVA transformers.

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

TRANSMISSION ASSETS FOR KZN PROVINCE	TRANSMISSION ASSETS FOR KZN PROVINCE	NEW ASSETS EXPECTED IN 2021 - 2025	TOTAL NEW ASSETS
POWER LINES (KM)			
765 kV	*0*	*410*	*410*
400 kV	*120*	*1 000*	*1 120*
275 kV	*0*	*0*	*0*
Total length (km)	*120*	*1 410*	*1 530*
TRANSFORMERS			
Number of units	*4*	*9*	*13*
Total capacity (MVA)	*1 065*	*10 500*	*11 565*
CAPACITORS			
Number of banks	*0*	*0*	*0*
Total capacity (MVar)	*0*	*0*	*0*
REACTORS			
Number of banks	*0*	*3*	*3*
Total capacity (MVar)	*0*	*600*	*600*

6.2.4 Underrated equipment

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

- Incandu substation, as part of the 3rd 400/132 kV transformer (500 MVA unit) project
- Mersey substation, as part of the 3rd 250 MVA 275/132 kV transformer project

6.2.5 Provincial summary

The increase in transmission assets by the end of 2020 and the end of 2025 and cumulative total are shown in Table 6.3.

The following projects are planned for the 2016 to 2025 period:

Table 6.4: KZN province – summary of projects and timelines

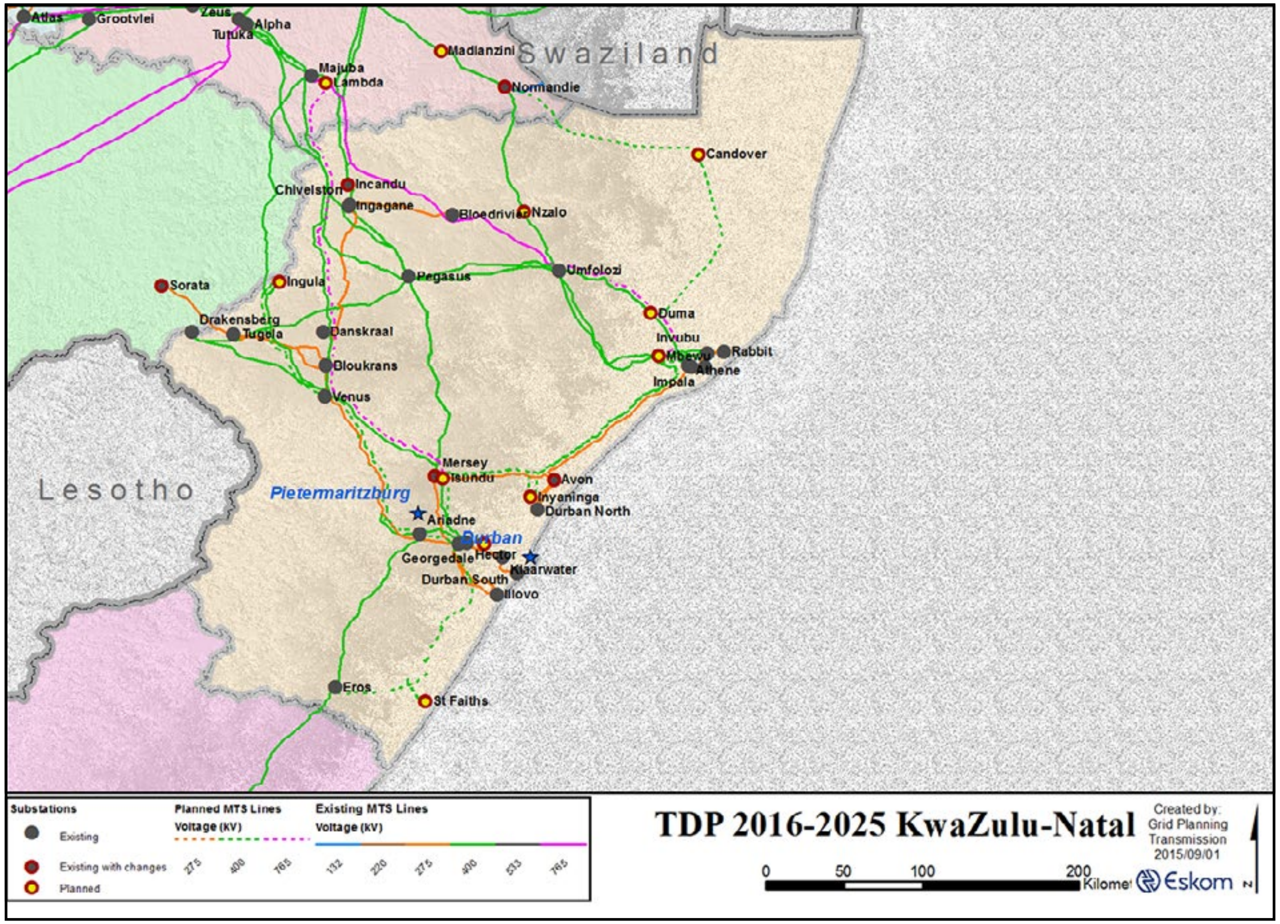
SCHEME NAME	PROJECT NAME	EXPECTED YEAR
Greater East London Strengthening - Phase 1	*Eros – Vuyani 1st 400 kV line*	*Energised*
	Avon 3rd 250 MVA 275/132 kV transformer	*2015*
Transnet Coal-Line Upgrade	*3 of 1 x 160 MVA 400/88 kV substations*	*2018*
	Loop-in Camden – Normandie 1 400 kV line, Normandie – Umfolozi 1 400 kV line & Pegasus – Athene 1 400 kV line respectively.	
Avon IPP	*IPP OCGT at Avon 275 kV*	*2016*
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 Transmission Substation Integration	*Ingula 400 kV busbar*	*2015*
	Loop-in Majuba – Venus 2 400 kV line into Ingula Substation	
	Ingula – Venus 2nd 400 kV line	
Incandu 3rd 400/132 kV transformer upgrade	*Incandu 3rd 400/132 kV transformer upgrade*	*2017*
KZN 765 kV Strengthening - Empangeni Integration	*Mbewu 1 x 2000 MVA 765/400 kV Substation*	*2023*
	Loop-in Athene – Umfolozi 1 400 kV line & Invubu – Umfolozi 1 400 kV line into Mbewu Substation	
	Umfolozi – Mbewu 765 kV line (extension of Majuba – Umfolozi 1 765 kV line)	
	Invubu – Mbewu 2nd 400 kV line	
KZN 765 kV Strengthening - Lambda Substation	*Lambda 2 x 2000 MVA 400/765 kV Substation*	*2023*
	Majuba – Lambda 1st 400 kV line	
	Divert Tutuka – Majuba 400 kV line from Majuba Substation to Lambda Substation and form Tutuka – Lambda 1st 400 kV line	

Table 6.4: KZN province – summary of projects and timelines

SCHEME NAME	PROJECT NAME	EXPECTED YEAR
KZN 765 kV Strengthening -Pinetown Integration	*Isundu 1 x 2000 MVA 765/400 kV Substation*	*2025*
	Loop-in Ariadne – Hector 2 400 kV (de-energised) circuit into Isundu Substation	
	Lambda-Isundu 1st 765 kV line	
KZN 765 kV Strengthening - Isundu – Mbewu 1st & 2nd 400 kV Lines	*Isundu – Mbewu 1st & 2nd 400 kV lines*	*2026*
eThekwini Electricity Network Strengthening	*Inyaninga 2 x 500 MVA 400/132 kV Substation*	*2027*
	Loop-in Isundu – Mbewu 1 400 kV line into Inyaninga Substation	
	Shongweni 2 x 500 MVA 400/132 kV Substation	*2024*
	2 x Hector – Shongweni 1st and 2nd 400 kV lines	
Mersey 3rd 250 MVA 275/132 kV transformer upgrade	*Mersey Ext 3rd 250 MVA 275/132 kV transformer*	*2016*
South Coast Strengthening	*Ariadne – Eros 2nd 400 kV line*	*2021*
	St. Faiths 2 x 500 MVA 400/132 kV Substation	*2022*
	Loop-in Ariadne – Eros 2 400 kV line into St. Faiths Substation	
NKZN Strengthening Phase 1	*Candover 400 kV busbar*	*2022*
	Normandie – Candover 1st 400 kV line	
	Candover 1 x 500 MVA 400/132 kV transformer	
NKZN Strengthening Phase 2	*Duma – Candover 1st 400 kV line*	*2026*
	Candover 1 x 500 MVA 400/132 kV transformer	

Single line diagrams indicating the major projects in the KZN province for the 10-year period are shown in Figure 6.6.

Figure 6.6: Future KZN province network diagram



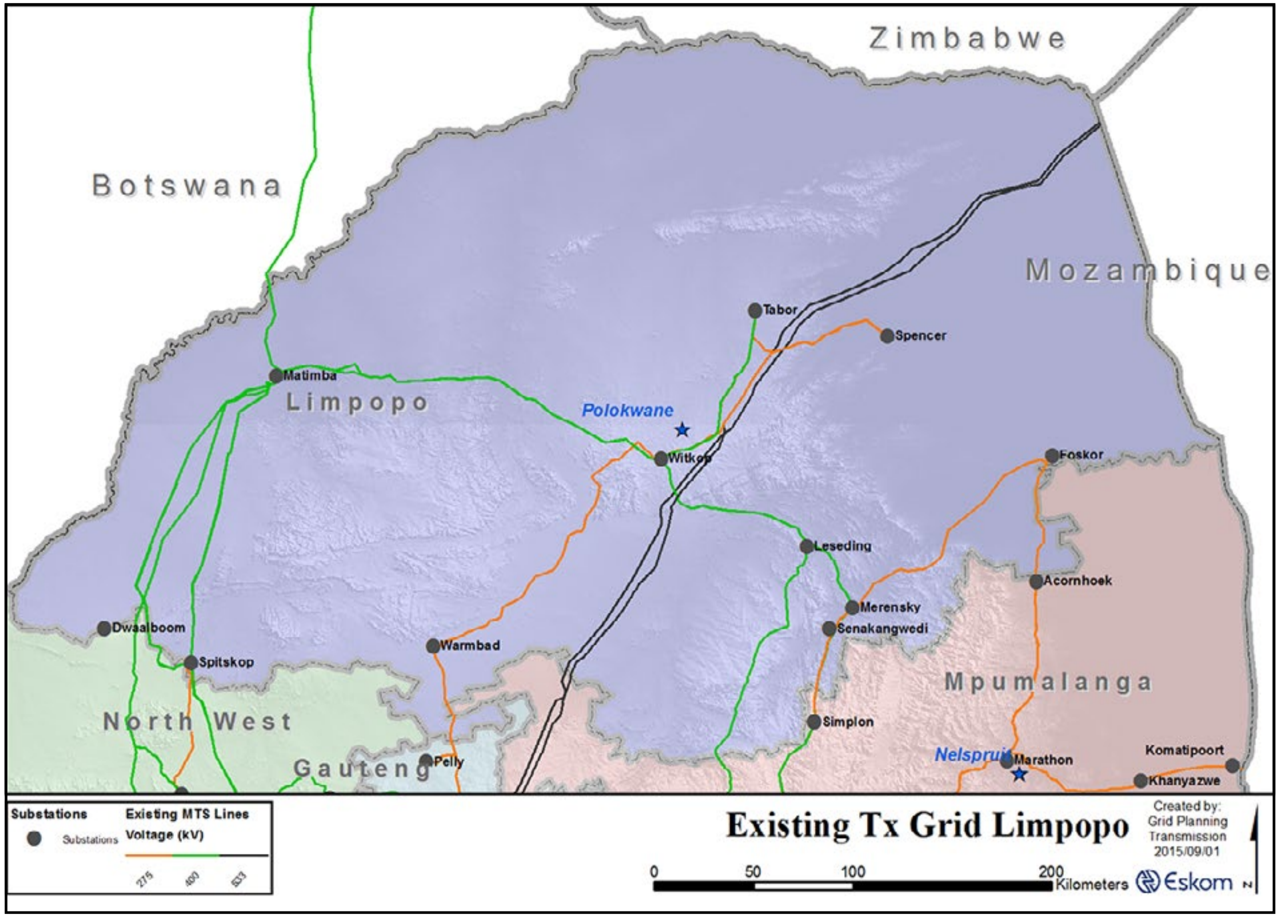
6.3 Limpopo province

The existing infrastructure in the Limpopo province is mainly comprised of 400 kV and 275 kV networks. Growth in Limpopo is primarily due to the platinum group metals (PGM) and ferrochrome mining and processing activities located in the Polokwane and Steelpoort areas. The establishment of coal mines is a key driver for expansion in the Lephalale area. There are also large electrification projects under way throughout Limpopo.

The major schemes in the province consist of the Medupi Power Station Integration and Silimela and Nzhelele Transmission Substations Integration. The current transmission network is shown in Figure 6.7.

The load forecast for the Limpopo province is shown in Figure 6.8.

Figure 6.7: Current Limpopo province network diagram



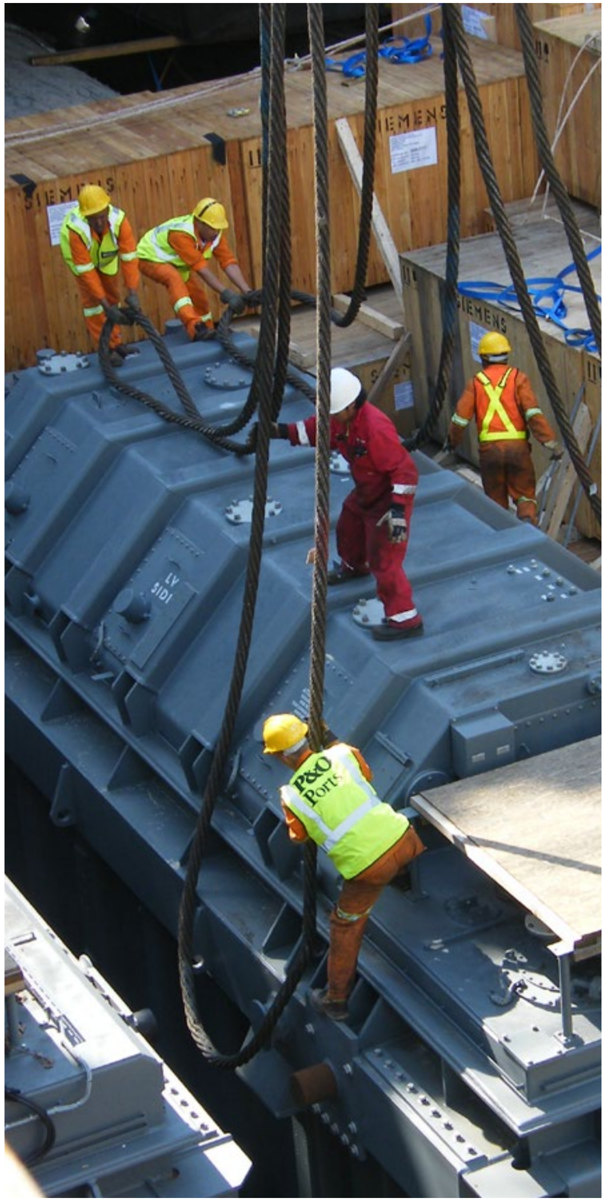
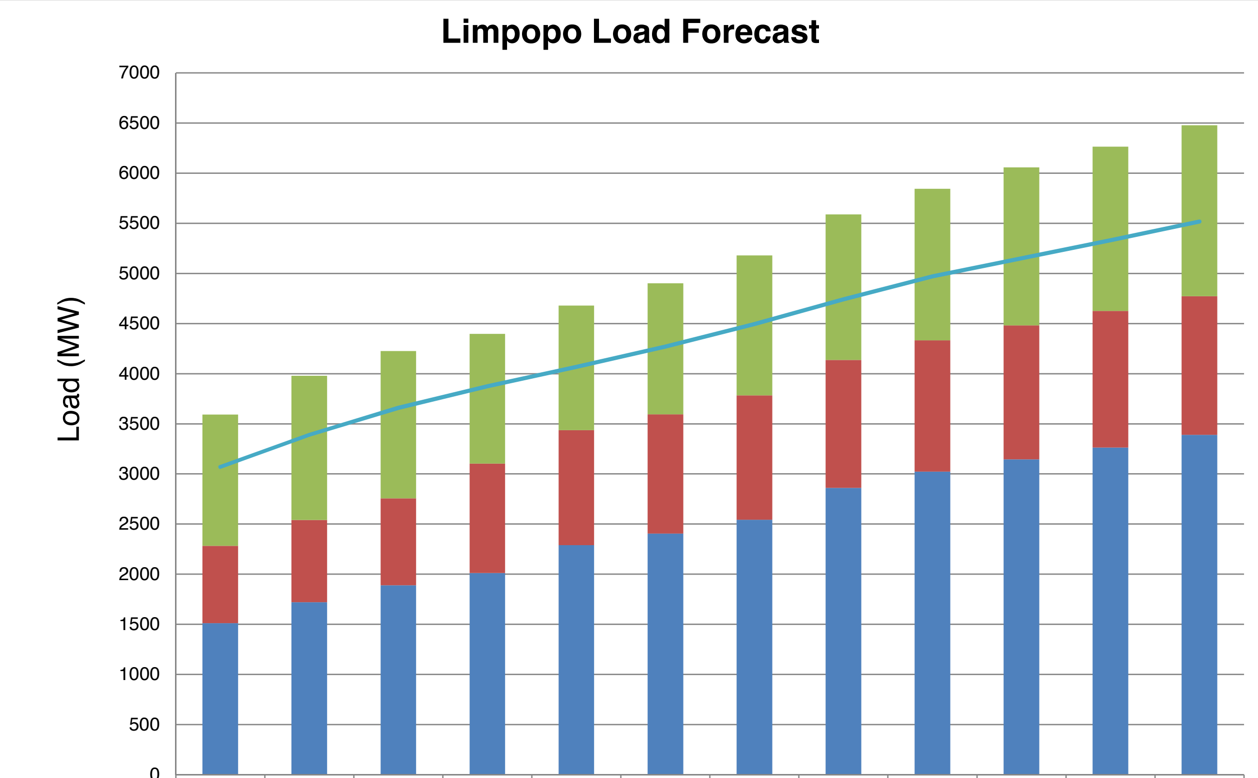


Figure 6.8: Limpopo province load forecast



	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Polokwane	1309	1437	1470	1294	1244	1307	1397	1452	1513	1575	1637	1704
Lephalale	772	821	866	1093	1146	1190	1240	1276	1308	1337	1363	1383
Phalaborwa	1512	1720	1889	2011	2289	2404	2543	2861	3024	3145	3263	3390
TOSP	3069	3390	3659	3875	4069	4271	4496	4741	4970	5151	5330	5518

6.3.1 Major schemes

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 main schemes in Limpopo are as follows:

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 to the North West Province and Polokwane CLN.

Medupi Stability Integration at 400 kV

This project initiated after receiving manufacturing data for the 6 x 800 MW generators planned to be installed at Medupi Power Station. It is required to ensure that Medupi Power Station and Matimba Power Station would be in compliance with the Grid Code in terms of transient stability.

Borutho Transmission Substation

Medupi Integration identified Borutho substation as one of the nodal points to evacuate power within the Lephalale CLN. The Borutho Substation Integration Project aims to strengthen the transmission and distribution networks in the Mokopane area.

Spitskop Substation Transformation Upgrade

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

Nzhelele 400 kV Integration

The Nzhelele integration is required 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.

Limpopo East Corridor Strengthening

The project entails building a new 110 km 400 kV line from Foskor substation to Spencer substation and the establishment of 400/132 kV transformation with the installation of 1 x 500 MVA 400/132 kV transformer at Spencer substation. The project will also require the 2nd Merensky-Foskor 275 kV line to be operated at 400 kV, since it will be built at 400 kV specifications. 400/275 kV transformation will be established at Foskor substation.

Silimela (Marble Hall) Transmission Substation

The existing Mapoch/Marble Hall and Mapoch/Wolwekraal 132 kV networks will not be capable of supplying the additional load growth beyond 2015 to 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 to the existing Wolwekraal distribution substation. The new transmission substation will deload Simplon substation. 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.

Senakangwedi B Transmission Substation

According to the load forecast for the Tubatse area, the load growth between 2015 and 2030 is expected to accelerate due to further developments in ferrochrome and platinum mining.

The transmission network supplying Tubatse area was voltage and thermally constrained under various N-1 contingencies until the recent commissioning of the Duvha-Leseding 400 kV line. However, the additional transmission network capacity created is not sufficient to cater for forecasted future load growth – hence, the need for the investigation into further transmission network strengthening plans, which resulted in the proposal of a new transmission substation 10 to 15 km south of the existing Senakangwedi substation. It is, therefore, proposed that a new transmission substation be built next to Uchoba distribution substation in the year 2020.

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. A 3rd 250 MVA 275/132 kV transformer has been approved for installation at Foskor substation. The existing 2 x 75 MVA 275/132 kV transformers at Acornhoek substation are over 40 years old and approaching the end of their life, so they will be replaced with 2 x 125 MVA 275/132 kV, which will provide the needed extra capacity and extend the useful life of the substation.

A 2nd Foskor-Merensky 275 kV line is proposed to address undervoltage and voltage stability constraints. New developments have recently arisen since the project was proposed; the load growth in the northern direction of Foskor substation, which includes the Tzaneen area (which is supplied by Spencer substation), has shown the need for additional transmission strengthening. The planned Nzhelele substation will slightly deload Spencer substation; hence, a new solution for Spencer substation is required. In order to align with future projects and to phase out the dependency on the 275 kV network in Limpopo province, the EA for the 2nd Merensky-Foskor line will be amended from 275 kV to 400 kV. The line will be built at 400 kV and operated at 275 kV.

Dwarsberg (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, now called Dwarsberg switching station.

6.3.2 Generation capacity

The baseload generation in Limpopo province is located in the Lephalale area, where the coal reserves are being exploited. The existing Matimba and the new Medupi Coal-fired Power Stations will provide almost 8.5 GW of generation. Imported generation from Botswana is expected to be approximately 150 MW, with the integration of Morupule B Power Station (PS).

Matimba Power Station: the coal-fired power station is designed to generate 4 000 MW; Matimba – the Tsonga word for "power" – is the largest direct dry-cooled power station in the world, with 6 x 665 MW turbo-generator units. The adjacent Grootegeluk Colliery has sufficient coal reserves to guarantee Matimba a minimum lifespan of 35 years, extending to a possible 50 years.

Medupi Power Station: Medupi Power Station will have a nominal generating capacity of 4 800 MW (6 x 800 MW units). On completion, Medupi Power Station will be the largest dry-cooled power station in the world. It will be slightly larger than the existing Matimba Power Station in terms of operation, design and dimensions.

The end-state total generation expected in the Lephalale area will be approximately 20 GW by 2030. This will be possible with the commissioning of two more coal-fired power stations similar in size to Medupi Power Station. Table 6.5 shows a summarised list of generation capacity in Limpopo province.

Table 6.5: Generation capacity for the Limpopo province

STATION	MA TIMBA POWER STATION	MATIMBA POWER STATION
Type	Baseload	Baseload
Total capacity (MW)	*6 x 665*	*6 x 800*

6.3.3 Renewable generation

Two solar PV plants of 30 MW and 28 MW have been commissioned and integrated into Witkop substation and Tabor substation, respectively in the Polokwane area. A 60 MW PV plant is also expected at Tom Burke.

6.3.4 Substation firm capacity

- A 3rd 250 MVA 275/132 kV transformer is planned for Foskor substation
- A 400 MVA 400/275 kV transformer is planned for Foskor substation
- Acornhoek substation transformation upgrade:
- From 2 x 75 MVA 275/132 kV transformers to 2 x 125 MVA 275/132 kV transformers
- Spitskop substation transformation upgrade:
- From 2 x 250 MVA 400/132 kV transformers to 2 x 500 MVA 400/132 kV transformers
- A 3rd 500 MVA 400/132 kV transformer is planned for the future Borutho substation. The project is customer dependent, as the major increase will be contributed by one large customer.
- Spencer substation transformation upgrade:
- An additional 1 x 500 MVA 400/132 kV transformer is planned for Spencer substation. The additional 1 x 500 MVA 400/132 kV transformer will be paralleled with the existing 2 x 250 MVA 275/132 kV transformers.

Table 6.6: Cumulative TDP transmission assets for Limpopo province

TRANSMISSION ASSETS FOR LIMPOPO PROVINCE	TRANSMISSION ASSETS FOR LIMPOPO PROVINCE	NEW ASSETS EXPECTED IN 2021 - 2025	TOTAL NEW ASSETS
Power lines (km)			
765 kV	*200*	*0*	*200*
400 kV	*560*	*660*	*1 220*
275 kV	*15*	*150*	*165*
Total length (km)	*775*	*810*	*1 585*
Transformers			
Number of units	*14*	*3*	*17*
Total capacity (MVA)	*5 925*	*520*	*6 445*
Capacitors			
Number of banks	*0*	*0*	*0*
Total capacity (MVar)	*0*	*0*	*0*
Reactors			
Number of banks	*1*	*2*	*3*
Total capacity (MVar)	*100*	*200*	*300*

6.3.5 Reactive power compensation

The Polokwane Reactive Power Compensation Project comprises of the following scope of work:

- Install 2 x 36 MVar capacitor banks on the 132 kV busbar, with associated bays, at Tabor, Spencer and Nzhelele substations

6.3.6 Underrated equipment

The underrated equipment at the following substations is currently being addressed as part of the Waterberg Generation Integration Fault Level Management Plan:

- Matimba
- Merensky
- Spitskop
- Witkop

6.3.7 Provincial summary

The increase in transmission assets by the end of 2020 and the end of 2025 and cumulative total are shown in Table 6.6.

The following projects are planned for the 2016 to 2025 period:

Table 6.7: Limpopo province – summary of projects and timelines

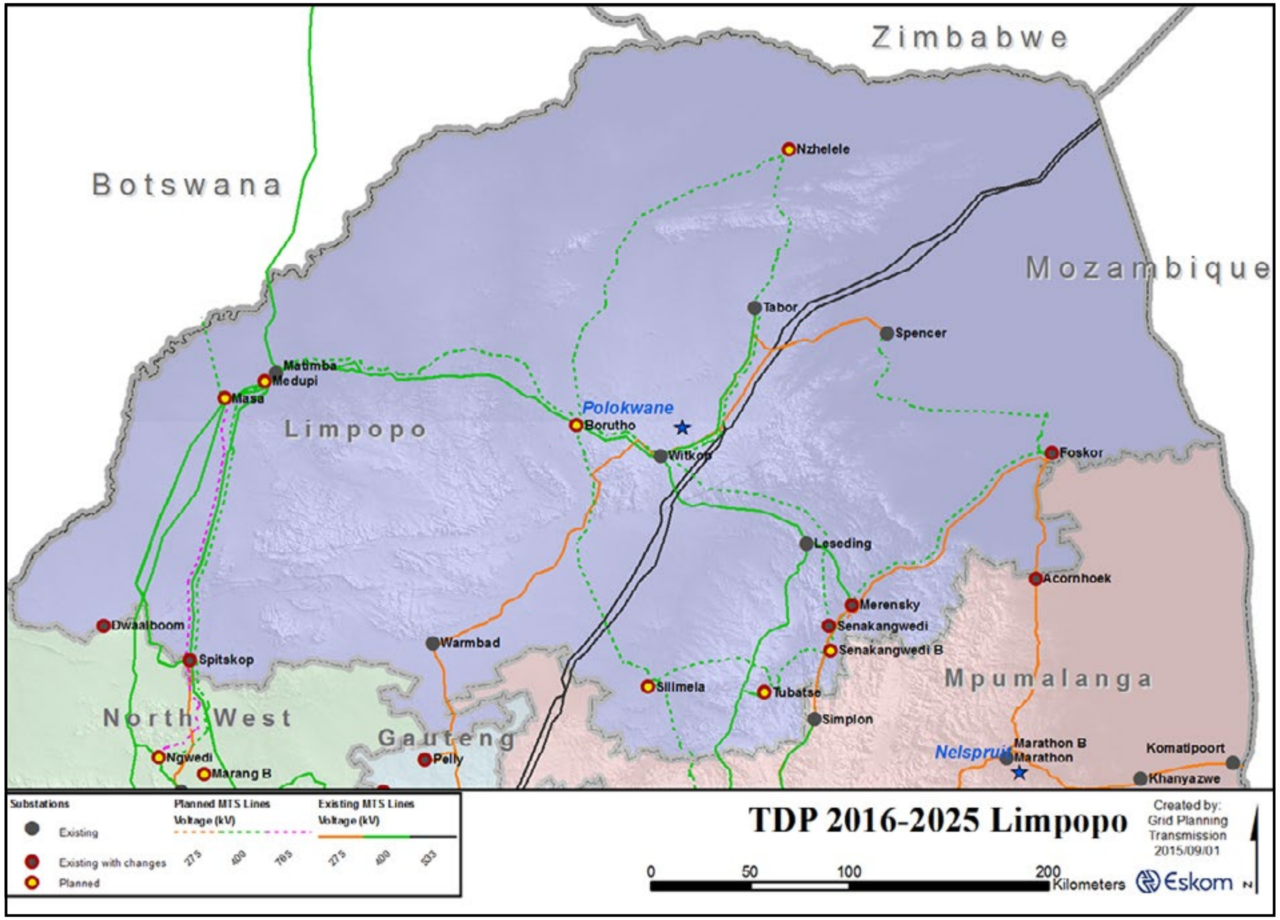
SCHEME	PROJECT	EXPECTED YEAR
Spitskop Transformation Upgrade	*Spitskop 2 x 500 MVA 400/132 kV transformer upgrade*	*2016*
Borutho 3rd 500 MVA 400/132 kV Transformer	*Borutho 3rd 500 MVA 400/132 kV transformer*	*Concept*
Nzhelele 400 kV Integration	*Nzhelele 400/132 kV substation (1st and 2nd 250 MVA)*	*2021*
	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),*	*2020*
	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)	
Highveld North-West and Lowveld North Reinforcement –Phase 2	*Silimela 400/132 kV substation*	*2019*
	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	

Table 6.7: Limpopo province – summary of projects and timelines

SCHEME	PROJECT	EXPECTED YEAR
Foskor and Acornhoek 275/132 kV Transformation Upgrades	*Foskor-Merensky 2nd 275 kV line*	*2018*
	Acornhoek Upgrade Phase 1 – 2 x 125 MVA 275/132 kV transformers	*2017*
	Foskor 3rd 250 MVA 275/132 kV transformer	
Dwaalboom 132 kV Switching Station	*Dwaalboom 132 kV switching station*	*2017*
Medupi Transmission Integration	*Medupi-Ngwedi (Mogwase) 1st 400 kV line*	*2017*
	Medupi-Ngwedi (Mogwase) 1st 765 kV line (energised at 400 kV)	
	Borutho 400/132 kV substation (2 x 500 MVA transformers)	*2015*
	Borutho 400 kV loop-in (Matimba-Witkop 1st 400 kV line)	
	Medupi-Borutho 1st 400 kV line	*2016*
	Borutho-Witkop 2nd 400 kV line	
Medupi Stability Integration at 400 kV	*Borutho-Marble Hall 1st 400 kV line*	2022
	Medupi-Phokoje 1st 400 kV line	
	Medupi-Witkop 1st 400 kV line	
	Witkop-Senakangwedi B 1st 400 kV line	
	Remote-end reactors	
Limpopo East Corridor Strengthening	*Foskor-Spencer 1st 400 kV line (110 km)*	2022
	Merensky-Foskor 2nd 275 kV line change-over to 400 kV line	
	Foskor 400/275 kV transformation (1st 400 MVA 400/275 kV transformer)	
	Spencer 400/132 kV transformation (1st 400 MVA 400/132 kV transformer)	
Polokwane Reactive Power Compensation	*Spencer 2 x 36 MVar capacitor banks installation*	*2019*
	Tabor 2 x 36 MVar capacitor banks installation	
	Nzhelele 2 x 36 MVar capacitor banks installation	2022

The future network diagram for the Limpopo province is shown in Figure 6.9.

Figure 6.9: Future Limpopo province network diagram



6.4 Mpumalanga province

The Mpumalanga province is considered the generation hub of South Africa's electricity network due to the concentration of power stations in this region and their close proximity to the large centres of loads. Currently, 11 of 13 Eskom coal-fired power stations, namely, Arnot, Camden, Duvha, Grootvlei, Hendrina, Kendal, Komati, Kriel, Matla, Majuba and Tutuka are located in the Mpumalanga Province. In addition to the 11 coal-fired power stations, one of the two Eskom power stations that are currently under construction, namely, Kusile Power Station, is located in Mpumalanga.

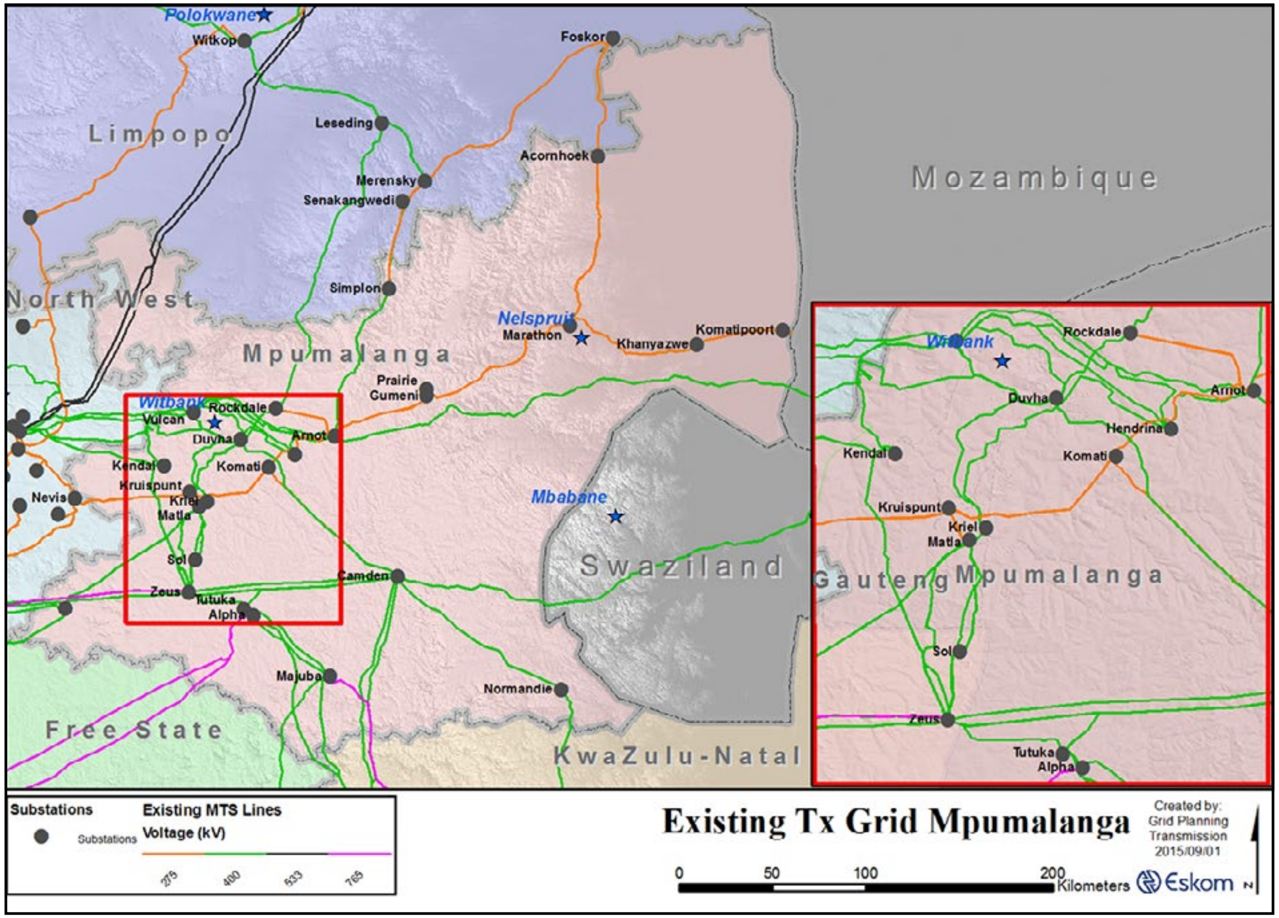
The Mpumalanga province consists of four customer load networks (CLNs) and each CLN is made up of a number of substations, as follows:

- Highveld South CLN – Sol, Camden, Alpha, Tutuka, Normandie, Majuba, Grootvlei and Zeus
- Lowveld CLN – Marathon, Prairie, Simplon, Komatipoort and Gumeni
- Middleburg CLN – Rockdale, Hendrina, Rockdale B, Duvha, Komati and Arnot
- Witbank CLN – Vulcan, Matla, Kendal, Kriel, Kruispunt and Kusile

Steady load growth is expected in the province as a result of commercial development, electrification and the establishment of the industrial development zone (IDZ). The future load mix is not expected to differ from the existing, which is mainly comprised of redistributors and mining, commercial and industrial customers.

The current transmission network is shown in Figure 6.10.

Figure 6.10: Current Mpumalanga province network diagram



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

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.

6.4.1 Major schemes

The main schemes in Mpumalanga are as follows:

Highveld North-West and Lowveld North Reinforcement – Phase 1

This scheme entails the establishment the new Emkhiweni 400/132 kV substation.

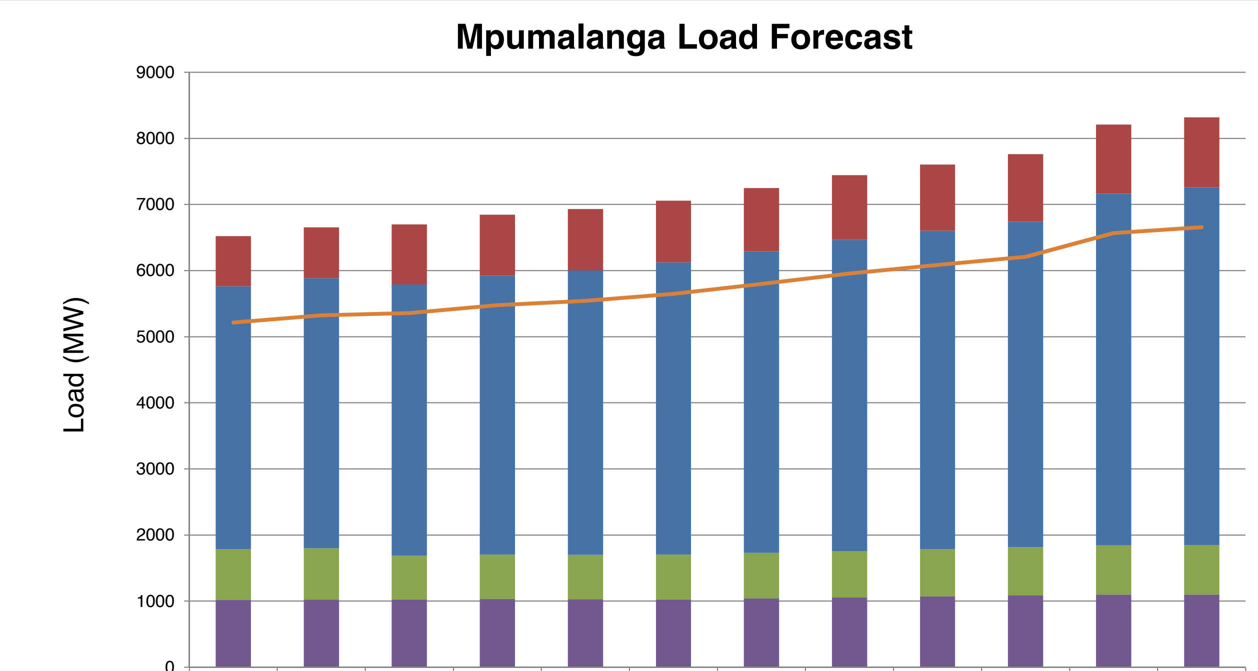
Highveld South Reinforcement Phase 2: Sol B Integration

This scheme entails the establishment the new Sol B 400/132 kV substation.

Kusile Power Station Integration

Figure 6.12 shows a single-line diagram (SLD) of the full Kusile Power Station Integration plan. The dotted lines represent the new 400 kV lines and new loops in and out from the existing 400 kV lines.

Figure 6.11: Mpumalanga province load forecast



	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Lowveld	755	768	906	923	927	934	956	978	1001	1024	1047	1056
Highveld South	3980	4088	4106	4218	4301	4423	4561	4707	4817	4922	5318	5415
Middleburg	768	778	659	670	672	675	689	704	718	732	746	750
Witbank	1017	1022	1027	1035	1030	1028	1042	1056	1070	1084	1099	1098
TOSP	5216	5324	5359	5476	5544	5648	5799	5956	6085	6210	6568	6655

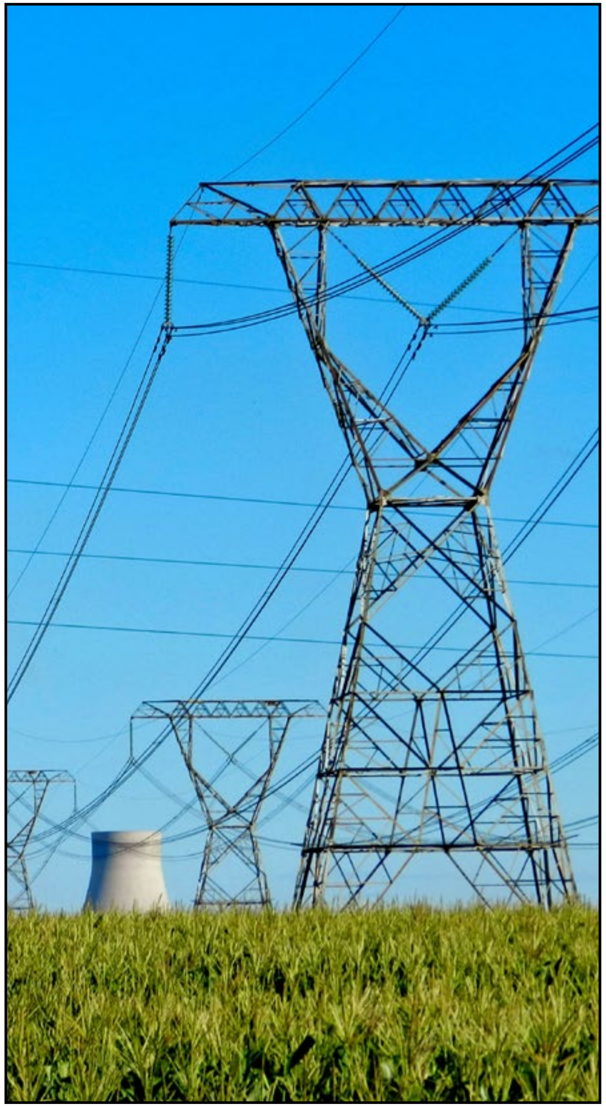
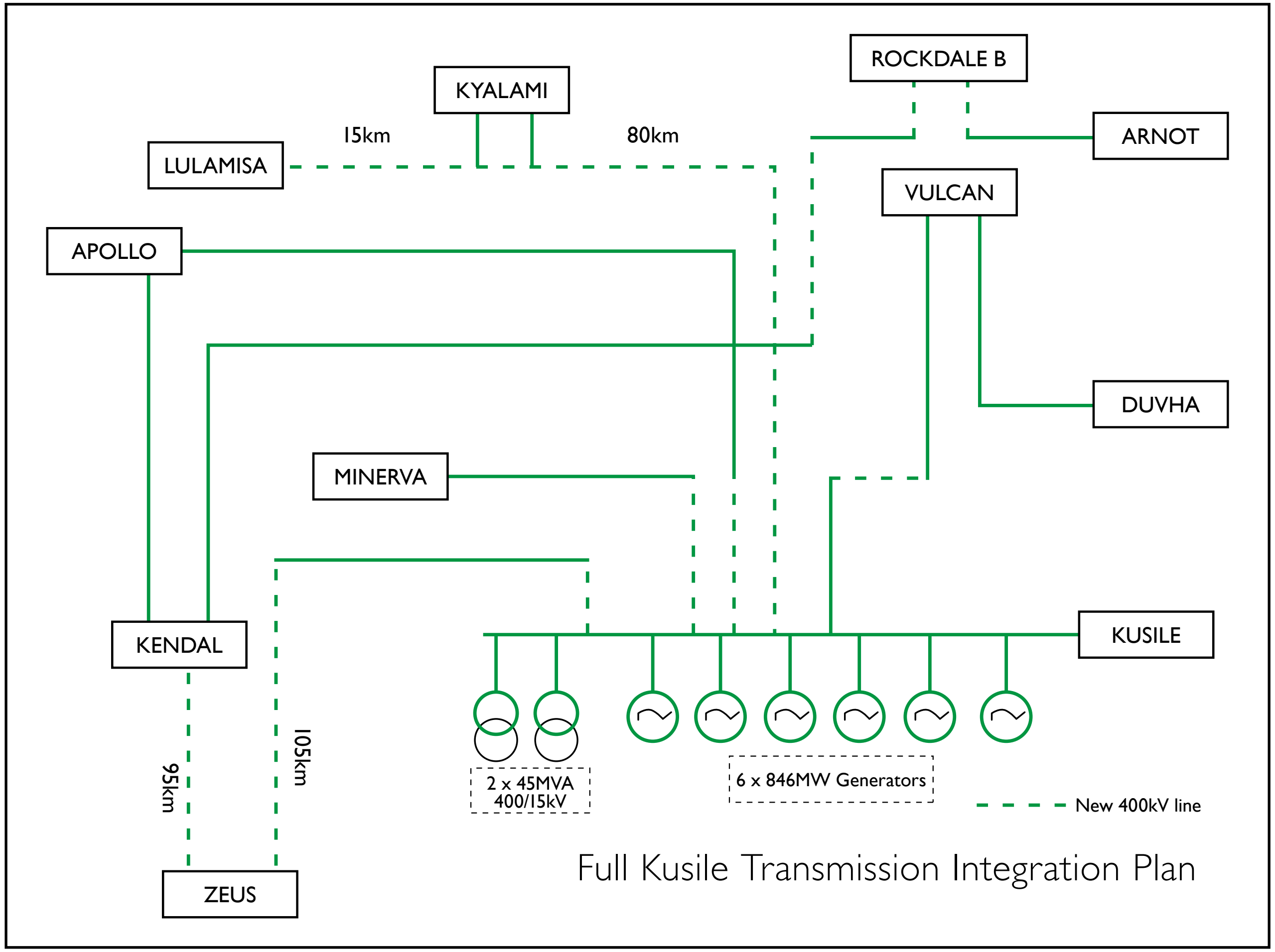


Figure 6.12: Kusile Power Station Integration single-line diagram



Lowveld Strengthening Phase 2A

This scheme entails establishment of the following:

- Gumeni 400/132 kV substation (1st 500 MVA 400/132 kV transformer)
- Hendrina-Gumeni 400 kV line

Kruispunt Reinforcement

This project proposes loop-in of the Komati-Matla 1st 275 kV line into Kruispunt 275 kV substation in order to restore N-1 compliance.

Hendrina-Arnot 400 kV Equipment Upgrade

Upgrading of the switchgear on the Hendrina-Arnot 400 kV line by replacing all underrated equipment.

Lowveld Strengthening Phase 2B

This scheme entails the establishment of a 400 kV busbar at the existing Marathon transmission substation. The proposed integration plan is as follow:

- Marathon 400/132 kV substation (1st 500 MVA 400/132 kV transformer)
- Marathon-Gumeni 400 kV line

Lowveld Strengthening Phase 3A

This scheme is dependent on the step load increase at Machadodorp and the future generation development between Mozambique and South Africa. The scheme entails the following scope:

- Gumeni 2nd 500 MVA 400/132 kV transformer
- Arnot-Gumeni 400 kV line

6.4.2 Generation capacity

The total capacity of Kusile Power Station on completion is expected to be 4 716 MW. Furthermore, additional generation in the form of IPP-operated coal-fired power stations is expected to be integrated into the Mpumalanga province within the current TDP period.

Table 6.8 shows all the Eskom power station units that are scheduled to be decommissioned within the analysis period. These power stations, namely, Arnot, Hendrina and Camden, are close to reaching the end of their lifespans. While it is likely that the lifespans of these power station will be extended, the technical assessment of this TDP is based on the currently available information, which represents the worst-case generation scenario.

6.4.3 Substation firm capacity

- Emkhiweni (Rockdale B) substation integration will be commissioned to support Rockdale substation.
- Sol B substation will be commissioned to mitigate existing transformation constraints at Sol substation.
- The 400/132 kV, 300 MVA and 250 MVA transformers at Vulcan substation will be replaced with 500 MVA transformers.
- Marathon 132/66 kV will be decommissioned.

6.4.4 Underrated equipment

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

Mpumalanga Underrated Equipment Upgrade Phase 1

- Equipment replacement (circuit-breakers, isolators and CTs) at both ends of the following lines to ensure alignment with line capacity:
- Apollo-Kendal 1 and 2 400 kV line
- Duvha-Minerva 400 kV line
- Duvha-Matla 400 kV line
- Kendal-Minerva 400 kV line
- Kriel-Zeus 400 kV line
- Upgrade of 5.63 km Twin Dinosaur section of the Kriel Zeus 400 kV line to Triple Dinosaur.

Table 6.8: Aging generators decommissioning schedule

YEAR OF DECOMMISSIONING	ARNOT POWER STATION	HENDRINA POWER	CAMDEN POWER STATION
2021		*Unit 4: 190 MW*	*Unit 6: 160 MW*
2022		*Unit 3: 190 MW* *Unit 5: 180 MW*	*Unit 7: 170 MW* *Unit 8: 180 MW*
2023	*Unit 3: 380 MW* *Unit 2: 380 MW*	*Unit 2: 190 MW*	*Unit 5: 180 MW* *Unit 4: 185 MW*
2024	*Unit 1: 376 MW*	*Unit 1: 376 MW*	*Unit 3: 185 MW* *Unit 2: 190 MW* *Unit 1: 190 MW*

Mpumalanga Underrated Equipment Upgrade Phase 2

- Upgrade of underrated equipment at the following substations:
- Vulcan 400 kV
- Rockdale 132 kV
- Hendrina 400 kV
- Kruispunt 132 kV
- Komati 275 kV
- Zeus 400 kV
- Arnot 400 kV and 275 kV
- Marathon 275 kV and 132 kV

Mpumalanga Underrated Equipment Upgrade Phase 3

- Reconfigure the transmission network:
- Bypass Tutuka substation by interconnecting the Tutuka ends of the Majuba-Tutuka and Kendal-Tutuka 400 kV lines.
- Equipment upgrades involving the following substations:
- Tutuka 400 kV, Alpha 400 kV, Majuba 400 kV and Matla 275 kV, as well as Matla substation fault-limiting reactors

Hendrina-Arnot 400 kV Equipment Upgrade

- This project will involve upgrading the equipment (isolators) on the Hendrina-Arnot 400 kV line, so that the line operates at its highest rating during emergencies.

Highveld South Reinforcement Phase 1: Sol MTS FCLR and Equipment Replacement

- Sol substation fault-limiting reactors in series with existing 400/132 kV transformers
- Replacement of all underrated equipment at Sol substation

6.4.5 Provincial summary

The increase in transmission assets by the end of 2020 and the end of 2025 and cumulative total are shown in Table 6.9.

The following projects are planned for the 2016 to 2025 period:

Table 6.9: Cumulative TDP transmission assets for Mpumalanga province

TRANSMISSION ASSETS FOR MPUMALANGA PROVINCE	NEW ASSETS EXPECTED IN 2016 - 2020	NEW ASSETS EXPECTED IN 2021 - 2025	TOTAL NEW ASSETS
Power lines (km)			
765 kV	*0*	*0*	*0*
400 kV	*397*	*102*	*499*
275 kV	*0*	*0*	*0*
Total length (km)	*397*	*102*	*499*
Transformers			
Number of units	*6*	*5*	*11*
Total capacity (MVA)	*2750*	*2800*	*5550*
Capacitors			
Number of banks	*1*	*0*	*1*
Total capacity (MVar)	*72*	*0*	*72*
Reactors			
Number of banks	*0*	*0*	*0*
Total capacity (MVar)	*0*	*0*	*0*

Table 6.10: Mpumalanga province – summary of projects and timelines

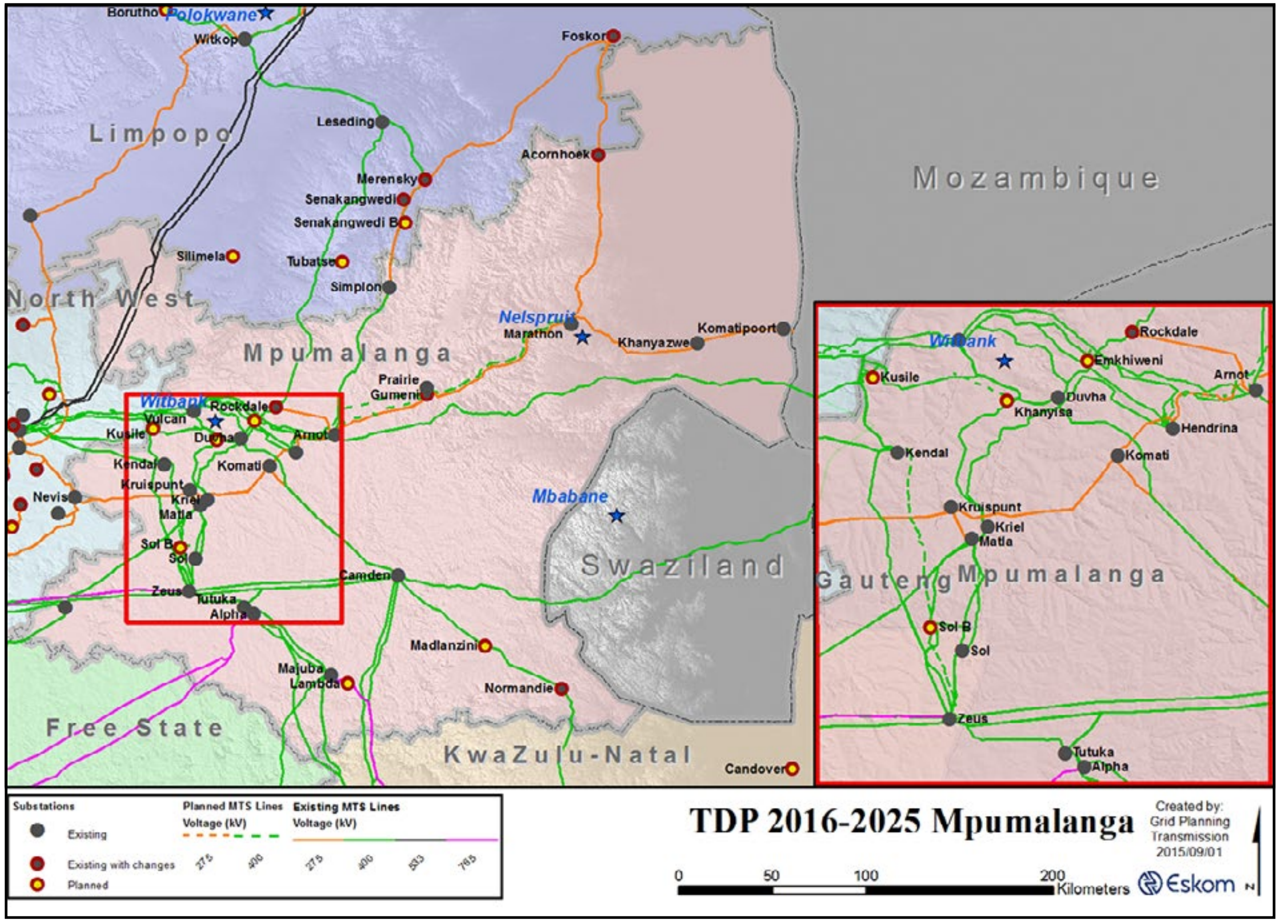
SCHEME NAME	PROJECT NAME	EXPECTED YEAR
Highveld Terminal Equipment Replacement	*Mpumalanga Underrated Equipment Upgrade (Apollo-Kendal 1 and 2, Duvha-Minerva, Duvha-Matla, Kendal-Minerva and Kriel-Zeus)*	*2015*
Highveld North-West and Lowveld North Reinforcement – Phase 1	*Rockdale 132 kV breakers upgrading*	*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*	*2015*
	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)*	*2016*
Highveld South Reinforcement	*Turn in Kriel-Tutuka 400 kV line into Sol B substation* *New Sol B 400/132 kV substation*	*2016*
	Turn in Kriel-Zeus 400 kV line into Sol B substation	
	Sol B Ext. equip 8 x 132 kV feeder bays	*2017*
Khanyisa Power Station Integration	*Khanyisa PS 400 kV switching station*	*2017*
	Turn in Kusile-Vulcan 400 kV line into Khanyisa PS	
	Kruispunt 275 kV loop-in Komati-Matla 1st 275 kV line	
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)*	*2018*
Kusile Integration Phase 3B: 400 kV Loop-in	*Kusile 400 kV loop-in (Apollo-Kendal 1st 400 kV line)*	*2018*
Kusile Integration Phase 4A	*Kendal-Zeus 1st 400 kV line*	*2020*

Table 6.10: Mpumalanga province – summary of projects and timelines

SCHEME NAME	PROJECT NAME	EXPECTED YEAR
Kusile Integration Phase 4B	*Kusile 400 kV bypass Kendal (Kendal bypass required to form the Kusile-Zeus 400 kV line from Kusile-Kendal and Kendal-Zeus lines)*	*2020*
	Kendal-Zeus 2nd 400 kV line	*2021*
Kusile Integration Phase 4B	*Kusile 400 kV bypass Kendal (Kendal bypass required to form the Kusile-Zeus 400 kV line from Kusile-Kendal and Kendal-Zeus lines)*	*2020*
	Kendal-Zeus 2nd 400 kV line	*2021*
Lowveld Strengthening Phase 2B	*Gumeni-Marathon 400 kV line*	*2023*
	Marathon 400/132 kV substation	
Lowveld 400 kV Strengthening – Phase 3A	*Gumeni 2nd 400/132 kV transformer*	*2023*
	Marathon 400/275 kV substation (2nd transformer)	
Lowveld 400 kV Strengthening – Phase 3B	*Gumeni-Marathon 2nd 400 kV line*	*2024*
	Marathon 400/275 kV substation (2nd transformer)	*Customer dependent*
Malelane 275 kV Reinforcement – Phase 3	*Khanyazwe (Malelane)-Marathon 400 kV line (operated as 2nd 275 kV line)*	*Customer dependent*
	Khanyazwe (Malelane) Ext. 1st 500 MVA 400/132 kV transformer	*Deferred (2026)*
Khanyazwe (Malelane) Reinforcement Phase 2	*Khanyazwe (Malelane) 132 kV, 72 MVar capacitor bank*	*Deferred (2026)*
Normandie Ext. 2nd 250 MVA 400/132 kV transformer	*Normandie Ext. 2nd 250 MVA 400/132 kV transformer*	*Deferred (2026)*
Hendrina-Arnot 400 kV Equipment Upgrade	*Hendrina-Arnot 400 kV equipment upgrade*	*Deferred (2026)*
Mpumalanga Underrated Equipment Upgrade Phase 2	*Upgrade underrated equipment at Vulcan 400 kV, Rockdale 132 kV, Hendrina 400 kV, Kruispunt 132 kV, Komati 275 kV, Zeus 400 kV and Arnot 400 kV and 275 kV*	
Mpumalanga Underrated Equipment Upgrade Phase 3	*Bypass Tutuka substation by interconnecting the Tutuka ends of the Majuba-Tutuka and Kendal-Tutuka 400 kV lines. Tutuka 400 kV, Alpha 400 kV, Majuba 400 kV and Matla 275 kV equipment upgrade, as well as Matla substation fault-limiting reactors*	

The future network diagram is shown in Figure 6.16.

Figure 6.13: Future Mpumalanga province network diagram



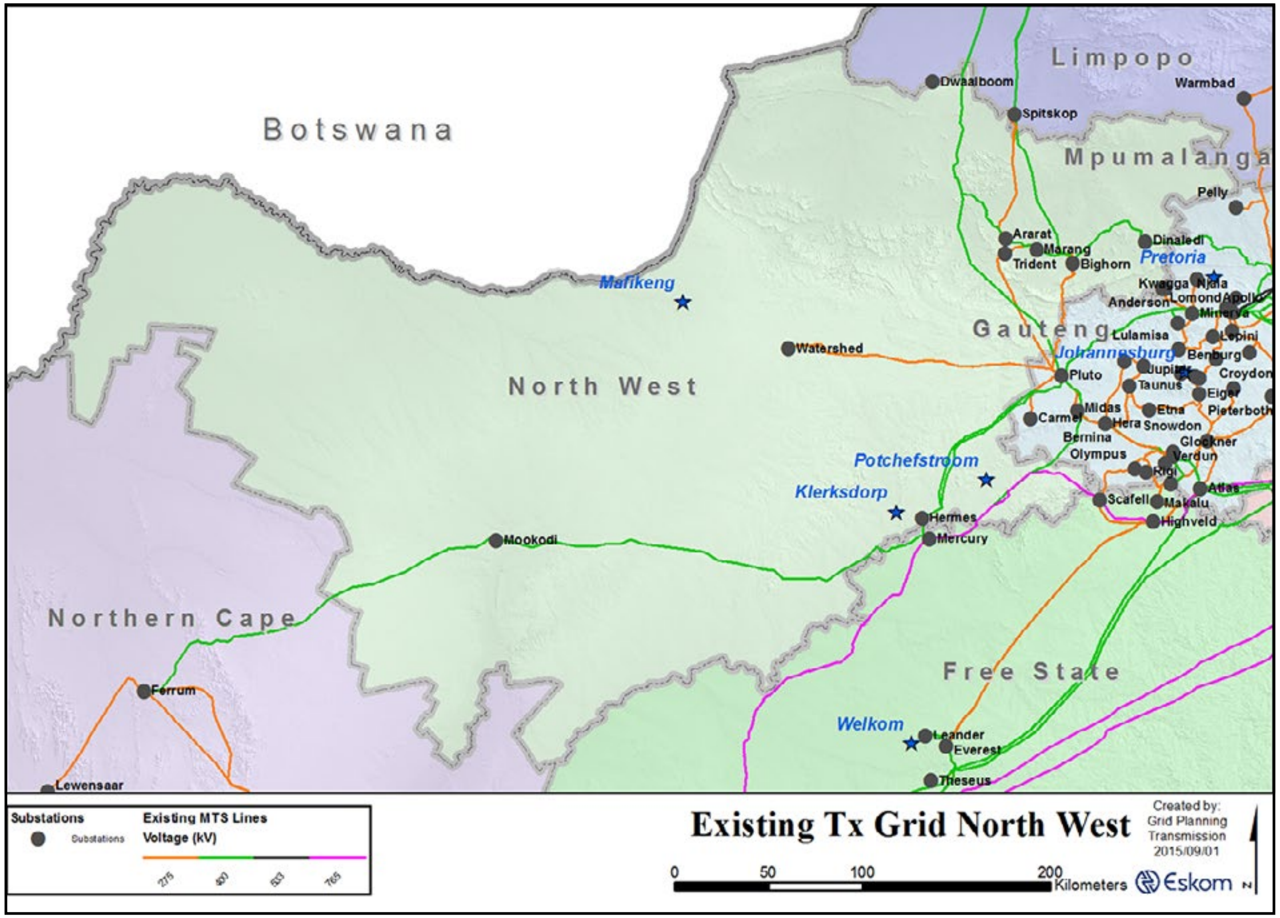
6.5 North West province

The North West province in South Africa, also known as the Platinum Province, is endowed with various mineral riches such as platinum group metals, dimension stone, fertile and vast agriculture soil, a strong manufacturing sector and opportunities in renewable energy and agro-processing. North West province is home to the largest platinum refinery and the two largest platinum mines, as well as the fourth-largest integrated ferrochrome producer. In addition, tourism activities and tourism investment opportunities thrive in the province, boasting, among others, internationally renowned tourism hubs. The eastern and southern parts are crop-growing regions that produce maize, sunflowers, tobacco, cotton and citrus fruits. The entertainment and casino complex at Sun City and the Lost City also contributes to the provincial economy.

The North West province comprises a highly connected 400 kV network, with an underlying 275 kV network. The integration of Medupi Power Station will further enhance the major power corridors into Rustenburg, extending into the Carletonville Customer Load Network. There is a need and determination to extend the network to untapped areas waiting to be explored – hence, the need to have adequate expansion network plans in place to meet the load demand. In addition to this, there is a need to unlock capacity for electrification and to create a platform for integration of renewable energy. The projects for the North West province are mainly the introduction of 400 kV lines and transformation to support or relieve the 275 kV networks.

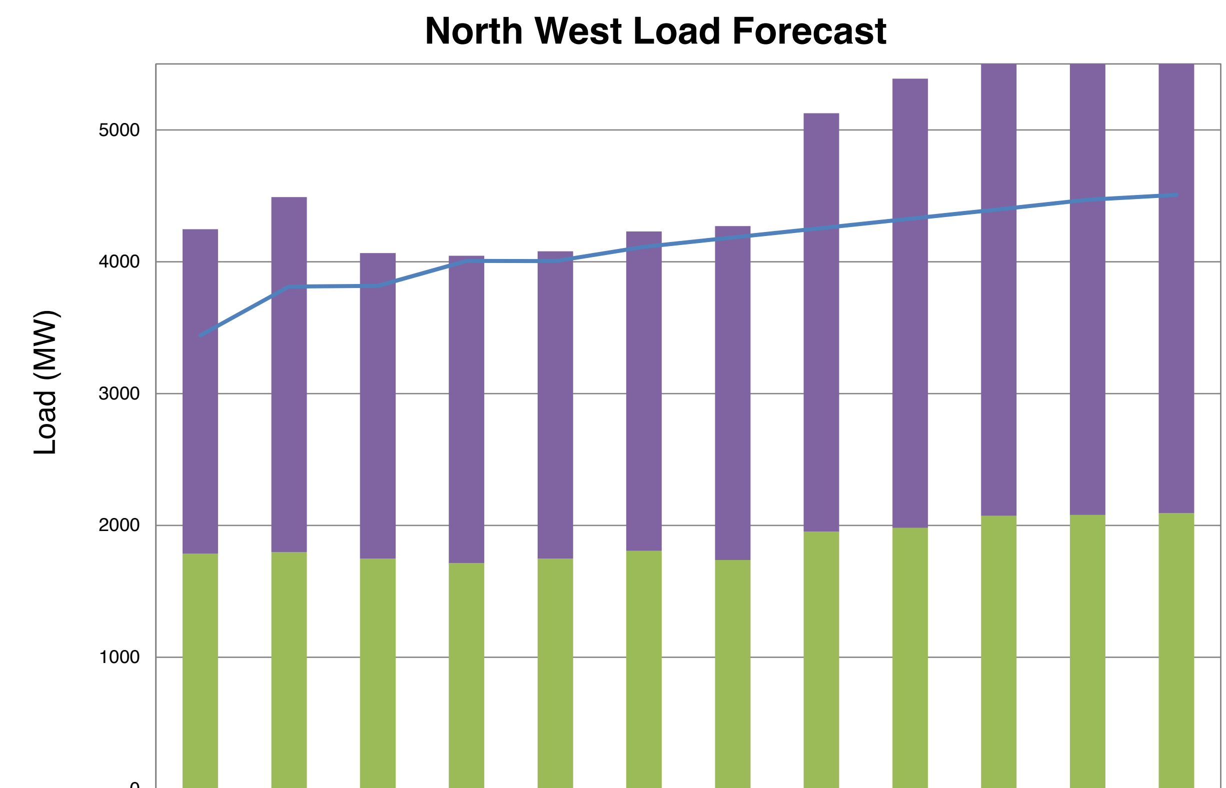
The current transmission network is shown in Figure 6.17.

Figure 6.14: Current North West province network diagram



The load forecast for the North West province is shown in Figure 6.15.

Figure 6.15: North West province load forecast



	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Rustenburg	2462	2694	2318	2332	2331	2423	2532	3175	3408	3518	3545	3676
Carletonville	1785	1796	1748	1714	1748	1807	1738	1952	1981	2073	2080	2093
TOSP	3442	3812	3817	4006	4005	4114	4185	4256	4327	4398	4470	4508

6.5.1 Major schemes

The following major schemes are planned for the 2016 to 2025 period:

Integration of Ngwedi MTS

This scheme deloads Ararat substation and reinforces the 400 kV backbone into Rustenburg. The first phase of the Ngwedi Integration comprises establishing a single 500 MVA transformer and a 132 kV busbar to make power available for customer connections. The second transformer and associated scope of work is incorporated in phase two.

Rustenburg Strengthening Phase 2

The scheme entails the extension of Marang substation (2 x 500 MVA), establishing a 400/132 kV transformation and extensive sub-transmission work (132 kV lines and substations). This scheme deloads existing Marang substation and introduces 132 kV in the Marang supply area. In addition to this, this scheme addresses the capacity insufficiency for future load growth demand for Marang supply area.

Rustenburg Strengthening Phase 3

This scheme addresses the low voltages in the Rustenburg CLN under the N-1 loss of the 400 kV in-feed from Matimba Power Station to Marang substation prior to the integration of Medupi Power Station. Shunt capacitor banks will provide reactive power support in the CLN.

Watershed Strengthening Phase 1 and 2

This scheme addresses transformation capacity and the under-voltage on the 275 kV Watershed busbar under N-1 conditions. The undesirable voltage step-change under switching operations associated with the existing 88 kV shunt capacitor banks will also be addressed. A new 250 MVA 275/132 kV transformer will be installed; together with 1 x 30 MVar 88 kV and 2 x 30 MVar 132 kV shunt capacitor banks.

Watershed (Backbone) Strengthening Phase 3

Beyond 2020, further network enhancements are required to address the Watershed insufficient transformation capacity and the poor voltage profile under N-1 contingency of the Pluto-Watershed 275 kV line. There is an additional load of 180 MW expected, approximately 60 km west of Watershed, in Mafikeng. This scheme deloads Watershed substation and introduces 400 kV injection in Mafikeng, via establishment of Pluto-Mafikeng and Mookodi-Mafikeng 400 kV lines and the new Mafikeng (Watershed B) 2 x 500 MVA 400/132 kV substation.

Kimberley Strengthening Phase 2

The transmission scope entails establishment of the 1st Mercury-Mookodi-Ferrum 400 kV line and Mookodi 2 x 250 MVA 400/132 kV substation. Mookodi was recommended for supplying the distribution and municipal networks in the Vryburg and Edwards Dam areas. The substation will deload both Watershed and Boundary substation. This project has been commissioned and is in service; however, the projects for Distribution's 132 kV lines are delayed due to servitude challenges.

6.5.2 Generation capacity

There are no power stations in the province, which is supplied from both Matimba and the Mpumalanga Power Pool. The load flows will change after the integration of Medupi Power Station and most of the power into the North West province will come from the Waterberg Power Pool.

Medupi Integration will increase fault levels in the transmission networks in close proximity to the power station as well as the neighbouring networks. This will aggravate existing fault level exceedances at some of the substations. The fault level exceedances caused by the integration of Medupi will be addressed by the Waterberg Generation Integration Fault Level Management Plan.

6.5.3 Renewable generation

There are currently no renewable energy plants in the province; however, there is interest in connecting solar PV plants at Mookodi and Watershed substations.

6.5.4 Substation firm capacity

- Ngwedi 2 x 500 MVA 400/132 kV substation Integration is planned to deload Ararat substation. A 3rd 500 MVA 400/132 kV transformer is also planned to restore transformation firm capacity at Ngwedi.
- Rustenburg Strengthening Phase 2, which entails the Marang Extension (2 x 500 MVA 400/132 kV transformers), is planned to deload the Marang 400/88 kV substation.
- A 3rd Dinaledi 500 MVA 400/132 kV transformer is planned to deload Lomond substation.
- Bighorn Extension (2 x 500 MVA 400/132 kV transformers) is planned to deload Bighorn substation.
- A single Watershed 250 MVA 275/132 kV transformer is planned for Watershed substation.
- Mookodi substation (2 x 250 MVA 400/132 kV transformers) is planned to deload Watershed.
- Watershed (Backbone) Strengthening Phase 3 – Mafikeng substation (Watershed B) (2 x 500 MVA 400/132 kV transformers) is planned to deload Watershed substation and support the load demand in Mafikeng.
- There will be a 132 kV load shift from Midas substation to Carmel substation to deload Midas 400/132 kV load. This project will be executed by Distribution.

6.5.5 Reactive power compensation

The following projects will address reactive concerns:

- Watershed substation 132 kV reactive power compensation (2 x 30 MVar shunt capacitor banks)
- Watershed substation 88 kV reactive power compensation (1 x 30 MVar shunt capacitor banks)
- Bighorn reactive power compensation (2 x 72 MVar 132 kV and 3 x 48 MVar 88 kV shunt capacitor banks)
- Marang reactive power compensation (5 x 48 MVar 88 kV shunt capacitor banks)
- Dinaledi reactive power compensation (3 x 72 MVar 88 kV shunt capacitor banks)

6.5.6 Underrated equipment

The underrated equipment at various substations will be addressed as part of the Waterberg Generation Integration Fault Level Management Plan. The project entails installing fault current limiting reactors at Marang substation, replacing underrated equipment 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 and Midas 132 kV.

6.5.7 Provincial summary

The increase in transmission assets by the end of 2020 and the end of 2025 and cumulative total are shown in Table 6.11.

Table 6.11: Cumulative TDP transmission assets for North West province

TRANSMISSION ASSETS FOR NORTH WEST PROVINCE	NEW ASSETS EXPECTED IN 2016 - 2020	NEW ASSETS EXPECTED IN 2021 - 2025	TOTAL NEW ASSETS
Power lines (km)			
765 kV	*0*	*0*	*0*
400 kV	*220*	*113*	*333*
275 kV	*0*	*0*	*0*
Total length (km)	*220*	*113*	*333*
Transformers			
Number of units	*6*	*3*	*9*
Total capacity (MVA)	*2750*	*1500*	*4250*
Capacitors			
Number of banks	*10*	*0*	*10*
Total capacity (MVar)	*840*	*0*	*840*
Reactors			
Number of banks	*0*	*0*	*0*
Total capacity (MVar)	*0*	*0*	*0*

The following projects are planned for the 2016 to 2025 period:

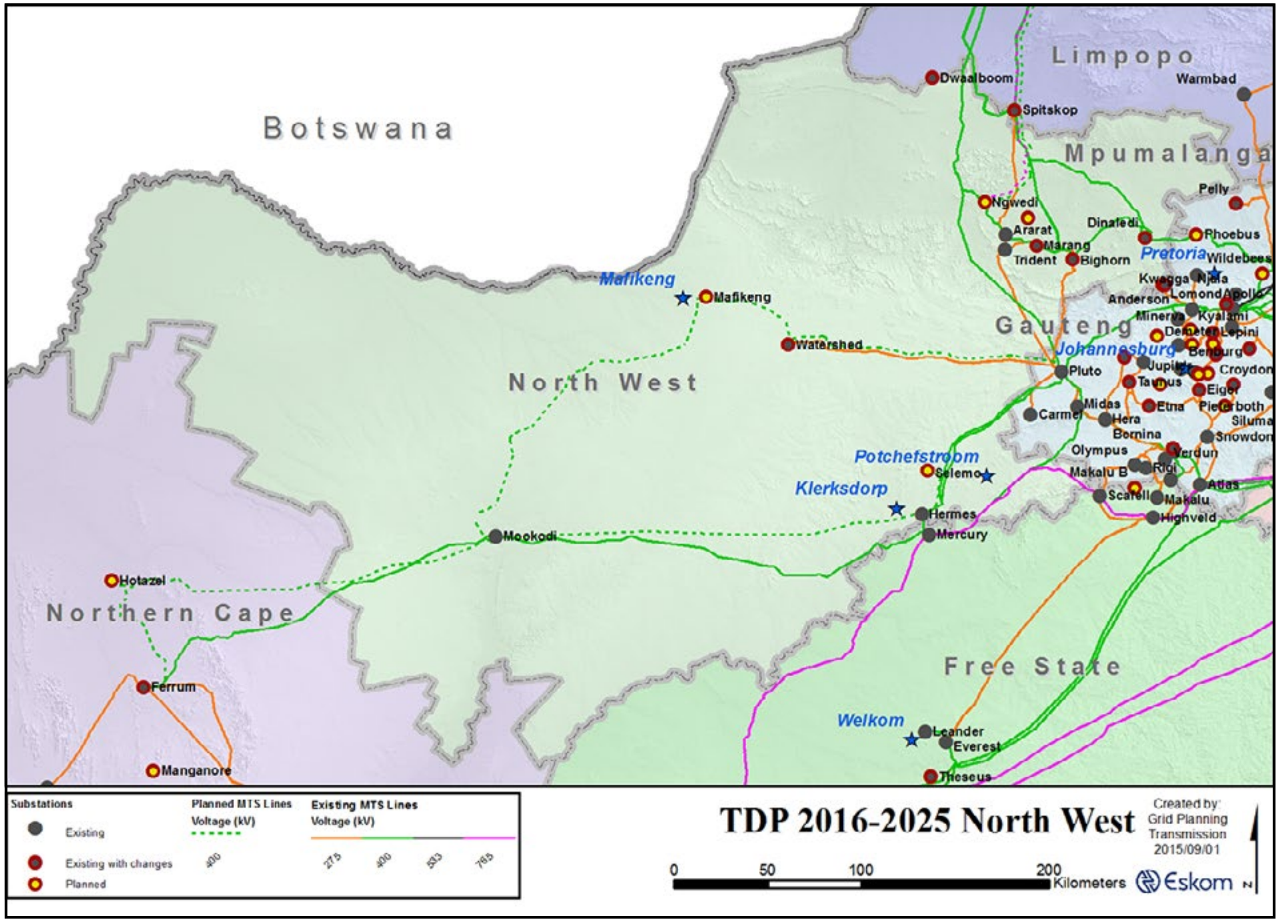
Table 6.12: North West province – summary of projects and timelines

SCHEME	PROJECT	EXPECTED YEAR
Watershed Strengthening	*Watershed substation 132 kV reactive power compensation (2 x 30 MVar capacitor banks)*	*2018*
	Watershed substation 88 kV reactive power compensation (1 x 30 MVar capacitor bank)	
	Watershed 275/132 kV substation 250 MVA 275/132 kV transformer	*2016*
Kimberley Strengthening Phase 2	*Mookodi (Vryburg)-Mercury 1st 400 kV line*	*Commissioned*
	Mookodi-Ferrum 400 kV line and establishment of Mookodi 2 x 250 MVA 400/132 kV substation	
	Multiple 132 kV lines for Mookodi integration (managed by Distribution Division)	*2016*
Watershed (Backbone) Strengthening Phase 3	*Pluto-Mafikeng 400 kV line*	*2022*
	Mookodi-Mafikeng 400 kV line	
	Mafikeng (Watershed B) 2 x 500 MVA 400/132 kV substation	
Kimberley Strengthening Phase 3	*Hermes-Mookodi (Vryburg) 1st 400 kV line*	*2020*
Rustenburg Strengthening Phase 1	*Bighorn 2 x 500 MVA 400/132 kV transformer*	*2022*
Rustenburg Strengthening Phase 2	*Marang Extension 2 x 500 MVA 400/132 kV transformers substation*	*2022*

Table 6.12: North West province – summary of projects and timelines

SCHEME	PROJECT	EXPECTED YEAR
Rustenburg Strengthening Phase 3	*Bighorn reactive compensation (2 x 72 MVar 132 kV and 3 x 48 MVar 88 kV shunt capacitor banks)*	*2024*
	Marang reactive power compensation (5 x 48 MVar 88 kV shunt capacitor banks)	
	Dinaledi reactive compensation (3 x 72 MVar 88 kV shunt capacitor banks)	
Medupi Integration Phase 2A: Mogwase	*Bighorn reactive compensation (2 x 72 MVar 132 kV and 3 x 48 MVar 88 kV shunt capacitor banks)*	*2024*
	Marang reactive power compensation (5 x 48 MVar 88 kV shunt capacitor banks)	
	Dinaledi reactive compensation (3 x 72 MVar 88 kV shunt capacitor banks)	
Medupi Integration Phase 2A: Mogwase	*Ngwedi 2 x 500 MVA 400/132 kV substation*	*2016 to 2019*
	Ngwedi 400 kV loop-in (Matimba-Midas and Mara-Midas 400 kV lines)	
	Medupi-Ngwedi 1st 400 kV line	
	Medupi-Ngwedi 1st 765 kV line (energised at 400 kV)	
Dinaledi Phase 1	*Dinaledi 3rd 500 MVA 400/132 kV 275 kV transformer*	*2017*
Ngwedi 3rd Transformer	*Ngwedi 3rd 500 MVA 400/132 kV transformer*	*2022*

Figure 6.16: Future North West province network diagram



6.6 Free State province

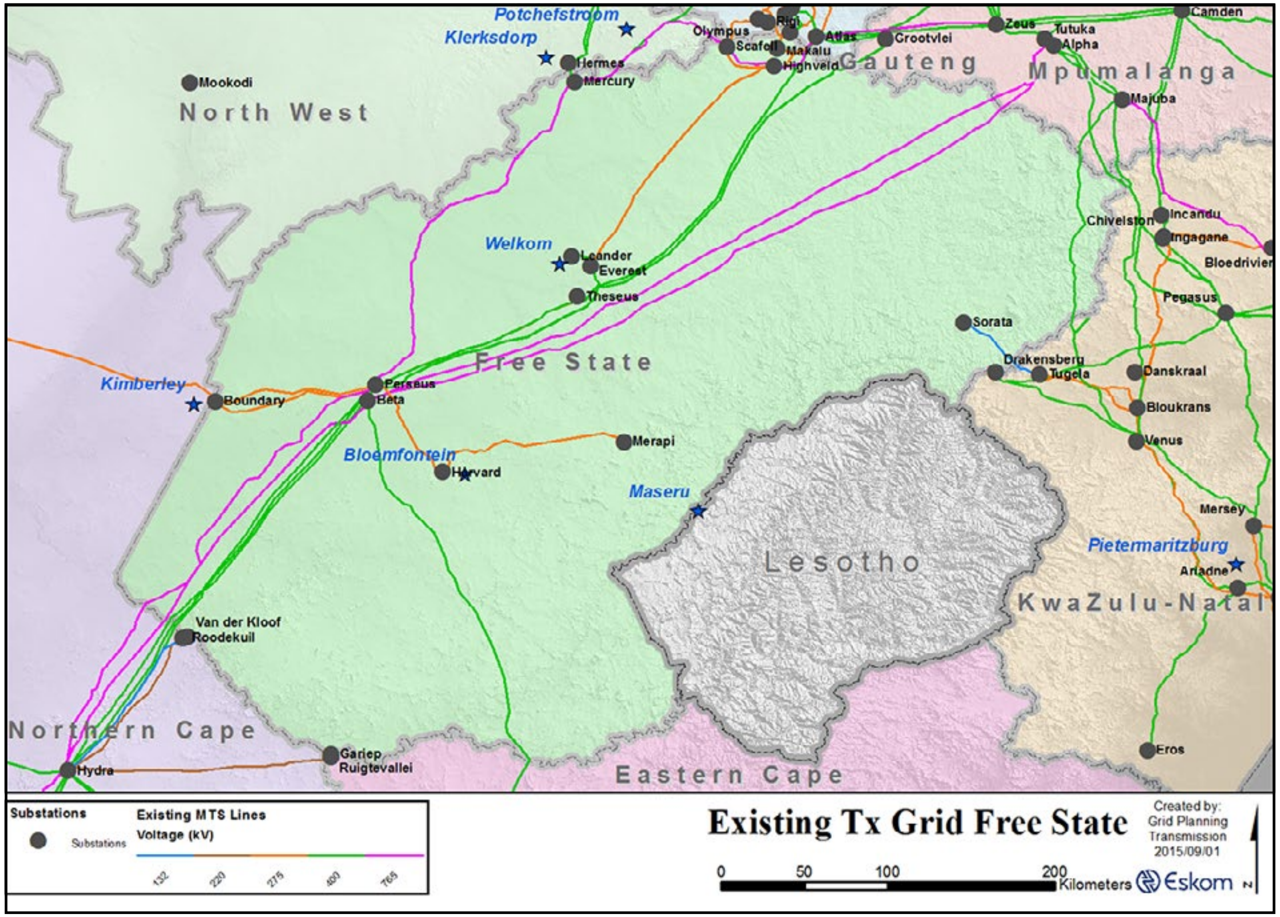
The Free State is South Africa's most centrally located province. For many decades, mining and agriculture were the bedrock of the economy in the province. It has borders with most other provinces and has Lesotho as its eastern neighbour. Important road and rail links traverse the province, including two of the busiest national highways, the N1 (Cape Town-Johannesburg) and the N3 (Durban-Johannesburg). There are plans to leverage this advantage through the creation of development corridors and the promotion of manufacturing, warehousing and storage opportunities. The Harrismith Logistics Hub (HLH) on the N3 is at the centre of these plans.

The Free State plans also include various projects for much-needed public infrastructure delivery, including household electrification, housing, schools, health facilities and water. These programmes will not only improve services, but will also benefit local suppliers and boost the construction sector enormously. There is also an interest by IPPs to establish PV plants in the province.

The power supply into the province is predominantly from Mpumalanga Power Pool and Lethabo Power Station (Vaal Triangle) via 400 kV and 275 kV lines. As the demand for electricity in the province increases, the existing transmission infrastructure is becoming heavily loaded and will eventually reach its full capacity. In order to cater for the anticipated growth over the next 10 years, a number of transmission network reinforcements have to be implemented.

The current transmission network is shown in Figure 6.17.

Figure 6.17: Current Free State province network diagram



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.

6.6.1 Major schemes

Bloemfontein Strengthening Phase 1B

The project involves establishing a 275 kV line from Everest substation to Merapi substation, built at 400 kV specification and operated at 275 kV.

Bloemfontein Strengthening Phase 2

The project involves acquiring servitudes for future 400 kV lines, that is, Beta-Harvard and Harvard-Merapi lines with the introduction of 400 kV at Harvard and Merapi substations.

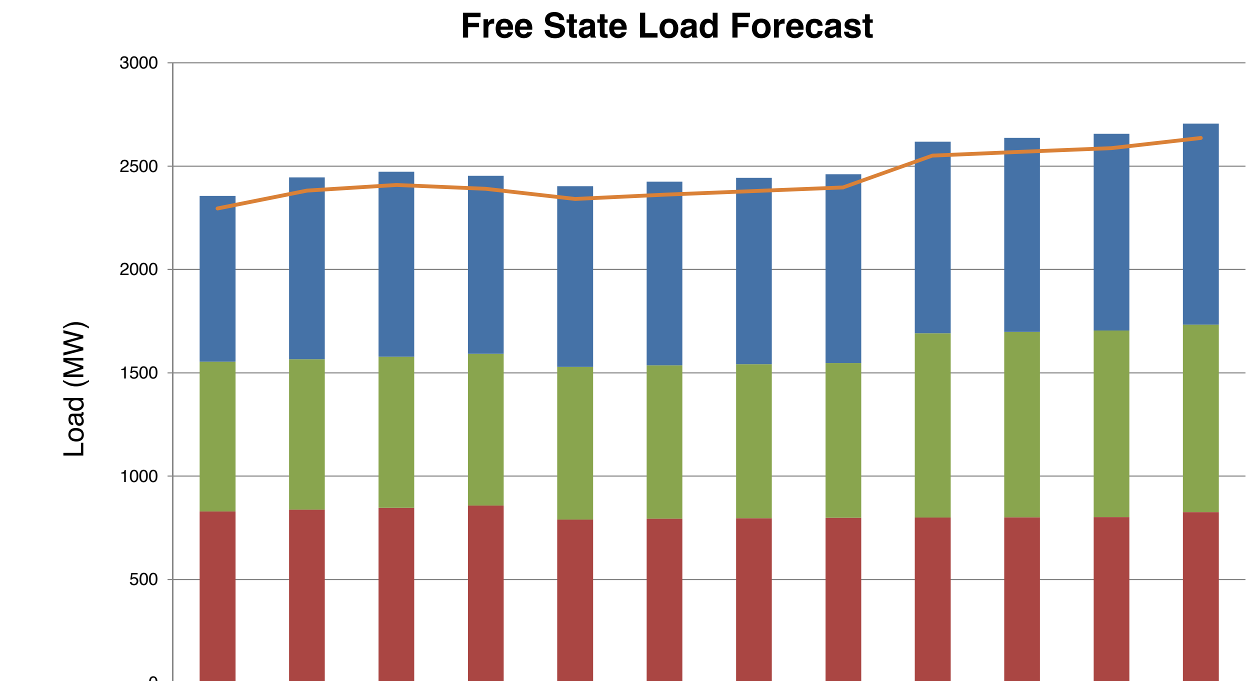
Harrismith Strengthening Phase 1

This project addresses imminent network capacity problems in the Harrismith region, which includes Tugela substation in KZN and Sorata 132 kV switching station in the Free State province. Sorata 132 kV switching station will be extended to a 275/132 kV substation in order to address the loading at Tugela substation. Sorata substation will be supplied by the existing Tugela-Sorata 275 kV line, which is currently operated at 132 kV.

Makalu Substation Strengthening

This project involves establishing Makalu B 275/88 kV substation and looping into one of the Lethabo-Makalu 275 kV lines to form Lethabo-Makalu B and Makalu-Makalu B 275 kV lines. Makalu B substation will deload Makalu substation and it will also assist in reducing network fault levels around Makalu substation.

Figure 6.18: Free State province load forecast



	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Bloemfontein	803	880	894	861	874	888	901	914	926	939	952	973
Welkom	724	727	731	735	739	742	745	749	892	897	902	906
Sasolburg	830	838	847	858	790	795	797	799	800	801	802	827
TOSP	2296	2382	2409	2390	2341	2362	2380	2397	2551	2569	2588	2636

6.6.2 Generation capacity

The power supply into the province is predominantly from the Mpumalanga Power Pool and Lethabo Power Station (Vaal Triangle) via 400 kV and 275 kV lines. There is also an interest by IPPs to establish PV plants in the province.

6.6.3 Substation firm capacity

- A transformation upgrade was completed at Merapi substation. It entailed replacing the two 275/132 kV 180 MVA transformers at Merapi substation with two 250 MVA 275/132 kV transformers. The first transformer was replaced in 2014 and the second transformer in 2015.
- Transformation constraints at Boundary substation will be partially resolved by the Mookodi Substation Integration in the North-West province. Boundary substation will be converted to 2 x 500 MVA 400/132 kV as part of Kimberley Strengthening Phase 4B as detailed in the Northern Cape province.

Bloemfontein Strengthening Phase 1B and 2 and Kimberley Strengthening Phase 4B, as well as the strengthening of the transmission networks connected to the other 275 kV supplies into the Vaal Triangle, will deload the Perseus 400/275 kV transformers.

6.6.4 Underrated equipment

- Underrated switchgear at Makalu substation will be resolved by the establishment of Makalu B substation and the refurbishment of Makalu substation. The establishment of Makalu B substation entails moving some of the generating plant and motor loads currently connected to Makalu substation onto Makalu B substation.
- The future 400 kV fault levels at Perseus substation will exceed the minimum 400 kV equipment rating due to the Kusile-Lulamisa-Pluto and Ngwedi-Midas-Hera 400 kV strengthening projects. This will be addressed as part of the Waterberg Generation Integration Fault Level Management Plan.
- The 132 kV fault level exceedance at Harvard substation is due to the integration of 400 kV at Harvard substation and the underrated equipment will be upgraded as part of Bloemfontein Strengthening Phase 2.

6.6.5 Provincial summary

The increase in transmission assets by the end of 2020 and the end of 2025 and cumulative total are shown in Table 6.13.

Table 6.13: Cumulative TDP transmission assets for Free State province

TRANSMISSION ASSETS FOR FREE STATE PROVINCE	NEW ASSETS EXPECTED IN 2016-2020	NEW ASSETS EXPECTED IN 2021 - 2025	TOTAL NEW ASSETS
Power lines (km)			
765 kV	*0*	*0*	*0*
400 kV	*110*	*180*	*290*
275 kV	*0*	*14*	*14*
Total length (km)	*110*	*194*	*304*
Transformers			
Number of units	*0*	*4*	*4*
Total capacity (MVA)	*0*	*1380*	*1380*
Capacitors			
Number of banks	*0*	*0*	*0*
Total capacity (MVar)		*0*	*0*
Reactors			
Number of banks	*1*	*0*	*1*
Total capacity (MVar)	*100*	*0*	*100*

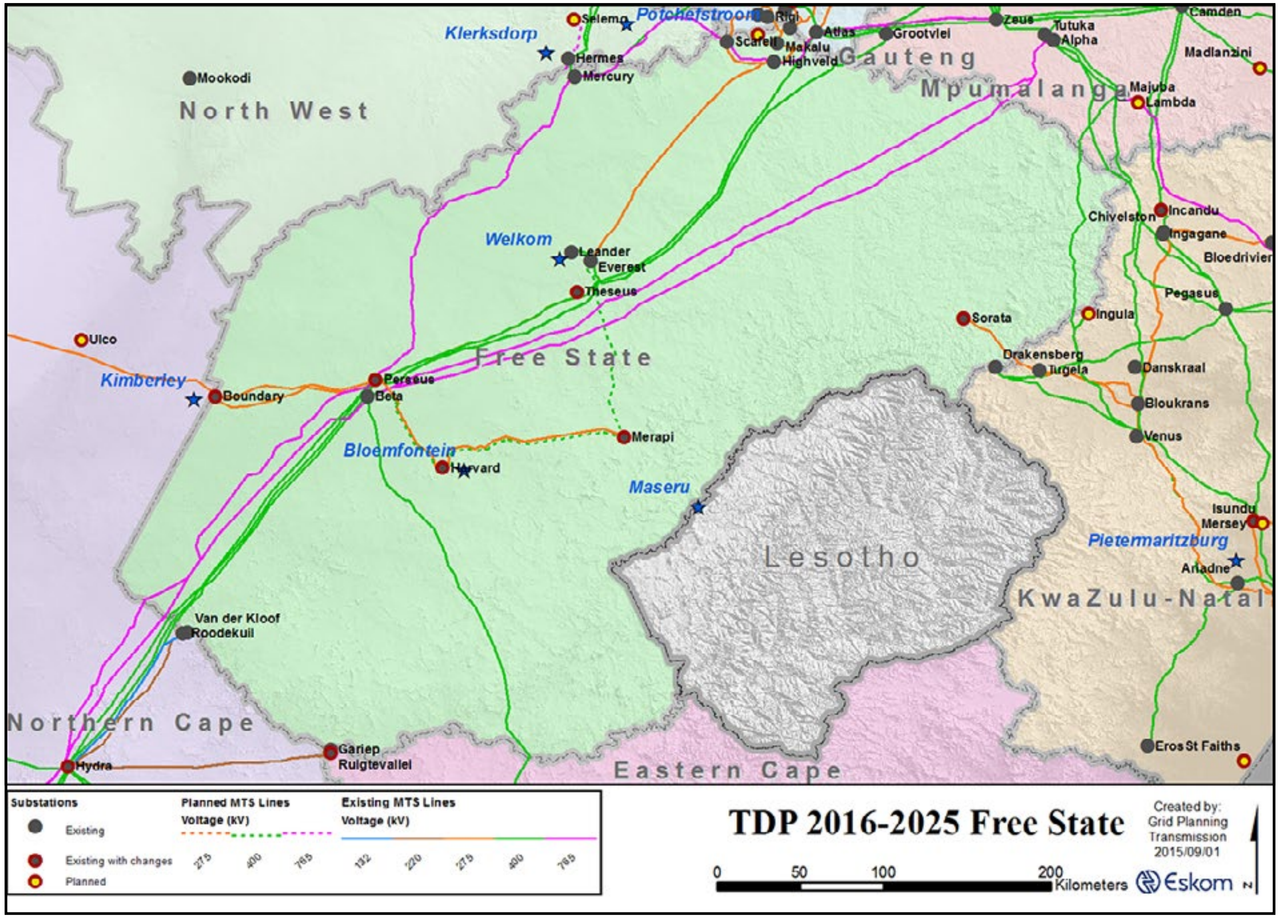
The following projects are planned for the 2016 to 2025 period:

Table 6.14: Free State province - summary of projects and timelines

SCHEME NAME	PROJECT NAME	EXPECTED YEAR
Bloemfontein Strengthening Phase 1A	*Merapi 2nd 275/132 kV 250 MVA transformer*	*2015*
Bloemfontein Strengthening Phase 1B	*Everest-Merapi 400 kV line (operated at 275 kV)*	*2018*
Bloemfontein Strengthening Phase 2	*2 x Beta-Harvard 400 kV lines*	*2023*
	1 x 500 MVA 400/132 kV Harvard substation	
	Harvard-Merapi 400 kV line	*2026*
	1 x 500 MVA 400/132 kV Merapi substation	
Harrismith Strengthening Phase 1	*Sorata 1st 275/132 kV 250 MVA transformer, operating Tugela-Sorata at 275 kV*	*2021*
	Sorata 400 kV busbar (operated at 275 kV)	
Makalu Strengthening	*Establish 2 x 315 MVA 275/88 kV Makalu B substation*	*2022*
	Loop-in one of Lethabo-Makalu 275 kV lines into Makalu B substation	
	Refurbishment of existing Makalu substation	

The following projects are planned for the 2016 to 2025 period:

Figure 6.19: Future Free State province network diagram



6.7 Northern Cape province

The Northern Cape is one of the largest provinces by landmass in South Africa. 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. There has been a lot of interest in increasing mining operations in the Kimberley area. Unfortunately, the province is supplied by radial lines and it has traditionally been a weak network.

Kimberley is supplied by means of the 275 kV network at Ferrum and Namaqualand by a radial 220 kV network supported by the newly commissioned 400 kV line from the North West province. The introduction of Nieuwehoop substation will link the Aries and Ferrum networks in order to strengthen the transmission system in the province. Other major transmission development plans in the province consist of the following projects:

- Upington Strengthening
- Aries SVC
- Juno-Gromis 400 kV line
- Gromis-Oranjemund 2nd 220 kV line constructed at 400 kV
- 2nd Aggeneis-Paulputs 220 kV line built at 400 kV
- Kimberley Phases 3 and 4
- Aries-Nieuwehoop and Nieuwehoop-Ferrum

Vanderkloof and Gariep Power Stations are hydro schemes straddling the provincial boundaries of the Free State within the Karoo CLN. Vanderkloof has a generating capacity of 240 MW, with two units rated at 120 MW each.

Gariep has a generating capacity of 360 MW, with four units rated at 90 MW each, evacuating its power directly onto Hydra 220 kV busbar via 2 x 220 kV lines. Gariep is located on the border of the Eastern Cape, Free State and Northern Cape and falls within the Eastern Cape border.

The current transmission network is shown in Figure 6.23.

The load forecast for the Northern Cape is shown in Figure 6 24. 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 primarily 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 is the future planned electricity export to Namibia via the 400 kV and 220 kV interconnections.

Figure 6.20: Current Northern Cape province network diagram

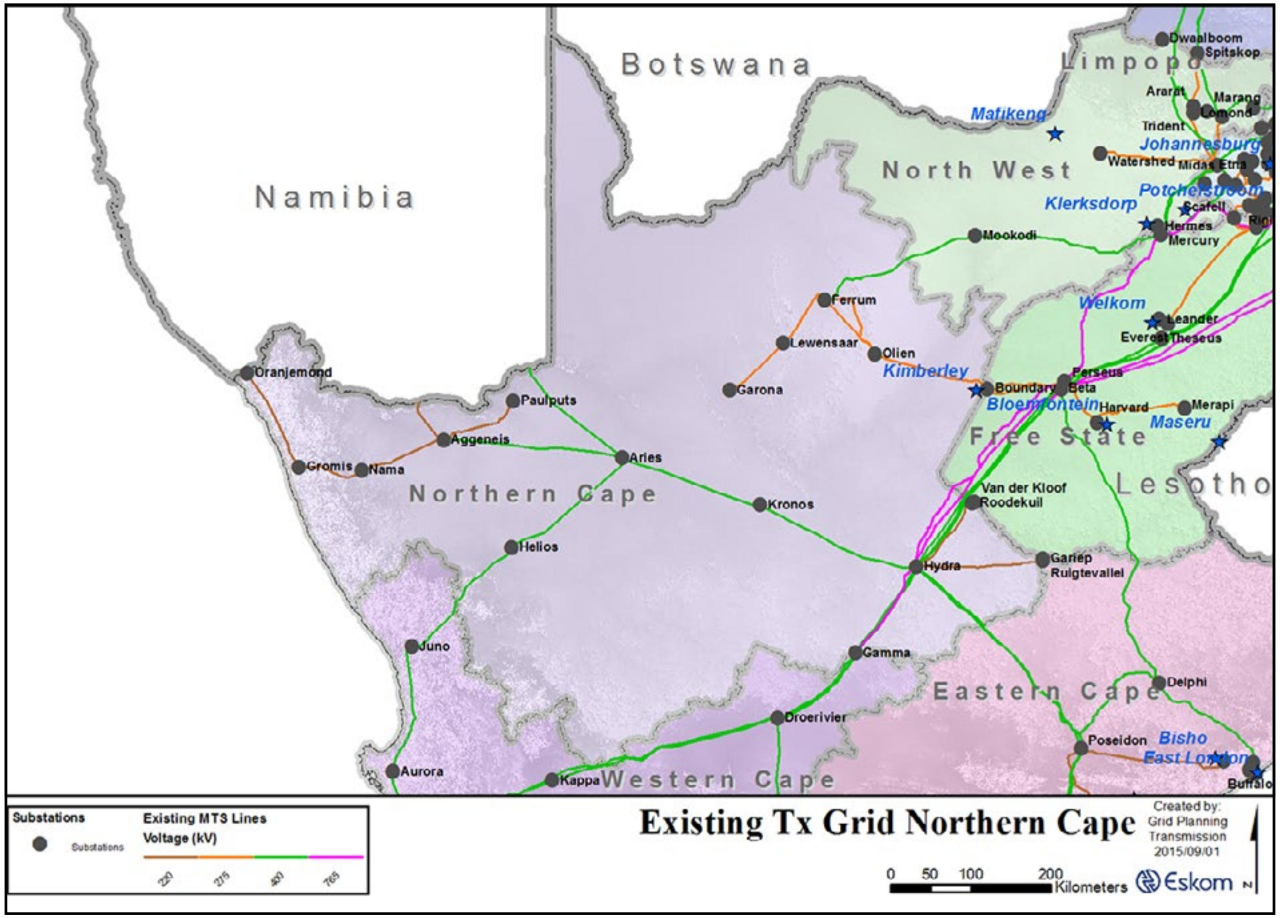
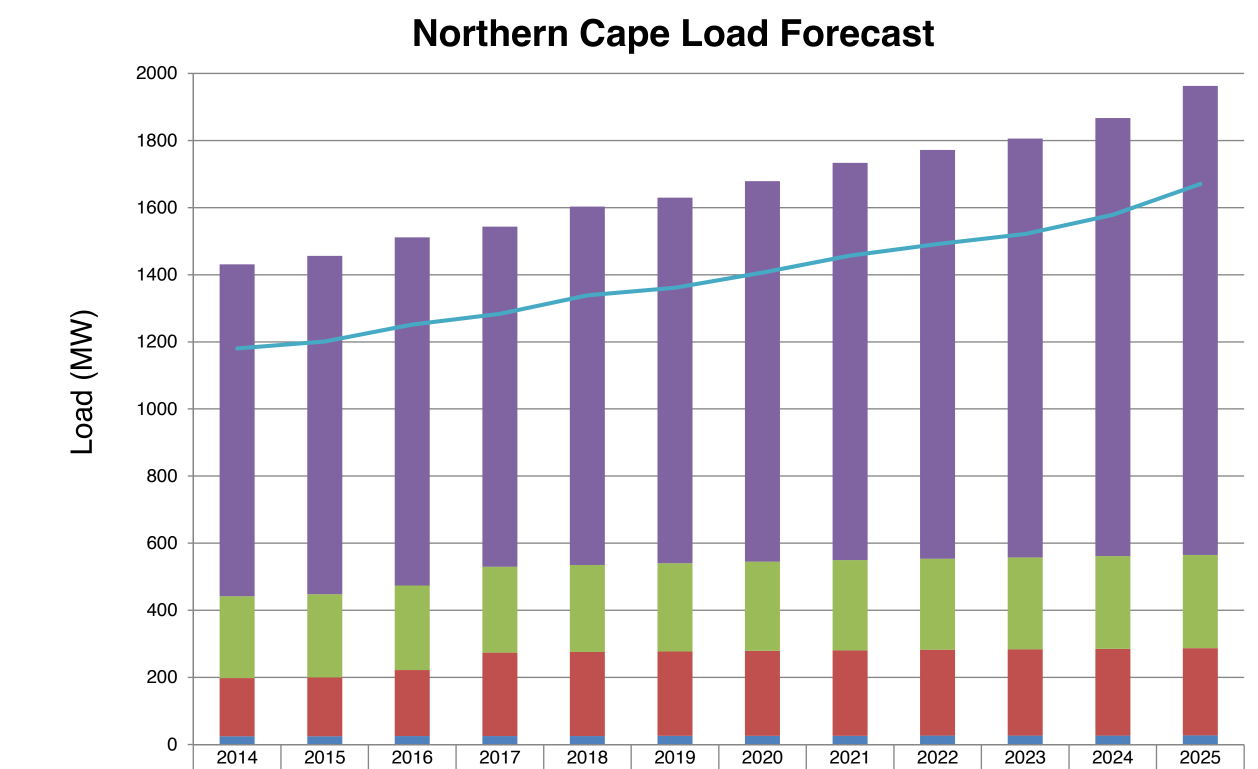


Figure 6.21: Northern Cape province load forecast



	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Kimberley	989	1008	1038	1014	1068	1090	1134	1185	1219	1248	1306	1398
Karoo	244	248	252	256	259	263	266	269	272	274	276	278
Namaqualand	174	175	197	249	250	252	253	255	256	257	259	260
West Coast	24	24	25	25	25	25	26	26	26	26	26	27
TOSP	1181	1201	1252	1284	1339	1361	1406	1457	1492	1522	1579	1671

6.7.1 Major schemes

Namaqualand Redundancy Evaluation Project

The Namaqualand Redundancy Evaluation Project introduces redundancy into the Namaqualand CLN. The project entails building the Juno-Gromis 400 kV line, line-banked at Gromis substation to 220 kV and Gromis-Oranjemund 220 kV line (constructed at 400 kV).

Northern Cape Reinforcement – Aggeneis-Paulputs 2nd 220 kV and Paulputs Transformation Framework

This project introduces the second Aggeneis-Paulputs 220 kV line built at 400 kV to meet the N-1 security standard for Paulputs area. It also provides a framework for future IPP connections at Paulputs

Upington Substation Integration

The integration includes the construction of two Upington-Aries 400 kV lines and Upington-Nieuwehoop and Upington-Ferrum 400 kV lines.

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.

Kronos Transformation

Kronos is currently a series capacitor station but the yard will be extended to include a 250 MVA 400/132kV transformer. Additional transformation that is required will be customer driven.

Paulputs Transformation

This project introduces a 220 kV busbar and a 250 MVA 220/132 kV transformer. This is required to accommodate IPP connections at Paulputs from round 4 and beyond.

Kudu Gas Power Station Integration

This project entails the integration of the 885 MW Kudu gas power station. It integrates into the Eskom network at Oranjemond substation. It introduces 400/220 kV transformation at Oranjemond and the construction of Oranjemond - Aggeneis 400 kV line. This project is dependent on the Juno - Gromis and Gromis - Oranjemond 400 kV line projects.

6.7.2 Renewable generation

The Northern Cape has a high potential for renewables energy due to its climate and proximity to the coastal line. Table 6.15 shows all the approved projects under REIPPPP 1 to 4 in the Northern Cape.

Table 6.15: Approved projects in the Northern Cape under the REIPPPP

REIPPPP ROUND	REIPPPP ROUND	CAPACITY (MW)
1	*CSP*	*150*
	Wind	*72*
	PV	*461*
	REIPPPP 1 capacity	*683*
2	*CSP*	*50*
	Wind	*3*
	PV	*269*
	REIPPPP 2 capacity	*322*
3	*CSP*	*400*
	Wind	*590*
	PV	*225*
	REIPPPP 3 capacity	*1 215*
4	*Wind*	*794*
	PV	*545*
	REIPPPP 4 capacity	*1 339*
Northern Cape total generation capacity		*3 559*

6.7.3 Substation firm capacity

The following projects will address the unfirm substations:

- Kronos transformation 400/132 kV under Garona Strengthening will address the Garona unfirmness.
- Helios 1 x 20 MVA 132/66 kV transformation will address the firmness of the 66 kV supply.
- Gariep Strengthening will address the overloading of the Hydra 400/220 kV transformer and poor performance of the existing Ruigtevallei-Hydra 220 kV line built at 132 kV.
- A 3rd 400/132 kV transformer rated at 500 MVA is to be installed at Hydra to accommodate the REIPPPP 3 successful bidders.
- A 2nd and 3rd 220/132 kV 250 MVA transformer is planned to accommodate future successful REIPPPs at Paulputs substation.

Table 6.16: Cumulative TDP transmission assets for Northern Cape province

TRANSMISSION ASSETS FOR FREE STATE PROVINCE	NEW ASSETS EXPECTED IN 2016-2020	NEW ASSETS EXPECTED IN 2021 - 2025	TOTAL NEW ASSETS
Power lines (km)			
765 kV	*0*	*0*	*0*
400 kV	*795*	*1260*	*2055*
275 kV	*0*	*94*	*94*
Total length (km)	*795*	*1354*	*2149*
Transformers			
Number of units	*16*	*27*	*43*
Total capacity (MVA)	*4770*	*9500*	*14270*
Capacitors			
Number of banks	*0*	*1*	*1*
Total capacity (MVar)	*0*	*36*	*36*
Reactors			
Number of banks	*0*	*5*	*5*
Total capacity (MVar)	*0*	*300*	*300*

6.7.4 Underrated equipment

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

- Aggeneis 66 kV will have underrated equipment due to the introduction of the 2nd Aggeneis-Paulputs 220 kV line. This will be addressed by the Aggeneis-Paulputs 2nd 220 kV built at 400 kV project
- At Ferrum substation, equipment will be underrated due to Kimberley Phase 3 strengthening. The Kimberley Phase 3 project will address this.
- The introduction of the Hydra 400/132 kV 500MVA transformer and IPP integration, equipment on the 400 kV and 132 kV will be underrated. The Hydra 400 kV and 132 kV equipment upgrade will address this.
- With the proposed Kimberley Phase 4, Olien, Manganore and Ulco substations will experience underrating of equipment. The Kimberley Strengthening Phase 4 project will address this.

- At Upington substation due to IPP integration will experience equipment underrating. The Upington substation is designed from the onset with a split busbar to mitigate for the anticipated high fault levels with great IPP penetration at that substation.

6.7.5 Provincial summary

The increase in transmission assets by the end of 2020 and the end of 2025 and cumulative total are shown in Table 6.16.

The following projects are planned for the 2016 to 2025 period:

Table 6.17: 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 feeder bays	
Upington Strengthening Phase 1A	*Nieuwehoop-Upington 1st 400 kV line*	*2018*
	Upington 1st 500 MVA 400/132 kV transformer	
	Upington 2nd 500 MVA 400/132 kV transformer	*2021*
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 transformer	
Kimberley Strengthening Phase 2	*Ferrum Ext. 1st and 2nd 500 MVA 400/132 kV transformers*	*2015*
	Ferrum-Mookodi 1st 400 kV line	
	Mookodi-Mercury 1st 400 kV line	

Table 6.17: Northern Cape province – summary of projects and timelines

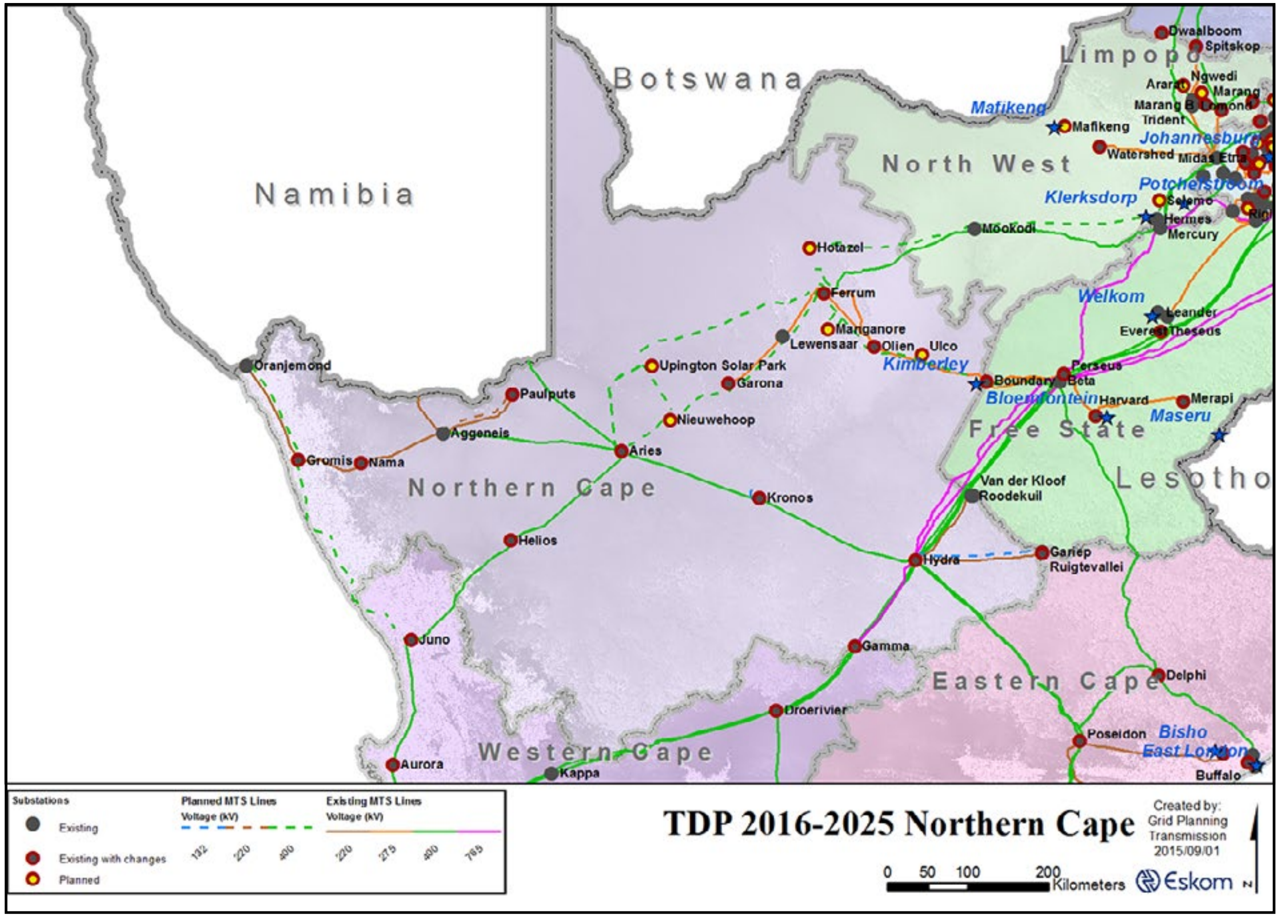
SCHEME NAME	PROJECT NAME	EXPECTED YEAR
Kimberley Strengthening Phase 3	*Hermes-Mookodi 1st 400 kV line*	*2019*
	Mookodi-Umtu 1st 400 kV line	
	Umtu 400/132 kV substation (1st and 2nd 500 MVA 400/132 kV transformers)	
	Umtu-Ferrum 400 kV 1st 400 kV line	
	Hotazel Ext. 132 kV 1st 36 MVar capacitor	*2020*
Kimberley Strengthening Phase 4A	*Ulco substation 1st and 2nd 500 MVA 400/132 kV transformers*	*2023*
	Beta-Ulco 1st 400 kV double-circuit line	
	Manganore substation 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 substation*	*2024*
Kimberley Strengthening Phase 4C	*Olien Strengthening: loop-in Ulco-Manganore 400 kV line into Olien substation*	*2024*
Garona Strengthening Phase 2	*Garona substation 1st 500 MVA 400/132 kV transformer*	*2025*
Gariep Network Strengthening	*Ruigtevallei-Hydra de-rating of 220 kV line to 132 kV*	*2016*
	Ruigtevallei 132 kV feeder bay to Dreunberg	
Ruigtevallei Transformation Upgrade	*Ruigtevallei 132/66 kV transformation upgrade*	*2019/20*
Roodekuil-Hydra Strengthening	*Re-template and modify the existing inter-tripping scheme to switch only one generator off when the Hydra – Roodekuil 220 kV line is tripped*	*2020*
Hydra Wind Phase 2	*Hydra 3rd 500 MVA 400/132 kV transformer*	*2018*

Table 6.17: Northern Cape province – summary of projects and timelines

SCHEME NAME	PROJECT NAME	EXPECTED YEAR
Hydra 400 and 132 kV Equipment Upgrade	*Hydra 400 kV and 132 kV equipment upgrade (fault level requirements)*	*2018*
Hydra B	*New Hydra B 500MVA 400/132 kV substation*	*2021*
Kronos Transformation	*Kronos 2nd 500 MVA 400/132 kV transformer*	*2019*
Northern Cape Transformation	*Helios 1 x 20 MVA 132/66 kV transformer*	*2019*
Northern Cape Reinforcement	*Aries 400 MVar SVC (Capacitive 250MVAr and Inductive 150MVAr)*	*2018*
Namaqualand Strengthening	*Juno-Gromis 400 kV line*	*2020*
	2nd Gromis-Oranjemund 220 kV line	
Northern Cape Reinforcement: Ferrum-Nieuwehoop-Aries 400 kV	*Aries-Nieuwehoop 400 kV line*	*2016*
	Ferrum-Nieuwehoop 400 kV line	*2018*
Paulputs Ext. 2nd 250 MVA 220/132 kV Transformer (Customer)	*Paulputs Ext. 2nd 250 MVA 220/132 kV transformer*	*2016*
Northern Cape Reinforcement: Aggeneis-Paulputs 2nd 220 kV	*Aggeneis-Paulputs 2nd 220 kV line*	*2021*
	Aggeneis 66 kV equipment upgrade (fault level requirements)	
Paulputs 3rd 220/132 kV 250 MVA transformer	*Paulputs 3rd 220/132 kV 250 MVA transformer*	*2021*
Nama substation Transformers Upgrade	*Nama 2 x 20 MVA 66/22 kV transformers*	*2016*
Northern Cape Voltage Unbalance	*Northern Cape line transposition*	*2020*

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

Figure 6.22: Future Northern Cape province network diagram



6.8 Eastern Cape province

The Eastern Cape province is home to two major motor manufacturing hubs in the Nelson Mandela Bay Metro in Port Elizabeth as well as Buffalo City Metro in East London. The provincial load peaked at 1 600 MW in 2014 and it is expected to surge to just above 2 500 MW in 10 years' time. There is huge potential for development in the Nelson Mandela Bay Metro in terms of load in the Port of Ngqura or Coega, as it is popularly known; hence, most of the load growth in this province is as a result of anticipated loads at Coega.

Overall, the load in the Port Elizabeth area is anticipated to increase from 1 000 MW to just over 1 600 MW in the next 10 years. The bulk of the 600 MW increase will be for industrial development. The Port Elizabeth area is supplied by means of three 400 kV transmission lines and a single 220 kV line, which also supports the manganese traction line.

The East London area has a mixture of rural and urban loads. Most of the rural electrification is anticipated in this area. The anticipated load growth in the East London area is just over 100 MW, which will increase the total load to 900 MW. The recently completed 400 kV line from KwaZulu-Natal to the East London area, as well as the new Vuyani substation in the Mthatha area, can unlock even more electrification in the area. The capacity of Vuyani substation has the potential of unlocking the electrification of more than 125 000 homes. The number of in-feeds into East London consists of two 400 kV lines and a 220 kV line.

The Eastern Cape province has experienced a huge interest in terms of renewable energy applications from the REIPPPP. The total number of approved projects so far amounts to just over 1 400 MW or close to 90% of the current load. All of these approved projects will be catered for without major upgrades. The interest in connecting renewable projects in this province is expected to continue due to excellent wind resources in the subsequent rounds of the programme. This will trigger major upgrades in the network to cater for this. Currently, the Renewable Energy Strategic Plan envisages that two new substations will be required to cater for this.

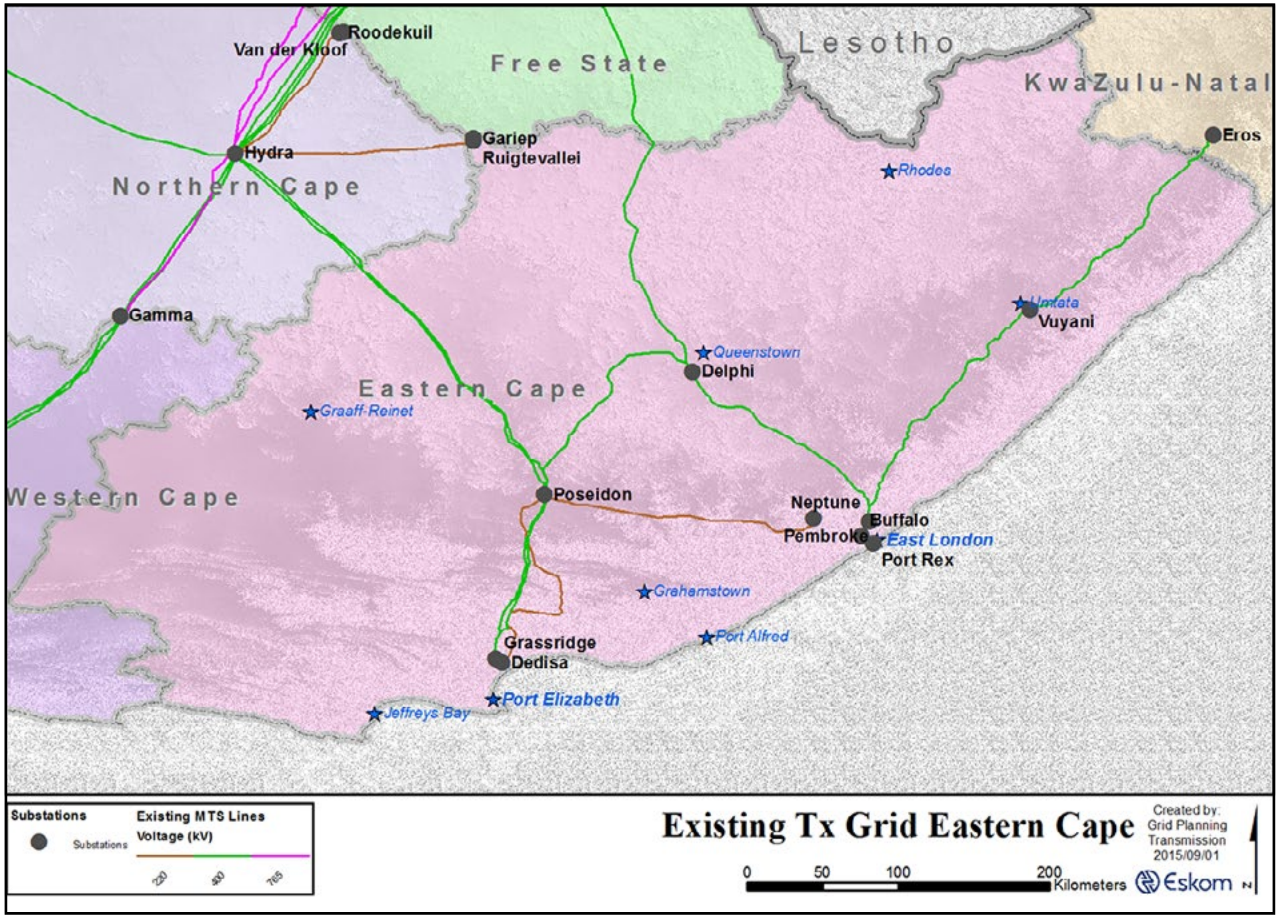
There has also been an increase in applications to connect gas generation plants close to the Port of Ngqura, amounting to about 2 500 MW. This is approximately the equivalent of the total anticipated loads of the entire province in 2025. Further generation connections that may materialise in the Eastern Cape include nuclear generation of about 4 800 MW. All the major generation projects mentioned will be integrated by means of huge infrastructure upgrades that are specifically linked to them.

The major anticipated developments in the Eastern Cape are as follows:

- Gamma-Grassridge 765 kV injection in the Port Elizabeth area
- Neptune-Pembroke 400 kV line to improve reliability in the East London area
- Pembroke 400 kV injection to improve the quality of supply in the East London area
- Poseidon-Pembroke 400 kV line to improve reliability of supply as the load increases in the East London area
- Installation of 100 MVar capacitor banks in selected substations
- Thyspunt Integration Project, depending on whether the nuclear project is approved
- Gas Plant Integration Project, depending on whether customers decide to go ahead
- Strategic IPP projects to establish two new substations, depending on IPP appetite

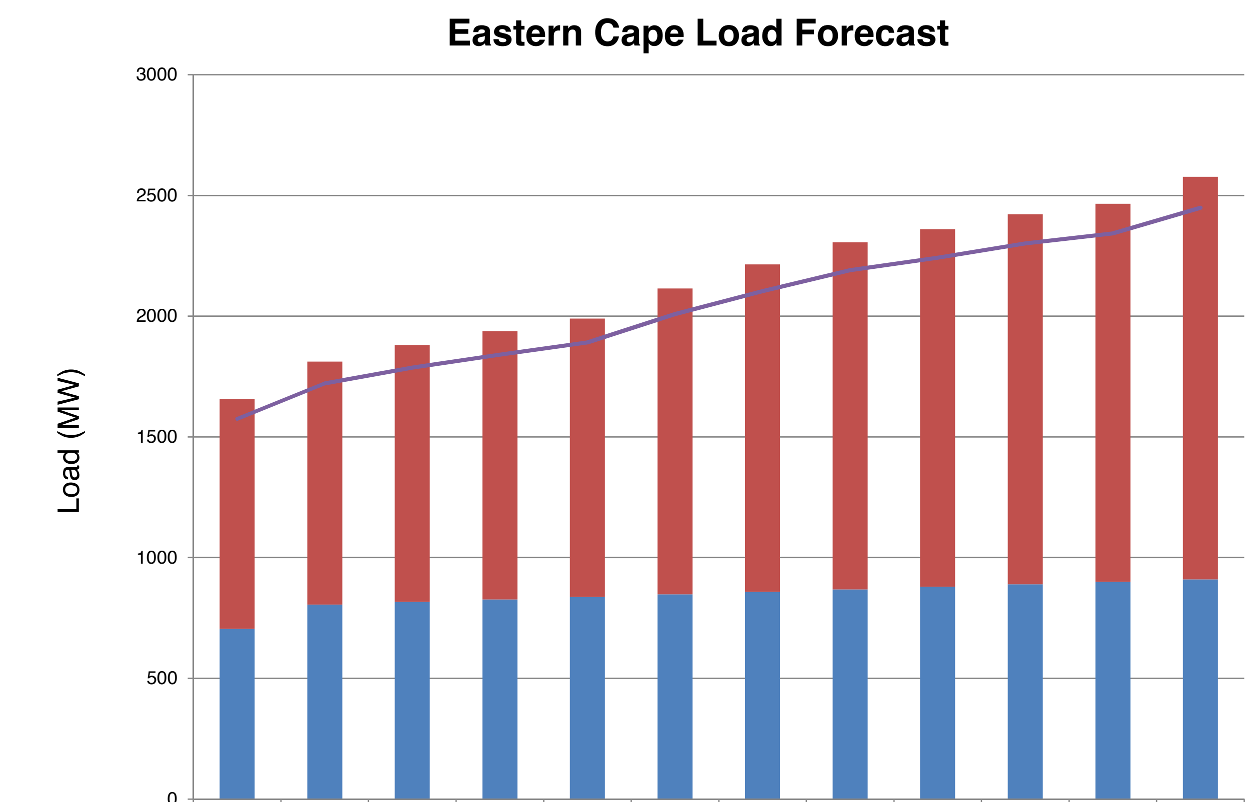
Over and above these projects, there are other local projects to augment transformation at Delphi, Pembroke, Poseidon, Grassridge and Dedisa, starting from 2019. This is to ensure that the substations still meet the requisite reliability criteria, where a single transformer can be lost without affecting supply to customers. The current transmission network is shown in Figure 6.23.

Figure 6.23: Current Eastern Cape province network diagram



The load forecast for the Eastern Cape Province is shown in Figure 6.24. 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.

Figure 6.24: Eastern Cape province load forecast



	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Port Elizabeth	952	1006	1064	1110	1153	1267	1357	1437	1481	1533	1566	1668
East London	705	806	817	827	837	848	858	869	879	889	900	910
TOSP	1574	1721	1787	1840	1891	2009	2104	2190	2242	2301	2342	2449

6.8.1 Major schemes

Greater East London Strengthening Phases 3 and 4

The re-phasing of the Greater East London Phase 3 scheme into the Greater East London Phase 3 and 4 schemes splits the Poseidon-Neptune 400 kV line project into two phases. The Greater East London Phase 3 scheme entails building a 50 km 400 kV line from Neptune to Pembroke and the introduction of 400 kV into Pembroke.

The 1st 400/132 kV 500 MVA transformer, as well as the 1st 132/66 kV 120 MVA transformer, will be introduced at Pembroke to run in parallel with the existing transformers. In the Greater East London Phase 4 scheme, the 400 kV link between Pembroke and Poseidon will be completed and the second set of transformers will be introduced at 400/132 kV and 132/66 kV voltages. At this stage, the 220 kV infrastructure and the old transformers will be decommissioned.

Southern Grid Strengthening Phase 3

The Gamma-Grassridge 1st 765 kV line is needed to address the growing load and associated voltage constraints in the Port Elizabeth (PE) CLN. Due to the huge amount of generation in the Eastern Cape, a second 765 kV line will be required if Thyspunt and further gas generation at Coega materialise.

PE Strengthening Phase 3

The PE Strengthening Phase 3 scheme entails the installation of 100 MVar shunt capacitor banks at Grassridge, Dedisa, Delphi and Poseidon. The shunt capacitor banks will ensure that voltage limits are not violated as the load increases in the Eastern Cape. An assessment conducted indicated that the PE Strengthening Phase 4 scheme, which would have entailed the installation of a second set of capacitor banks at the same substations, will no longer be required.

IPP Integration

There has been a huge interest from wind IPPs in the Eastern Cape, resulting in congestion around Poseidon and Grassridge substations. 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 IPP projects in this province amount to just over 1 400 MW up to Round 4 of the REIPPPP. To accommodate future rounds of the REIPPPP, strategic studies are currently under way to investigate additional substations around Poseidon and Delphi.

Dedisa OCGT

A 373 MW OCGT power station will be commissioned at Dedisa substation in the current year. Construction of this plant has already been concluded and it is currently being tested before full commissioning.

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 project is called "Nuclear 1". The preferred location is Thyspunt and the TDP is based on this assumption. The following 400 kV lines of approximately 110 km each are required based on current assumptions:

- Thyspunt-Grassridge 400 kV line
- Thyspunt-Dedisa 400 kV lines 1 and 2
- Thyspunt-PE substation-Grassridge 400 kV line
- Thyspunt-PE substation-Dedisa 400 kV line

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.

6.8.2 Generation capacity

Historically, the Eastern Cape did not have huge generation capacity. The only sizeable generation in the province was Port Rex with a capacity of 3 x 57 MW which operates as peaking plant. The Gariep Hydropower Station is located on the border of the Northern Cape and Eastern Cape and most of the power is evacuated via the Northern Cape networks. The current power challenges mean that these generators operate as support for baseload plant, even outside the usual peak periods.

There is a possibility of a nuclear power station in the province with a total generation varying from 3 000 MW to about 4 500 MW and preliminary integration plans have already been done to accommodate this capacity.

Other generation plans in the pipeline include the possibility of approximately 2 500 MW of gas generation. If all these generation plans materialise, the Eastern Cape will be a net exporter of energy by a huge margin. A new high capacity interconnection with KwaZulu Natal will be required if all these generation projects materialise to evacuate the excess power, which may either be a 765 kV EHV link or more likely a 600 kV HVDC scheme between Port Elizabeth and the Durban area.

6.8.3 Renewable generation

There has been a proliferation of renewable energy IPPs in the Eastern Cape and most of them have been wind IPPs. The total capacity that has been approved in the Eastern Cape so far amounts to 1 432 MW, comprised of 150 MW in the East London CLN and 1 282 MW in the Port Elizabeth CLN. The composition is shown in Table 6.18.

Table 6.18: Approved projects in the Eastern Cape under the REIPPPP

REIPPPP ROUND	TECHNOLOGY	CAPACITY (MW)
1	*Wind*	*470*
	REIPPPP 1 capacity	*470*
2	*Wind*	*337*
	REIPPPP 2 capacity	*337*
3	*Wind*	*197*
	REIPPPP 3 capacity	*197*
4	*Wind*	*429*
	REIPPPP 4 capacity	*429*
Eastern Cape total generation capacity		*1 432*

6.8.4 Substation firm capacity

The following substations have been identified as presently unfirm:

Pembroke 220/66 kV

The firmness of the Pembroke substation 2 x 90 MVA transformers was resolved by the commissioning of Debenek distribution substation as well as Vuyani transmission substation in 2014; this reduced the load to 80 MVA.

Poseidon 220/132 kV

The Poseidon transformers (1 x 80 MVA + 1 x 40 MVA) had a temporary reprieve in 2012 and 2013 when the Zebra distribution substation was commissioned; however, this was short-lived. The substation became unfirm again in 2014 as load crept up. There is a proposal to replace the 40 MVA transformer with an 80 MVA transformer to resolve the unfirmness.

Delphi 400/132 kV

The load at Delphi 2 x 120 MVA has also decreased after the commissioning of Vuyani substation; however, the total load is still above firm capacity. This unfirmness is mitigated when there is a loss of one of the transformers because the higher impedance of the remaining transformer means that load is redirected through other networks. In 2015, the load has already peaked slightly above the firm capacity of 120 MVA. Studies done indicate that this will decrease when the distribution integration at Vuyani has been concluded. In the medium term, a third transformer is planned at Delphi to resolve the problem.

Transformer Normalisation Project

Buffalo and Pembroke substations have transformers with tertiary windings that feed into reticulation loads. Reticulation loads are prone to a high number of faults, which may jeopardise the longevity of the main transformers.

Furthermore, these tertiary transformers are now unfirm in both substations. The Buffalo 11/22 kV and Pembroke 66/11 kV are presently affected by this problem. In order to address the above constraints, the normalisation and upgrade of Buffalo 11/22 kV and Pembroke 66/11 kV unfirm transformers were proposed.

Table 6.19: Cumulative TDP transmission assets for Eastern Cape province

TRANSMISSION ASSETS FOR FREE STATE PROVINCE	NEW ASSETS EXPECTED IN 2016-2020	NEW ASSETS EXPECTED IN 2021 - 2025	TOTAL NEW ASSETS
Power lines (km)			
765 kV	*0*	*350*	*350*
400 kV	*191*	*531*	*722*
275 kV	*0*	*0*	*0*
Total length (km)	*191*	*881*	*1 072*
Transformers			
Number of units	*3*	*9*	*12*
Total capacity (MVA)	*1125*	*6320*	*7445*
Capacitors			
Number of banks	*0*	*4*	*4*
Total capacity (MVar)	*0*	*400*	*400*
Reactors			
Number of banks	*0*	*1*	*1*
Total capacity (MVar)	*0*	*400*	*400*

6.8.5 Reactive power compensation

The Port Elizabeth CLN is envisaged to grow substantially in the next 10 years; this will result in undervoltage problems at Grassridge and Dedisa under contingencies of the Poseidon-Grassridge/Dedisa 400 kV lines.

The PE Phase 3 Project, which entails the installation of capacitor banks at Grassridge, Dedisa, Poseidon and Delphi, will alleviate these problems for a limited period until the implementation of the Gamma-Grassridge 765 kV project.

6.8.6 Underrated equipment

The Southern Grid fault level mitigation report proposes ways of mitigating the rising fault levels in the province. The Grassridge busbar and equipment upgrade planned for 2016 will mitigate the problem.

Fault levels will rise further with the advent of large-scale generation integration. A mitigation plan will be developed when it is required.

6.8.7 Provincial summary

The increase in transmission assets by the end of 2020 and the end of 2025 and cumulative total are shown in Table 6.19.

The following projects are planned for the 2016 to 2025 period:

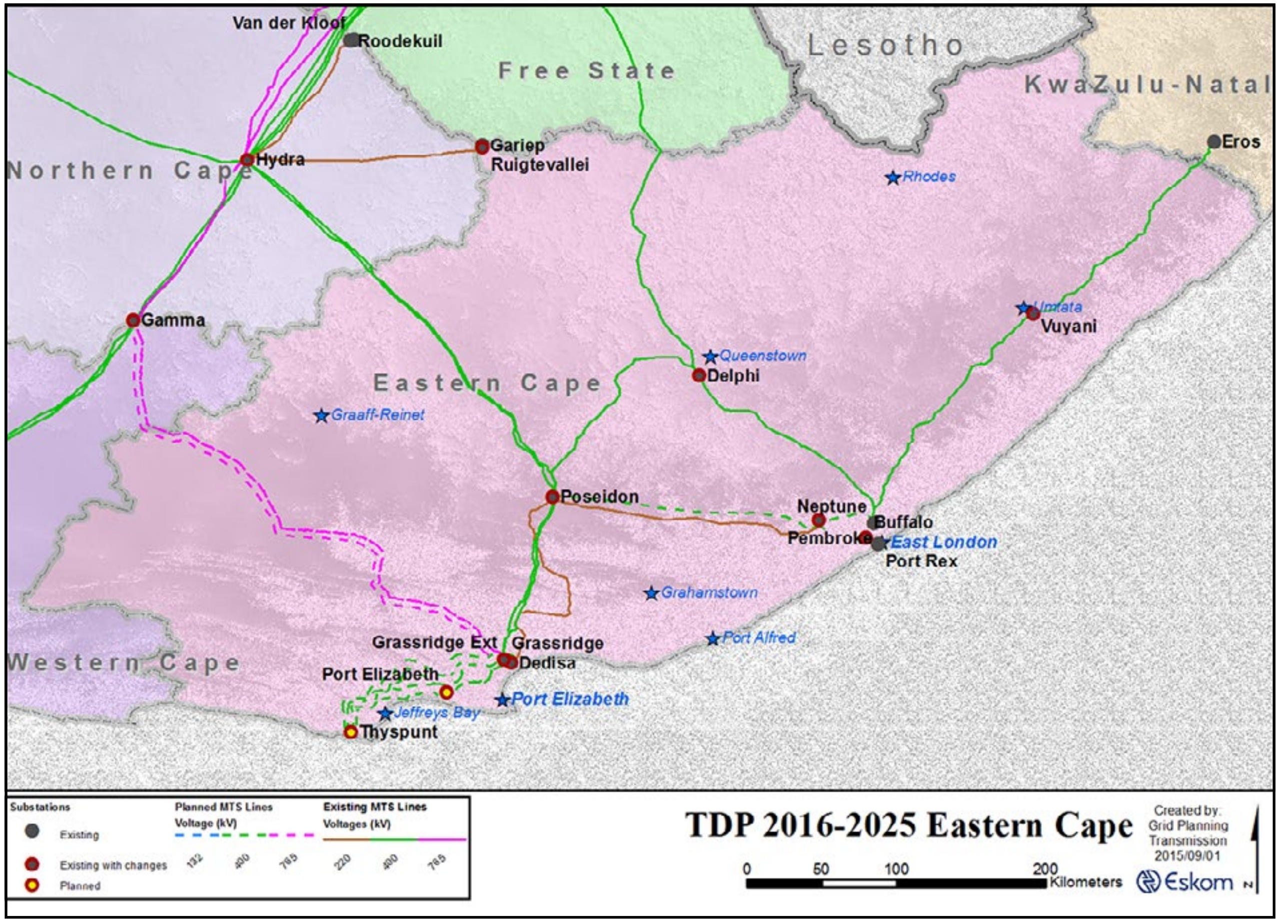
Table 6.20: Summary of Eastern Cape province projects and timelines

SCHEME NAME	PROJECT NAME	EXPECTED YEAR
Greater East London Phase 1 and 2	*Greater East London Phase 1 and 2: Vuyani 400/132 kV substation and Vuyani-Neptune 400 kV line*	*Commissioned*
Greater East London Phase 1 and 2	*Greater East London Phase 1 and 2: Eros-Vuyani 400 kV line*	*Commissioned*
Grassridge-Dedisa Future Network Strengthening	*Grassridge-Dedisa 1st 132 kV line*	*2016*
Buffalo and Pembroke Transformer Normalisation	*Buffalo and Pembroke transformer normalisation*	*2016*
PE Strengthening Phase 3	*PE Strengthening Phase 3: 1st shunt capacitor bank at Poseidon, Delphi, Grassridge and Dedisa*	*2016*
Grassridge Busbar and Equipment Upgrade (Fault Levels)	*Grassridge busbar and equipment upgrade (fault levels)*	*2016*
Poseidon 400/132 kV 500 MVA Transformer	*Poseidon 400/132 kV 500 MVA transformer*	*2016*
Greater East London Phase 3	*Greater EL Phase 3: Neptune-Pembroke 400 kV line*	*2019*
	Greater EL Phase 3: Pembroke 1st 400/132 kV 500 MVA transformer	
	Greater EL Phase 3: Pembroke 1st 132/66 kV 120 MVA transformer	
Grassridge-Dedisa Future Network Strengthening	*Grassridge 3rd 500 MVA 400/132 kV transformer*	*2019*
Delphi 3rd Transformer	*Delphi 3rd 120 MVA 400/132 kV transformer*	*2019*
Grassridge-Dedisa Future Network Strengthening	*Dedisa 3rd 500 MVA 400/132 kV transformer*	*2020*

Table 6.20: Summary of Eastern Cape province projects and timelines

SCHEME NAME	PROJECT NAME	EXPECTED YEAR
Greater East London Phase 4	*Greater EL Phase 4: Poseidon-Pembroke 400 kV line*	*2023*
	Greater EL Phase 4: Pembroke 2nd 400/132 kV 500 MVA transformer	
	Greater EL Phase 4: Pembroke 2nd 132/66 kV 120 MVA transformer	
Southern Grid Phase 3	*Southern Grid Phase 3: 1st Gamma-Grassridge 765 kV line*	*2024*
Nuclear 1 Integration	*Nuclear 1 Integration: Thyspunt*	*2024*
	Port Elizabeth SS Integration	
Southern Grid Phase 4	*Southern Grid Phase 4: 2nd Gamma-Grassridge 765 kV line*	*2027*
PE Strengthening Phase 4	*PE Strengthening Phase 4: 2nd shunt capacitor bank at Poseidon, Delphi, Grassridge and Dedisa*	*Cancelled*

Figure 6.25: Eastern Cape province network diagram



6.9 Western Cape province

The Western Cape GDP makes the third-highest contribution to the country's total at around 15% and the province has one of the fastest-growing economies in the country. Industries in the Western Cape are comprised of financial and business services, manufacturing, tourism, agriculture and fishing. The province's economy is dominated by the City of Cape Town where the vast majority of all non-agricultural economic activity takes place.

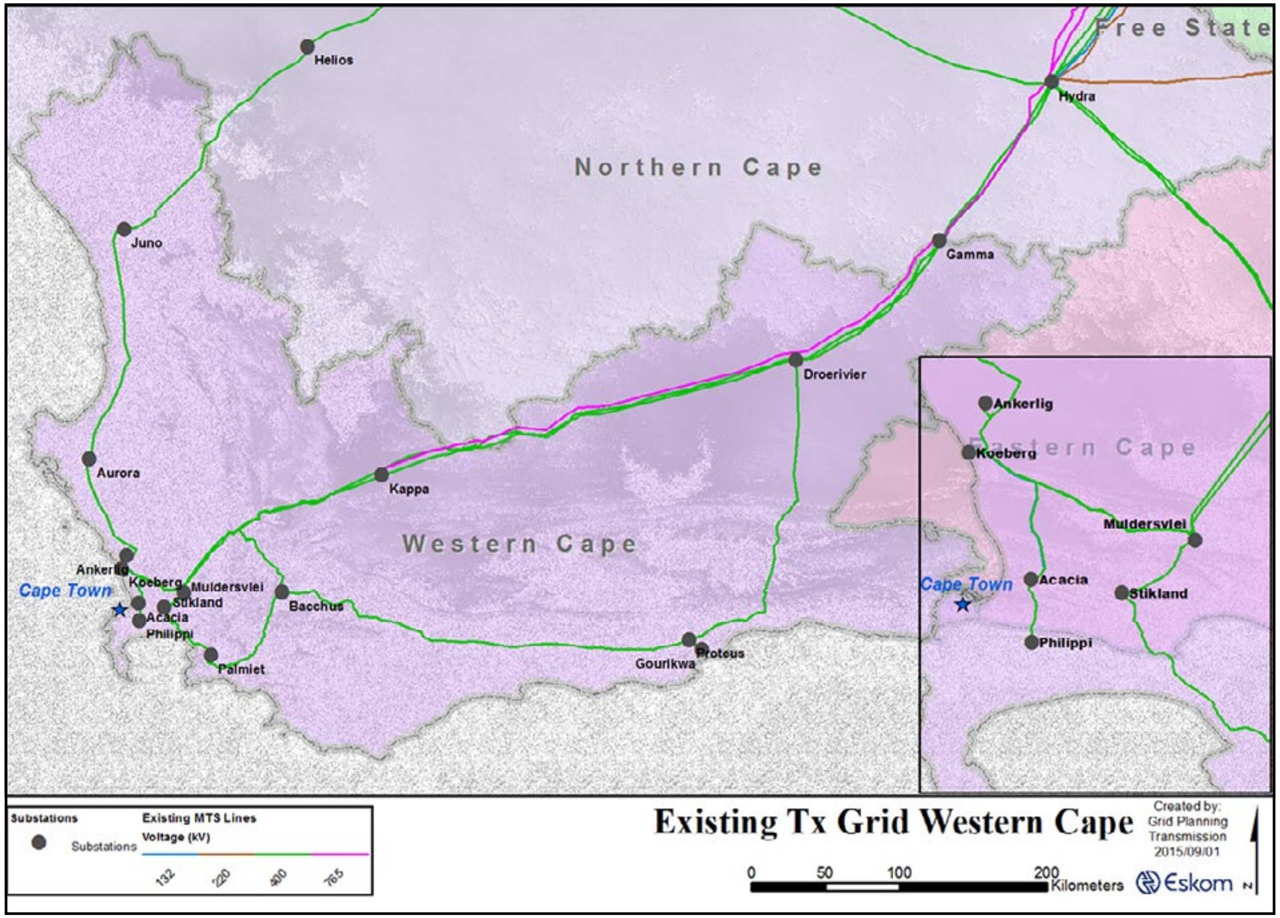
The province has shown a huge potential for renewable energy due to its climate and proximity to the coastline. To date, 330 MW of renewable energy plants have been integrated into the Western Cape, one of which is Sere Wind Farm, a 100 MW Eskom wind generating facility, which was completed in January 2015. There has also been considerable interest in gas and oil imports as well as gas generation.

The Western Cape transmission network stretches over a distance of about 550 km from Gamma substation (near Victoria West) to Philippi substation (near Cape Town). Koeberg Power Station is the only baseload power station situated locally. There are also four peaking plants in the Western Cape, consisting of pumped-storage and gas turbine generation, which help to meet the demand.

The deficit between Koeberg generation and the Greater Cape load is offset by the generation pool in the Highveld via the Cape Corridor. The first 765 kV line is planned for completion in 2016 and will increase the Cape Corridor's capability by approximately 1 500 MW.

Local strengthening is also planned across the province, mainly comprised of 400/132 kV substations. Additional 400 kV line infrastructure is also required, primarily to integrate these substations and to assist with power evacuation from the existing power stations.

Figure 6.26: Current Western Cape province network diagram



The current transmission network for the Western Cape and Greater Cape is shown in Figure 6.26 and 6.27 respectively.

6.9.1 Load forecast

The past strong residential, commercial and light industrial load growths in the Peninsula area are expected to continue for a number of years. Some areas of interest are the areas around Philippi and Mitchells Plain, where higher-density residential properties are being developed in existing residential areas.

Substantial load growth along the West Coast is expected due to the Saldanha Bay Industrial Development Zone (IDZ). The 120 hectare area, which was designated as an IDZ in October 2013, is well situated to service the marine oil and gas markets on the African continent. The Western Cape Department of Economic Development is also investigating the feasibility of establishing a floating liquefied natural gas terminal for the importation of gas.

The load forecast is shown in Figure 6.28.

Figure 6.27: Single-line diagram of the existing Greater Cape transmission network

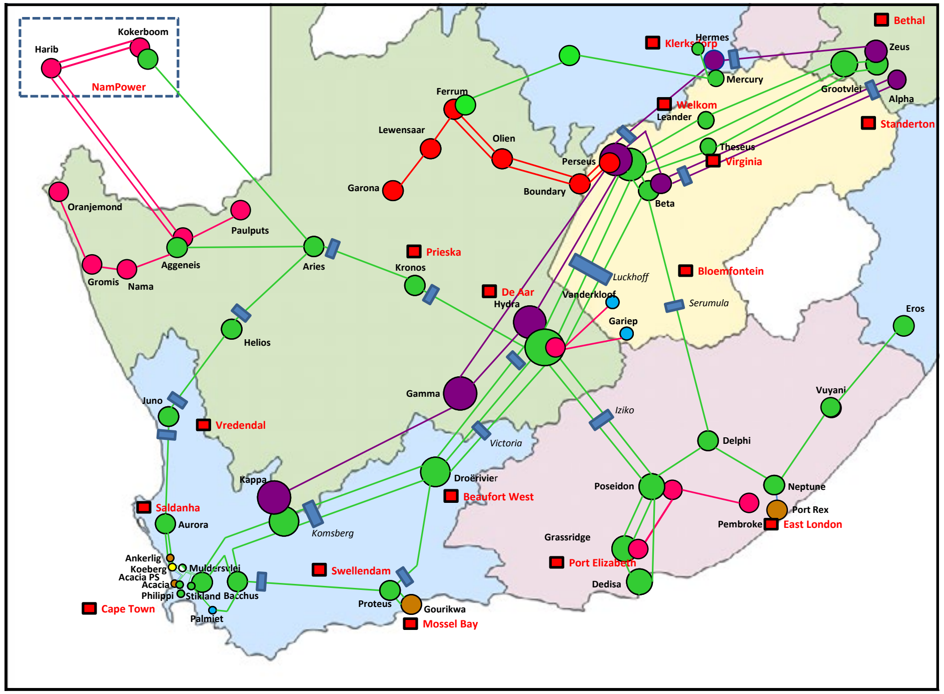
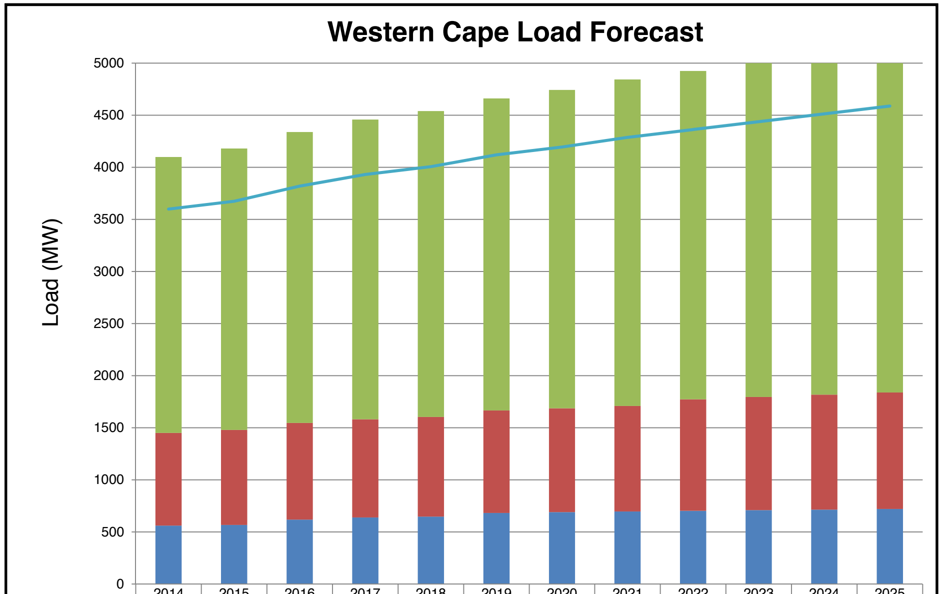


Figure 6.28: Load forecast for the Western Cape province



	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Peninsula	2650	2702	2792	2877	2936	2996	3055	3135	3152	3211	3270	3328
Outeniqua	890	912	927	943	958	983	998	1013	1071	1087	1103	1119
West Coast	560	567	619	640	646	683	689	696	702	708	715	721
TOSP	3600	3675	3821	3932	4007	4120	4195	4288	4364	4438	4513	4588

Major schemes

The immediate problems in the corridor between Beta, Perseus and Hydra substations have been addressed to a large extent by the strengthening north of De Aar. The Beta-Delphi 400 kV line has also brought additional relief to said corridor. In addition, the OCGT power stations in the Western Cape provide assistance to this corridor during the peak. However, the planned duty cycle for the OCGTs and associated fuel costs of running these generators may not be able to cater for the energy growth.

The Cape Corridor has therefore been strengthened in this regard with the following 765 kV lines that have been commissioned and energised over the last three years:

- Zeus-Mercury and Mercury-Perseus in December 2012
- Hydra-Perseus in July 2013
- Perseus-Gamma and Hydra-Gamma in February 2014
- Gamma-Kappa in April 2015

The Kappa-Sterrekus 765 kV line and its associated 765/400 kV substation are planned for commissioning in 2016. This will provide a sizeable (~ 1 500 MW) improvement in overall power transfer capacity.

Additional strengthening of the Cape Corridor will be provided by the Aries-Nieuwehoop-Ferrum 400 kV line. This will result in network adequacy until 2023, after which the preferred strengthening option will be a second Zeus-Sterrekus 765 kV line.

6.9.2 Generation capacity

Koeberg Power Station

Koeberg Power Station is situated at Duynefontein, 27 km north of Cape Town on the Atlantic coast. Koeberg ensures a reliable supply of electricity to the Western Cape, one of the fastest-growing regions in South Africa. It has operated safely and efficiently for 29 years and has a further active life of about 21 years. Koeberg Power Station has a generating capacity of 1 860 MW. The two units are rated at 930 MW each.

Acacia Power Station

Acacia Power Station forms part of the peaking group of power stations and consists of 3 x 57 MW gas turbine engines, at an installed capacity of 171 MW. Acacia also operates predominantly in synchronous condenser operation (SCO) to regulate the voltage. In addition, it provides an off-site electrical supply to Koeberg Nuclear Power Station as per the National Nuclear Regulator licensing requirement.

Ankerlig and Gourikwa Power Stations

The open-cycle gas turbines (OCGTs) were built to meet the rapidly increasing demand for peaking power on the Eskom grid. The gas turbine engines are similar to those used in the aviation industry and use liquid fuel (diesel). In addition to its generating capabilities, some of the units at these two power stations are also used to regulate network voltages when running in SCO.

Ankerlig Power Station is located at Atlantis in the Western Cape and has an installed capacity of 1 350 MW (9 x 150 MW).

Gourikwa Power Station is located at Mossel Bay and has an installed capacity of 750 MW (5 x 150 MW).

Palmiet Pumped-storage Scheme

Palmiet Pumped-storage Scheme is a joint venture between Eskom and the Department of Water Affairs and Forestry. It is situated in the ecologically sensitive Kogelberg Nature Reserve in the Western Cape near Grabouw.

The power station delivers 400 MW (2 x 200 MW) of peak power into the Eskom national grid and carries out a frequency and voltage regulating role. It is also part of an intercatchment water transfer project supplying water to Cape Town.

For generating purposes, water flows from an upper reservoir to the machines located in an underground power station. The water is collected in a lower reservoir and pumped back to the upper reservoir during off-peak periods.

6.9.3 Renewable generation

Klipheuwel Wind Energy Demonstration Facility

Klipheuwel Wind Energy Demonstration Facility is an Eskom wind generating facility that was completed in February 2003 and has a capacity of 3.16 MW (three wind turbines of 660 kW, 1.75 MW and 750 kW). It is located around 50 km north of Cape Town in Durbanville.

Darling Wind Power

Darling Wind Power generating facility is a Department of Energy demonstrator site that was completed in 2008 and has a capacity of 5.2 MW. It is located 70 km north of Cape Town, between Darling and Yzerfontein on the West Coast of South Africa.

Sere Wind Farm

Sere Wind Farm is an Eskom wind generating facility that was completed in January 2015 and has a capacity of 100 MW. It is located north-west of Vredendal at Skaapvlei, approximately 300 km north of Cape Town.

Several projects have also been approved in the Western Cape under the DoE's Renewable Energy IPP Procurement Programme (REIPPPP), as per Table 6.21. The integration of these projects will lead to additional transmission infrastructure.

Table 6.21: Approved projects in the Western Cape under the REIPPPP

REIPPPP ROUND	TECHNOLOGY	CAPACITY (MW)
1	*Wind*	*91*
	PV	*41*
	REIPPPP 1 capacity	*132*
2	*Wind*	*225*
	PV	*18*
	REIPPPP 2 capacity	*243*
3	*PV*	*75*
	REIPPPP 3 capacity	*75*
4	*Wind*	*558*
	REIPPPP 4 capacity	*558*
Western Cape total RE generation capacity		*1 008*

6.9.4 Substation firm capacity

The following strengthening plans are in place to address the capacity or refurbishment requirements at the substations:

- Acacia 66/11 kV – with the establishment of the CoCT's Richmond Estate 132/11 kV substation, all of the 11 kV load will be transferred off Acacia substation.
- Muldersvlei 400/132 kV – Pinotage substation will be established, which will deload Muldersvlei substation. 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.
- Stikland 400/132 kV – the unfirm problem at Stikland substation will be resolved by establishing Pinotage substation, which will deload both Stikland and Muldersvlei substations. Erica substation will be established, which will further deload Stikland substation.
- Philippi 400/132 kV – Erica substation will be established in order to address the loading at Philippi substation. A third 500 MVA 400/132 kV transformer is also planned for Philippi substation, the commissioning to be determined after the establishment of Erica substation.
- Juno 400/132 kV – the 2 x 120 MVA transformers will be replaced with 2 x 500 MVA units. This capacity is mainly required for integration of renewable generation in the area.
- Juno 132/66 kV and 66/22 kV – the remaining transformation capacity at Juno substation will be upgraded by:
- 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.
- Bacchus 400/132 kV – the unfirm problem at Bacchus substation will be resolved by establishing Agulhas and Asteria substations.
- Droërivier 400/132 kV – the 120 MVA transformer was replaced with a 250 MVA transformer in April 2015.
- Proteus 400/132 kV – Proteus substation will be deloaded by establishing Narina substation.

6.9.5 Reactive power compensation

Additional capacitor banks will be installed at Aurora 132 kV, Bacchus 132 kV and Proteus 132 kV. The Muldersvlei 132 kV 72 MVar capacitor bank, which formed part of this project, was commissioned in 2015.

As spares are no longer available for the power supply of the control system of the Muldersvlei SVC, it will be decommissioned once the 765 kV network has been completely commissioned and is completely in service. This is anticipated to occur in 2016.

6.9.6 Underrated equipment

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

- 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-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 circuit-breakers at Muldersvlei will also be upgraded as part of a future project.
- At Stikland substation, the 132 kV equipment is being upgraded to 40 kA as part of a distribution refurbishment and upgrade project.
- 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.
- A potential fault level exceedance has emerged at Droërivier substation and will be investigated further.

6.9.7 Provincial summary

The increase in transmission assets by the end of 2020 and the end of 2025 and cumulative total are shown in Table 6.22.

Table 6.22: Cumulative TDP transmission assets for Western Cape province

TRANSMISSION ASSETS FOR WC PROVINCE	NEW ASSETS EXPECTED IN 2016-2020	NEW ASSETS EXPECTED IN 2021 - 2025	TOTAL NEW ASSETS
Power lines (km)			
765 kV	*150*	*1000*	*1150*
400 kV	*92*	*294*	*386*
275 kV	*0*	*0*	*0*
Total length (km)	*242*	*1294*	*1536*
Transformers			
Number of units	*10*	*13*	*23*
Total capacity (MVA)	*6500*	*6000*	*12500*
Capacitors			
Number of banks	*0*	*0*	*0*
Total capacity (MVar)	*0*	*0*	*0*
Reactors			
Number of banks	*4*	*4*	*8*
Total capacity (MVar)	*467.5*	*1600*	*2067.5*

The following projects are planned for the 2016 to 2025 period:

Table 6.23: Western Cape province – summary of projects and timelines

SCHEME NAME	PROJECT NAME	EXPECTED YEAR
Muldersvlei 132 kV Capacitor Bank	*Muldersvlei 5 132 kV 72 MVar capacitor bank*	*Completed*
Aurora 132 kV, Bacchus 132 kV and Proteus 132 kV Capacitor Banks	*Aurora 1 and 2 132 kV, Bacchus 1 and 2 132 kV and Proteus 1 132 kV 72 MVar capacitor banks*	*2015*
Droërivier Transformer Upgrade	*Replace the 120 MVA 400/132 kV unit with a 250 MVA unit*	*Completed*
Cape Corridor Phase 2: Gamma-Kappa-Sterrekus 765 kV Line	*Gamma-Kappa 1st 765 kV line*	*Completed*
	• *Kappa-Sterrekus 1st 765 kV line* • *Loop-in-and-out Koeberg-Muldersvlei 400 kV line into Sterrekus* • *Sterrekus substation 1st 765/400 kV 2 000 MVA transformer*	*2016*
Muldersvlei SVC	*Decommission Muldersvlei SVC*	*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*
Muldersvlei Ext. 3rd 500 MVA 400/132 kV Transformer and 132 kV Series Reactors	*Replace the 2 x 240 MVA units with a 3rd 500 MVA 400/132 kV transformer and 132 kV series reactors*	*2018*
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*	*2018*
Komsberg Substation	• *Komsberg 400/132 kV substation (1st 500 MVA transformer)* • *Loop-in-and-out Droërivier-Kappa 1 400 kV line* • *Resize Komsberg 1 series capacitor bank*	*2018*
Kappa Substation Extension	*Kappa Ext. 400/132 kV (1st 500 MVA transformer)*	*2018*
Ankerlig-Sterrekus 1st and 2nd 400 kV Lines	*Ankerlig-Sterrekus 1st and 2nd 400 kV lines*	*2019*

Table 6.23: Western Cape province – summary of projects and timelines

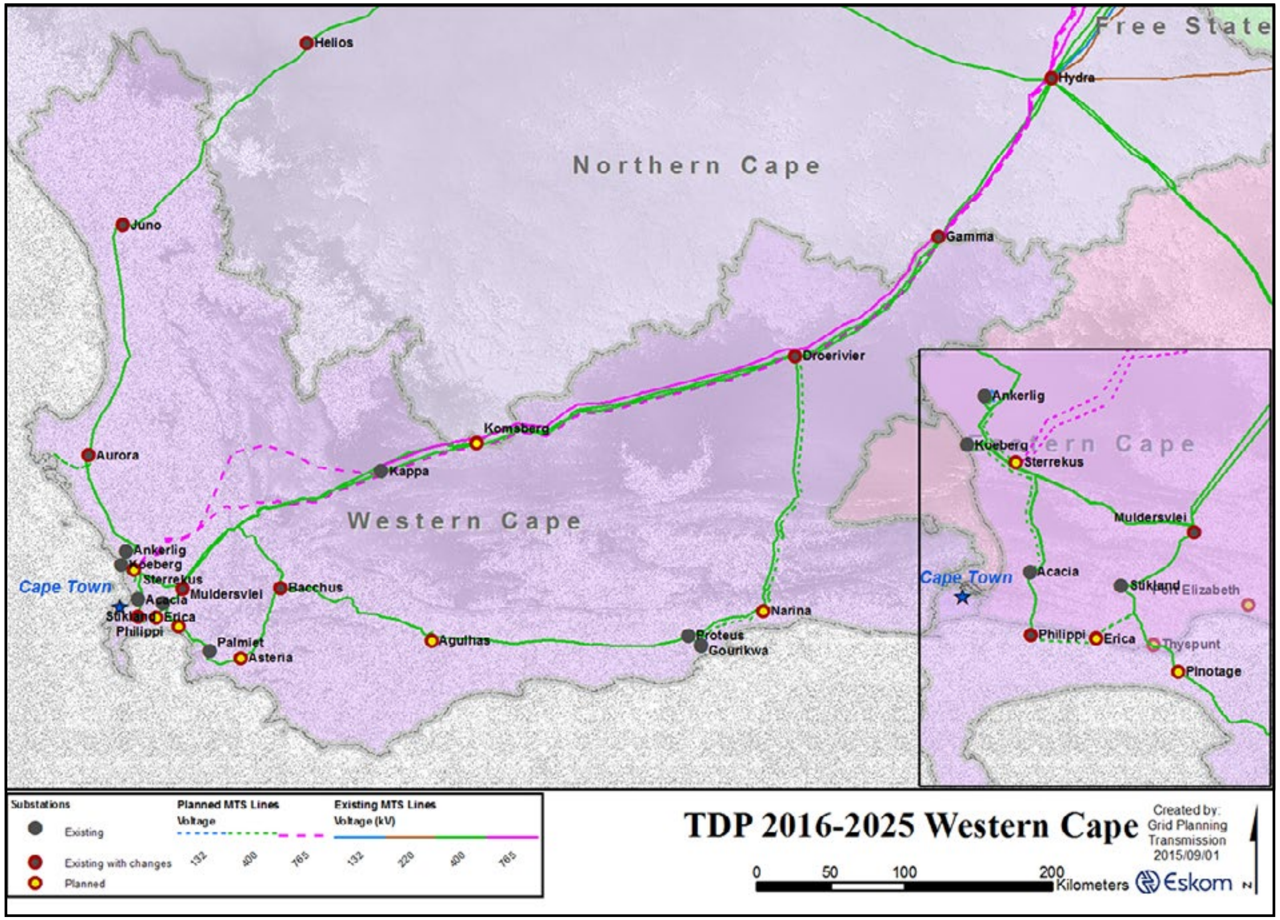
SCHEME NAME	PROJECT NAME	EXPECTED YEAR
PCB Phase-out Plan	*Decommission Helios series capacitor*	*2019*
Koeberg 400 kV Busbar Reconfiguration and Transformers Upgrade	• *Koeberg 400 kV busbar* • *Replace 2 x 250 MVA transformers with new units* • *Koeberg 400 kV lines rerouting to the new busbar*	*2021*
Juno Substation Transformation Upgrade	*Replace the 2 x 120 MVA 400/132 kV units with 2 x 500 MVA units*	*2021*
	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	
2nd Koeberg-Acacia 400 kV Line	*2nd Koeberg-Acacia 400 kV line*	*2020*
Erica Substation *(Mitchells Plain Transmission Substation)*	• *Erica substation (1st and 2nd 400/132 kV 500 MVA transformers)* • *Loop-in-and-out Pinotage-Stikland 400 kV line*	*2021*
Philippi Substation Extension	• *Establish 400 kV busbar* • *Make provision for Philippi 3rd 400/132 kV 500 MVA transformer* • *Philippi-Erica 400 kV line*	*2020*
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* • *Bypass Bacchus series capacitor bank*	*2022*
Saldanha Bay Network Strengthening *(Phase 1)*	• *At Aurora substation, replace two of the four existing 400/132 kV 250 MVA units with 2 x 500 MVA units 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*	*2022*
Saldanha Bay Network Strengthening *(Phase 2)*	• *Blouwater Transmission substation (1st and 2nd 400/132 kV 500 MVA transformers)* • *Loop-in Ankerlig-Aurora 1 400 kV line*	*Deferred*

Table 6.23: Western Cape province – summary of projects and timelines

SCHEME NAME	PROJECT NAME	EXPECTED YEAR
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*	*2021*
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* • *Relocate Proteus series capacitor bank to Narina*	*2021*
PCB Phase-out Plan	*Decommission Juno, Victoria and Hydra series capacitors*	*2022*
Cape Corridor Phase 4: 2nd Zeus-Sterrekus 765 kV Line	• *Zeus-Perseus 1st 765 kV line* • *Series compensation at Zeus and Perseus* • *Perseus-Gamma 2nd 765 kV line*	*2027*
	• *Gamma-Kappa 2nd 765 kV line* • *Kappa-Sterrekus 2nd 765 kV line* • *Loop-in-and-out Koeberg-Stikland 400 kV line into Sterrekus* • *Sterrekus Ext. 2nd 765/400 kV 2 000 MVA transformer*	
Windmill Transmission Substation	• *Windmill 400/132 kV substation (1st and 2nd 500 MVA transformers)* • *Loop-in-and-out Bacchus-Muldersvlei 400 kV line*	*Deferred*
Droërivier-Narina-Gourikwa 400 kV Line (Droërivier-Proteus 2nd 400 kV Line)	*Droërivier-Narina-Gourikwa 400 kV line*	*2022*
Cape Corridor Phase 3: Series Compensation on the 765 kV Lines Between Perseus and Kappa	*Series compensation on the 765 kV lines between Perseus and Kappa*	*Deferred*
Cape Corridor Phase 5: 3rd 765 kV Line	*3rd 765 kV line (West Coast alignment)*	*Strategic*
Stikland 132 kV Series Reactors	*Stikland 132 kV series reactors*	*Deferred*

A network diagram of the major projects in the Western Cape is shown in Figure 6.29.

Figure 6.29: Western Cape province network diagram



Chapter 7
Grid access for generation beyond 2020

The initial bid windows of the Renewable Energy IPP Programme of the DoE have taken advantage of the available generation connection capacity on the existing transmission grid. However, this capacity has been rapidly allocated, especially in the areas with better renewable resources and there are areas with very good renewable energy resources that have no transmission grid access at all. The grid will have to be extended to create more access for the bid windows beyond Round 4, specifically for the period 2020 to 2025. In addition, there are a number of other IPP programmes such as coal and gas that must also be catered for and overall, these programmes impact each other for grid development.

Generation assumptions for these IPP programmes have been made for this TDP ; however, it is difficult to propose specific Transmission projects on these assumptions when the actual IPP projects are to be selected by a competitive bidding process and thus, their locations are unknown. Including all of the potentially required Transmission projects in the TDP would lead to excess capacity in many areas and an enormous requirement of capital to execute. There is the likelihood that the inappropriate grid expansion may be committed based on the TDP assumptions whereas, at the end of an IPP bidding process, an alternative Transmission project should rather have been implemented first.

To address this issue, a new approach for creating additional generation connection capacity has been undertaken. Taking into account the generation assumptions, IPP connection requests, internal assessments, independent studies and interactions with the DoE and other stakeholders, a number of potential transmission infrastructure projects have been identified. Some are included in the TDP and others appear in the list of potential project proposals referred to in Chapter 2, IPPS: connections and strategic plans. It is recommended that preparation work on all of these projects be undertaken in order that they can be expedited should they be required for an IPP programme.

Resulting from this would be a collection of Transmission projects ready for release, from which only the final selected ones need approval and funding, thus enabling faster construction and commissioning than previously possible. In this way, the delivery dates can closely match the targeted connection dates, especially if the IPP programmes and Transmission commitment programmes are in alignment, to the benefit of the needs of the DoE IRP and the country.

Two types of transmission infrastructure will be required; one to enable the collection of dispersed renewable energy generation to be transported to where it is required and another to evacuate concentrated generation such as nuclear, coal, or large gas. These projects have different requirements, but impact each other.

7.1 Dispersed renewable energy generation

The expected renewable energy generation is spread across the three Cape provinces, excluding solar PV, which could potentially be installed almost anywhere in the country. The locations of the successful and shortlisted bidders in the REIPPPP Windows 1 to 4 are known. The locations of the renewable generation allocated for the period 2020 to 2025 have been assumed and the likely transmission infrastructure required identified.

7.1.1 The Eastern Cape

A total of 1 900 MW of wind generation has been assumed, mainly in the Somerset East and Queenstown areas. Much of this would be in the proposed REDZs for this province.

To accommodate this generation, at least two new 400/132 kV substations will be required in the vicinity of the Poseidon and Delphi substations, including additional 400 kV lines, to enable the evacuation of the renewable energy out of the province.

7.1.2 The Northern Cape

A total of 1 100 MW of wind generation has been assumed, mainly in the Namaqualand and De Aar areas. Much of this, along with solar PV, would be in the proposed REDZs for this province. A further 600 MW of CSP generation has also been assumed, mainly around Upington and close to Sishen.

To accommodate this generation, at least one new 400/132 kV substation is required in the Hydra substation area and possibly a new 400/132 kV substation around the Nama area, in addition to establishing 400/132 kV at Aggeneis substation. The Hydra area substation will need 400 kV lines to integrate it into the grid and for the Nama area substation, a new Gromis-Aggeneis 400 kV line. The 220 kV network must be either overlaid or replaced with 400 kV to facilitate the evacuation of the renewable energy out of the province.

7.1.3 The Western Cape

A total of 1 000 MW of wind generation has been assumed, mainly in the Beaufort West and Laingsburg areas, as well as in the proposed REDZs for this province.

To accommodate this generation, at least one new 400/132 kV substation is required in the Droërivier substation area and the establishment of 400/132 kV transformation at the Komsberg series capacitor site and Kappa substation. This may result in additional 400 kV lines being required to help evacuate the collected generation.

7.2 Concentrated generation

There are two areas that will require the evacuation of concentrated generation into the grid based on the TDP assumptions: the Lephalale area for coal IPP plants and the Port Elizabeth area for nuclear and a large gas power plant. The impact of these generation plants being located elsewhere is addressed in Chapter 8, Impact of the DoE generation scenarios.

7.2.1 The Lephalale area

A total of 2 250 MW of IPP coal generation has been allocated to the Lephalale area from 2022 after the completion of the Medupi Power Station. Due to the available transmission infrastructure in this area, it is unlikely that it will be possible to evacuate more than 600 MW from this area. Servitude constraints would make it short-sighted to create a grid bottleneck by incremental strengthening of the 400 kV network.

To evacuate additional coal generation from this area, it is recommended that a 600 kV HVDC scheme be constructed from the Massa substation into the Johannesburg area, with terminal stations at the Jupiter B and Etna substations, providing a capacity of up to 3 000 MW. This HVDC link will serve a dual purpose with the injection of power into the Gauteng networks, in that it will create a window to allow for the upgrading of sections of the 275 kV networks to 400 kV. The recycling of certain 275 kV lines to 400 kV is needed to meet the increasing load density demands around Johannesburg.

The 600 kV HVDC is not included in the TDP yet, but has been identified as a ring-fenced Transmission project that will require funding should additional connection capacity be needed in the Lephalale area.

7.2.2 The Port Elizabeth area

The 765 kV infrastructure from Gamma substation to Grassridge substation in Port Elizabeth will be able to evacuate around 4 000 MW of generation. This would be adequate for either nuclear generation at the Thuyspunt site or a large gas generation plant within the Coega area, but not for both.

An additional 400 kV line linking Port Elizabeth via Vuyani substation in the Eastern Cape to Eros substation in KwaZulu-Natal will be required if the final nuclear generation configuration at the Thyspunt site significantly exceeds 4 000 MW. This would also provide capacity to evacuate the accumulating wind generation in the Eastern Cape.

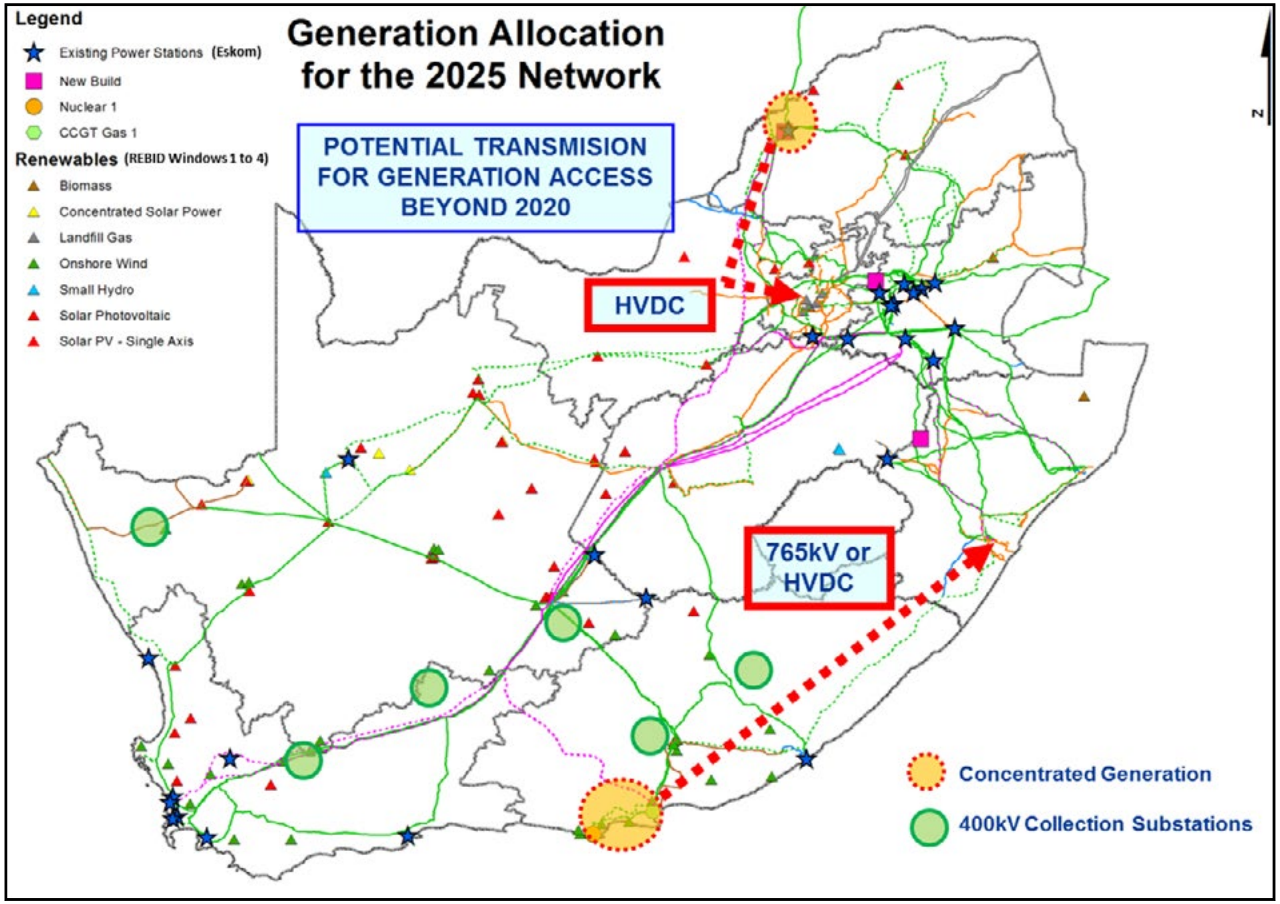
An even stronger connection to KwaZulu-Natal will be required if a large gas plant in excess of 1 000 MW is established in the Coega area, as well as the nuclear at Thyspunt. Assuming that this gas plant will be in the order of 2 000 MW to 3 000 MW, then, in addition to the above 400 kV link, a direct link at 765 kV or even a 600 kV HVDC link will need to be established from Grassridge into KwaZulu-Natal to evacuate this amount of excess concentrated generation.

The additional 400 kV line, 765 kV integration or 600 kV HVDC are excluded from the TDP list, as these options are entirely dependent on the confirmation of the timing and location of the nuclear and gas generation. However, these new transmission lines will be routed in the Eastern Power Corridor, as identified in the SIP 10 SEA study, which will facilitate the required environmental authorisations for the servitude acquisitions.

Once this generation commitment is known, the actual configuration of the transmission infrastructure required can be identified and prepared for approval and funding. Critical to the success of this integration is the alignment of the phasing of the transmission and generation programmes.

The map in Figure 7.1 indicates the relative location of the potential new 400/132 kV collection substations and the general route of the new 765 kV or 600 kV HVDC transmission lines that may be required for additional generation connection capacity beyond 2020.

Figure 7.1: Location of collector stations and major corridors beyond 2020



Chapter 8

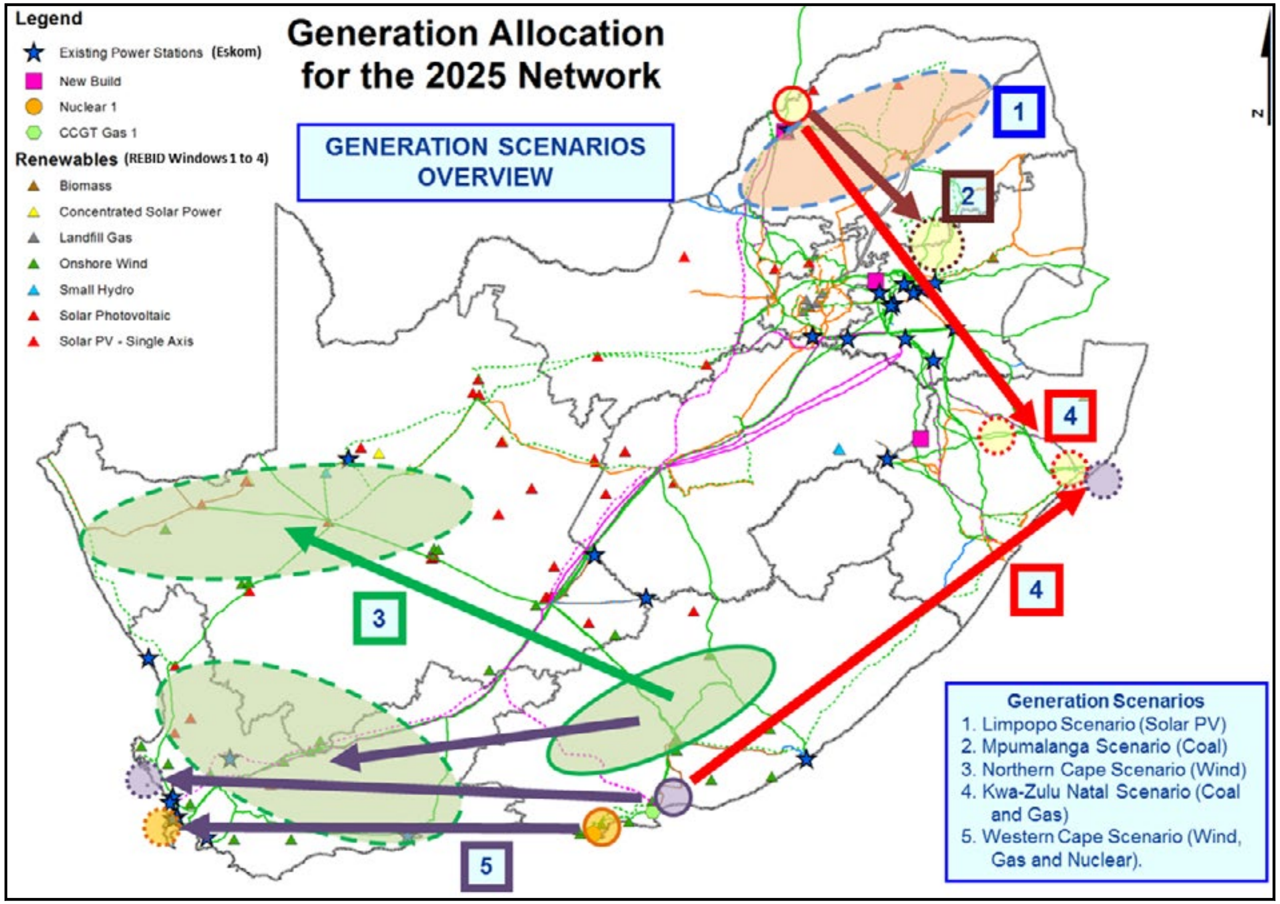
Impact of the DoE generation scenarios

The TDP is based on the baseline generation assumptions however the potential impact of other generation scenarios as specified by the DoE were considered during the end of the TDP horizon in terms of high-level sensitivities. These generation scenarios are listed below and the specific assumptions and likely impact of each scenario are discussed separately. The year of consideration for these scenarios is 2025, as only the full impact was considered, not the phased roll-out of these scenarios.

The scenarios are defined as follows:

- Limpopo scenario (solar PV)
- Mpumalanga scenario (coal)
- Northern Cape scenario (wind)
- KwaZulu-Natal scenario (coal and gas)
- Western Cape scenario (wind, gas and nuclear)

Figure 8.1: Overview of the generation scenario location changes



8.1 Limpopo scenario (solar PV)

The purpose of this scenario is to determine the impact on the transmission network within the Limpopo province if 1 000 MW of large solar PV generation is moved from the Northern Cape to Limpopo.

An additional 1 000 MW of future solar PV was allocated to the following substation locations in Limpopo:

- Medupi: 200 MW
- Witkop: 200 MW
- Nzhelele: 200 MW
- Tabor: 200 MW
- Spencer: 200 MW

Impact of the scenario

There is no significant impact of this generation scenario on the Limpopo province. The allocated amounts of solar PV can be absorbed within the local loads and the existing and planned transmission network.

The 200MW PV at Matimba may be difficult to evacuate unless there is a significant load increase in the area around Lephalale. Once this level of PV penetration is reached in the Limpopo province studies will need to be done to determine if there is any negative impact on the operation and stability procedures for the two large coal power stations.

8.2 Mpumalanga scenario (coal)

The purpose of this scenario is to determine the impact on the transmission network within Mpumalanga if 1 600 MW of coal generation is moved from the Lephalale/Waterberg area into the Mpumalanga province.

The locations for new coal in Mpumalanga are:

- the Coal IPP 1 site, with an additional 400 MW (total 800 MW);
- the Coal IPP 3 site near Kriel, with an additional 400 MW (total 800 MW);
- Kendal Power Station, with an additional 400 MW (representing a Delmas area IPP); and
- Kruispunt substation, with an additional 400 MW.

Impact of the scenario

There is no significant impact of this generation scenario on the Mpumalanga province. The allocated amounts of coal generation can be absorbed and transported utilising the transmission capacity of the existing and planned networks in the province. Some reconfiguration of the networks may be required to better share the power flows, but this should not require significant transmission infrastructure. There is likely to be fault level constraints, but these can also be resolved with network reconfiguration. Actual requirements will be dependent on the final location and size of the IPP coal plants which can be different to those given above, but are not expected to be limited and any reinforcement required, easily implemented.

8.3 Northern Cape scenario (wind)

The purpose of this scenario is to determine the impact on the transmission network within the Northern Cape if 2 500 MW of wind generation is moved from the Eastern Cape into the Northern Cape. This includes some substations in the northern part of the Western Cape.

The locations for new wind generation for this scenario are as follows:

- Nama: 400 MW
- Gromis: 400 MW
- Aggeneis: 400 MW
- Oranjemund: 400 MW
- Hydra: 300 MW
- Kronos: 300 MW
- Gamma: 300 MW

Impact of the scenario

There is a significant impact from this generation scenario on the Northern Cape province.

The 220 kV network in the Namaqualand area, running from Aggeneis-Nama-Gromis-Oranjemond will be overwhelmed with RE generation to be collected and evacuated out of the area. Accommodating this amount of additional IPP generation will require this network to be overlaid with 400 kV. This will entail the construction of the following as a minimum:

- Energising the new Gromis-Oranjemond 400 kV line
- A new Oranjemond-Aggeneis 400 kV line (300 km)
- A new Gromis-Nama-Aggeneis 400 kV line (200 km)
- A new Aggeneis-Helios 400 kV line (150 km) or 2nd Aggeneis-Aries 400 kV line (150 km)
- A 2nd Aries-Ferrum 400 kV line
- At least one new 400/132 kV collector substation in the Nama-Gromis area, plus the 400 kV lines to integrate it
- A new Ferrum-Olien-Perseus 400 kV line to reinforce the 275 kV link via Kimberley to provide an additional evacuation path for network security.

The Hydra/Kronos/Gamma generation will require the establishment of 400 kV/132 kV at Gamma, an additional substation in the Hydra area (Hydra B) and the extension of Kronos 400/132 kV. A second Hydra-Kronos-Aries 400 kV line (400 km) may be required. The new Hydra B substation may also require additional 400 kV lines for integration.

8.4 Kwazulu-Natal scenario (coal and gas)

The purpose of this scenario is to determine the impact on the transmission network within KwaZulu-Natal when coal generation is moved from Lephalale into the KwaZulu-Natal area and gas is moved from Coega to Richards Bay.

This scenario was represented as follows:

Gas (LNG)

All the new gas units (11 in total) were removed from the Dedisa (Coega) site and placed at Invubu substation to represent a Richards Bay gas IPP (3 126 MW).

Coal

The Coal IPP 2 and Coal IPP 4 units at Massa substation were switched off and replaced with additional generator units placed as follows:

- 1 000 MW at Chivelston substation to represent a Colenso coal IPP
- 600 MW at Invubu substation to represent a Richards Bay coal IPP

Impact of the scenario

There is no significant impact of this generation scenario on the KwaZulu-Natal province.

The allocated coal generation can be absorbed and transported utilising the transmission capacity of the existing and planned networks in the province.

The gas allocation of over 3 000 MW is more of a challenge, but there is significant load in the area and only the excess power will need to be evacuated from Richards Bay. The 765 kV and 400 kV lines can be utilised for this purpose, including the new double-circuit 400 kV line running from Mbewu to Isundu and on to Hector and Ariadne, linking Richards Bay to the greater Durban area. This new 400 kV link will enable development along the coastal areas between the two load centres as well as provide an evacuation route for the excess power.

The allocation of 3 000 MW of gas generation to the Richards Bay area will relieve the requirements from evacuating excess power from the Eastern Cape if it had been placed at the Coega site (Dedisa) instead. Thus the reinforcement of the new transmission corridor to KwaZulu-Natal will be delayed in terms of capacity and timing.

8.5 Western Cape scenario (wind, gas, and nuclear)

The purpose of this scenario is to determine the impact on the transmission network within the Western Cape if large gas, nuclear and large wind generation is to be evacuated from this province.

This scenario was represented as follows:

Gas (LNG)

All the new gas units (11 in total) were removed from Dedisa (Coega) and placed at the Aurora substation to represent a Saldanha gas IPP (3 126 MW).

Nuclear

The three nuclear units were removed from Thyspunt and placed at the Sterrekus 400 kV busbar to represent the Duynefontein site (4 800 MW).

Wind generation

A total of 2 500 MW had to be moved from the Eastern Cape to the Western Cape. The additional wind generation had to be added, as listed below. The Eastern Cape wind generation was reduced and the wind in the substations listed below was run at full 100% output:

- Aurora B (north of Aurora): 400 MW
- Agulhas (Vryheid): 300 MW
- Asteria (Houhoek): 300 MW
- Juno: 300 MW
- Komsberg: 500 MW
- Droërivier: 300 MW
- Kappa: 400 MW

Impact of the scenario

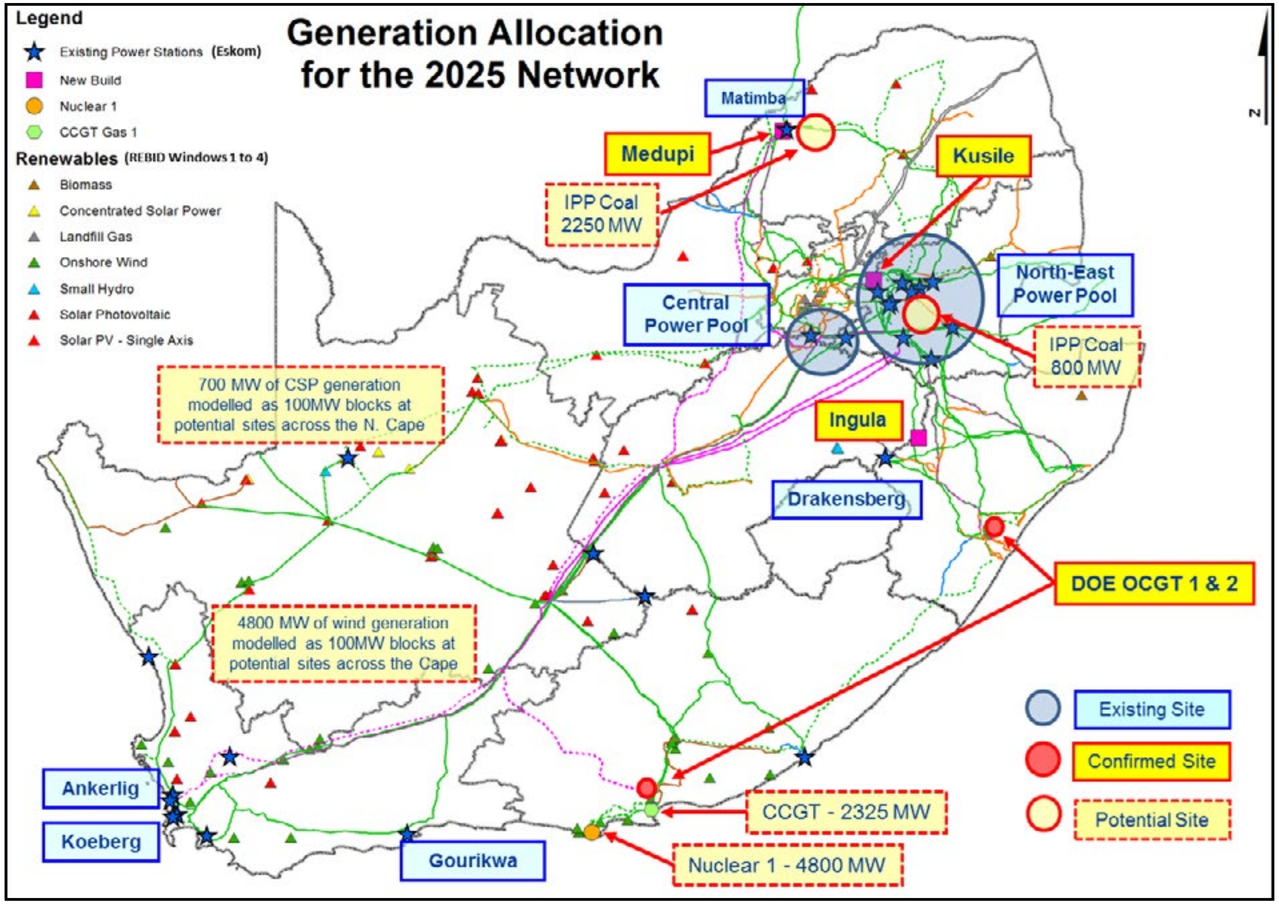
There is a significant impact of this generation scenario on the Western Cape province.

The new generation far exceeds the available load in the Western Cape and significant excess generation power has to be evacuated out of the Cape to the north, which will require the construction of several very long high-capacity transmission lines. The expected load in the Western Cape is expected to be around 6 000 MW by 2025 and the available generation as per the TDP assumptions will be as follows:

- Existing generation of Koeberg (1 860 MW), Palmiet (400 MW), Ankerlig (1 327 MW), Gourikwa (740 MW) and Acacia (171 MW), giving a total of 4 438 MW
- Renewables from REIPPPP and allocation by 2019 of 931 MW
- Renewables allocation after 2019 in the TDP assumptions of 1 000 MW

This results in an expected total of 6 369 MW of installed generation in the Western Cape by 2025, effectively balancing with the expected load.

Figure 8.2: Overview of the impact of the generation scenarios



This scenario will result in the installation of an additional 7 926 MW of dispatchable generation, plus an intermittent wind generation of 2 500 MW, in total 10 426 MW. Effectively, almost all of this power will need to be evacuated out of the Western Cape.

Taking into account the intermittency of the wind generation and the operation of Palmiet, Ankerlig, Gourikwa and Acacia as peaking plant, the 765 kV network and 400 kV lines can be used to evacuate most of the power during normal operations. However, to account for baseload operation of the nuclear plants, high utilisation of the CCGT plant and high wind output operating conditions, additional transmission corridors will be required to evacuate between 3 000 MW and 4 000 MW out of the province.

The first objective would be to reinforce the Northern Cape evacuation route. This would entail, as a minimum and effectively, doubling of the 400 kV line route via the Northern Cape to the North West province. Thus, a new Aurora-Juno-Helios-Aries-Ferrum-Mookodi-Mercury 400 kV link, approximately 1 400 km long, plus appropriate compensation, should be constructed. This will also facilitate the collection and evacuation of renewable energy generation in the Northern Cape.

The main component of the additional corridor could either be at 765 kV EHV or 600 kV HVDC to provide a power transfer of around 3 000 MW of power over a distance of at least 1 200 km to where it is required. The main generation in the Eastern Cape has been relocated to the Western Cape and the strategic intention of the grid development is to supply KwaZulu-Natal from the future Cape Power Pool. Therefore, the proposal for this scenario would be to establish a new 600 kV HVDC scheme from the Cape Peninsula area directly to KwaZulu-Natal via the Eastern Cape. This will utilise the identified power corridor routes under the SIP 10 initiative.

The overview of the impact of the Northern Cape scenario and the Western Cape scenario is illustrated in the map in Figure 8-2. Note that for the Western Cape scenario (indicated in red) most of the 400 kV expansion in the Northern Cape scenario (indicated in orange) will also be required.

Chapter 9 Capital expenditure plan

The total capital expenditure for Transmission amounts to R206 798 million. This summary is shown in Table 9.1. 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.

Table 9.1: Capital expenditure per category of projects for FY2016 to 2025

Categories	Rand (millions)
Capital expansion	*146 822*
Capital expansion for IPPs	*30 570*
Refurbishment	*14 943*
Capital spares	*2 427*
Telecoms	*3 698*
Aviation	*501*
Production equipment	*596*
Other	*1 694*
Land and rights	*5 547*
Total	**206 798**

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.

Table 9.2 shows the provincial split for transmission expansion projects which amount to R146 billion over the next ten years. Projects spanning over multiple provinces were classified as national projects.

Table 9.2: Capital expenditure for expansion projects for FY2016 to 2025 per province

Province	Expansion Cost (millions)
Eastern Cape	*14 603*
Free state	*3 883*
Gauteng	*19 878*
KwaZulu Natal	*24 924*
Limpopo	*14 788*
Mpumalanga	*8 243*
North West	*5 264*
Northern Cape	*24 458*
Western Cape	*10 741*
National	*19 898*

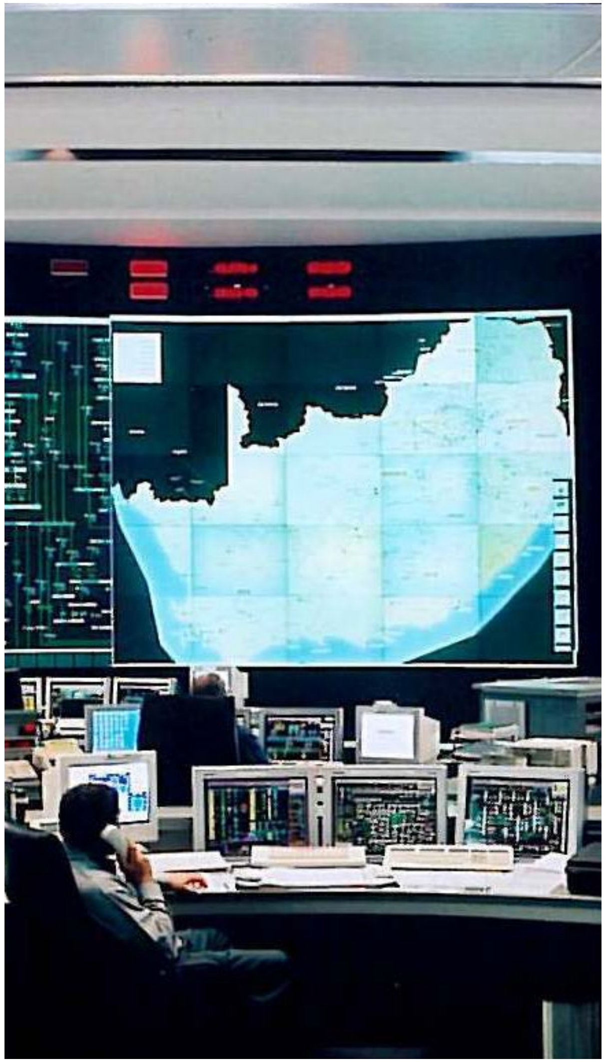
Chapter 10
Conclusion

The most visible difference between this TDP and the 2014 TDP is the re-phasing of projects in the execution phase. 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 first four rounds of the DoE REIPPPP that are under construction have been added, as well as the projects required for the 13 additional IPP successful bidders announced by the DoE in Round 4. There is an assumed plan for Rounds 5 and 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 an N-1 contingency event will happen at the time of the peak loading. 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. It is 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 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 mainly due 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.



Appendix A:
Generation assumptions

Table A1: The Conventional Generation Plan for the TDP 2016 to 2025

2010 IRP Calendar Year	Medupi Unit MW	Kusile Unit MW	Ingula Unit MW	DoE OCGT 1 Dedisa Unit MW	Doe OCGT 2 Avon Unit MW	Nuclear Unit Location MW	New Coal Unit Location MW	O & C CGT Unit Location MW	HYDRO import Unit Location MW	Camden Decomm Unit MW	Hendrina Decomm Unit MW	Arnot Decomm Unit MW
2015	*1 738* *2 738*		*1 333*	*1 147* *2 147*	*1 147* *2 147* *3 147* *4 147* *5 147*							
2016		*1 738*	*2 333* *3 333*									
2017	*3 738* *4 738*	*2 738*	*4 333*									
2018	*5 738*	*3 738* *3 738*										
2019	*6 738*	*5 738*					*1 Coal IPP 1 200* *2 Coal IPP 1 200*	*3 Dedisa 237*				
2020		*6 738*					*1 Coal IPP 3 200* *2 Coal IPP 3 200*	*4 Dedisa 237*				
2021								*5 Dedisa 237*		*6 -160*	*4 -190*	
2022							*1 Coal IPP 2 250* *2 Coal IPP 2 250* *1 Coal IPP 4 250* *2 Coal IPP 4 250*	*6 Dedisa 269* *7 Dedisa 269* *8 Dedisa 269*	*1 Maputo 570* *2 Maputo 570*	*7 -170* *8 -180*	*3 -190* *5 -180*	
2023						*1 Thyspunt 1600*	*3 Coal IPP 2 250* *3 Coal IPP 4 250* *4 Coal IPP 4 250*		*3 Maputo 570* *4 Maputo 570*	*5 -180* *4 -185*	*2 -190*	*3 -380* *2 -380*
2024						*2 Thyspunt 1600*	*4 Coal IPP 2 250*		*5 Maputo 283*	*3 -185* *2 -190* *1 -190*	*1 -190*	*1 -376*
2025						*3 Thyspunt 1600*	*5 Coal IPP 4 250*	*9 Dedisa 269* *10 Dedisa 269* *11 Dedisa 269*				

Table A2: The Renewable Generation Plan for the TDP 2016 to 2025

2010 IRP Calendar Year	Wind				CSP				PV				Other RE			
	Unit ID	Unit	Location	MW	Unit ID	Unit	Location	MW	Unit ID	Unit	Location	MW	Unit ID	Unit	Location	MW
2015	*1202W*	*1*	*Aurora*	*65*	*1798C*	*1*	*Garona*	*50*	*1163P*	*1*	*Aries*	*10*	*10029B*	*1*	*Etna*	*18*
	1123W	*1*	*Bacchus*	*26*	*1118C*	*1*	*Paulputs*	*100*	*1164P*	*3*	*Aurora*	*5*				
	1043W	*1*	*Delphi*	*97*					*1037P*	*1*	*Bacchus*	*36*				
	1186W	*2*	*Grassridge*	*134*					*1155P*	*1*	*Bighom*	*7*				
	1138W	*4*	*Grassridge*	*26*					*1572P*	*1*	*Boundary*	*48*				
	1148W	*4*	*Grassridge*	*78*					*1443P*	*1*	*Douglas*	*10*				
	1036W	*3*	*Hydra*	*73*					*1696P*	*2*	*Douglas*	*20*				
	1225W	*1*	*Poseidon*	*135*					*1444P*	*1*	*Ferrum*	*75*				
	Eskom	*1*	*Juno (Sere)*	*100*					*1031P*	*1*	*Harvard*	*64*				
									1182P	*1*	*Hydra*	*48*				
									1064P	*2*	*Hydra*	*10*				
									1159P	*5*	*Hydra*	*73*				
									1564P	*6*	*Hydra*	*75*				
									1065P	*1*	*Kronos*	*20*				
									1032P	*2*	*Olien*	*64*				
									1118P	*1*	*Paulputs*	*100*				
									1128P	*2*	*Paulputs*	*10*				
									1052P	*1*	*Tabor*	*28*				
									1035P	*1*	*Witkop*	*30*				
2016	*100092W*	*7*	*Hydra*	*139*					*100771P*	*4*	*Aurora*	*75*	*10149B*	*1*	*Impala*	*16.5*
	100093W	*8*	*Hydra*	*96.5*					*102692P*	*2*	*Kronos*	*75*				
	100242W	*4*	*Poseidon*	*86.6*					*102693P*	*3*	*Konos*	*75*				
									10338P	*1*	*Matimba*	*60*				
2017	*1309W*	*4*	*Aurora*	*91*	*1002C*	*2*	*Garona*	*50*	*1373P*	*2*	*Aurora*	*9*	*1815H*	*3*	*Paulputs*	*10*
	1364W	*1*	*Grassridge*	*60*	*10056C*	*2*	*Paulputs*	*100*	*1270P*	*2*	*Ferrum*	*74*	*1490H*	*1*	*Tugela*	*4.3*
	1303W	*5*	*Grassridge*	*95*	*10040C*	*1*	*Upington*	*100*	*1764P*	*3*	*Garona*	*9*				
	1014W	*1*	*Muldersvlei*	*135*					*1523P*	*4*	*Hydra*	*37*				
	1372W	*1*	*Pembroke*	*21*					*1168P*	*7*	*Hydra*	*75*				
	1240W	*2*	*Poseidon*	*138*					*1375P*	*1*	*Juno*	*9*				
	1362W	*3*	*Poseidon*	*23*					*1562P*	*1*	*Olien*	*75*				
	100281W	*1*	*Helios*	*138*					*1750P*	*1*	*Perseus*	*60*				
	100284	*9*	*Hydra*	*79*					*1527P*	*1*	*Ruigtevallei*	*70*				
	100281W	*2*	*Helios*	*128*					*100064P*	*3*	*Ferrum*	*75*				
	101361W	*6*	*Grassridge*	*110*					*103461P*	*2*	*Boundary*	*75*				
2018	*BW4 Proxy*	*7*	*Grassridge*	*140*	*BW3.5*	*1*	*Ferrum*	*100*	*BW4 Proxy*	*2*	*Upington*	*150*				
	BW4 Proxy	*1*	*Komsberg*	*140*					*BW4 Proxy*	*1*	*Aggeneis*	*50*				
	BW4 Proxy	*3*	*Poseidon*	*140*					*BW4 Proxy*	*3*	*Paulputs*	*100*				
2019	*BW4 Proxy*	*2*	*Komsberh*	*140*	*BW3.5*	*1*	*Olien*	*100*	*BW4 Proxy*	*3*	*Upington*	*150*	*BW4 Proxy*	*2*	*Tugela*	*10*
	BW4 Proxy	*4*	*Poseidon*	*140*					*BW4 Proxy*	*1*	*Boundary*	*75*				
	BW4 Proxy	*1*	*Droerivier*	*100*					*BW4 Proxy*	*1*	*Marathon*	*30*				
									BW4 Proxy	*1*	*Helios*	*150*				
2020		*1*	*Nama*	*100*		*2*	*Ferrum*	*100*	*BW4 Proxy*	*2*	*Aggeneis*	*150*				
		1	*Koruson*	*100*					*BW4 Proxy*	*2*	*Helios*	*150*				
		2	*Droerivier*	*100*												
		2	*Pembroke*	*100*												

2010 IRP Calendar Year	Wind				CSP				PV				Other RE			
	Unit ID	Unit	Location	MW	Unit ID	Unit	Location	MW	Unit ID	Unit	Location	MW	Unit ID	Unit	Location	MW
2021		*2*	*Nama*	*100*		*4*	*Upington*	*100*								
		2	*Koruson*	*100*												
		3	*Droerivier*	*100*												
		3	*Pembroke*	*100*												
2022		*1*	*Delphi*	*100*		*5*	*Upington*	*100*								
		2	*Delphi*	*100*												
		4	*Droerivier*	*100*												
		3	*Pembroke*	*100*												
2023		*5*	*Poseidon*	*100*		*6*	*Upington*	*100*								
		5	*Droerivier*	*100*												
		3	*Delphi*	*100*												
		4	*Nama*	*100*												
2024		*6*	*Droerivier*	*100*		*4*	*Garona*	*100*								
		7	*Droerivier*	*100*												
		1	*Hydra B*	*100*												
		2	*Hydra B*	*100*												
		6	*Poseidon*	*100*												
		7	*Poseidon*	*100*												
		4	*Delphi*	*100*												
		5	*Delphi*	*100*												
2025		*8*	*Droerivier*	*100*		*7*	*Upington*	*100*								
		1	*Thyspunt*	*200*												
		3	*Hydra B*	*200*												
		4	*Hydra B*	*200*												
		5	*Hydra B*	*200*												
		4	*Pembroke*	*200*												
		8	*Doseidon*	*100*												
		5	*Delphi*	*200*												
		6	*Delphi*	*200*												

Appendix B:
Publication team

Although the publication of the document did not comprise a formal team, the following people were instrumental in its release. The Grid Planning staff, who are responsible for formulating the Strategic Grid Plan as well as the Regional Grid Plans are acknowledged for their invaluable contribution.

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