# Transmission Development Plan 2018 - 2027

Eskom

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# Foreword by Group Executive

*Electricity is the lifeblood of the 21st century lifestyle in ways so many of us take for granted. People whose homes, workplaces, schools, and clinics are connected to the grid for the first time find their lives transformed for the better in ways they could previously only dream of.*

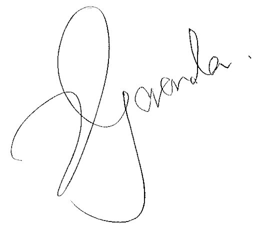
Electricity is generated in power stations all over South Africa. The bulk of South Africa's electricity is still produced by coal-fired power stations located on the coalfields of the Mpumalanga Highveld and near Lephalale. The REIPP programme of the DoE has resulted in increasing amounts of electricity being produced from renewable sources, mainly wind and solar, located primarily in the Eastern Cape, Western Cape, and Northern Cape.

The transmission system's primary role is to transport electricity in bulk from wherever it is generated to load centres throughout South Africa and the region. From there, distribution networks owned by Eskom, the Metros and municipalities deliver electricity to individual end-users. The system requires augmentation and reinforcement to connect new loads and sources of generation to the grid, as well as to meet the changing needs of customers, both load and generation. The transmission system also requires regular planned maintenance, and refurbishment or replacement of plant that has reached the end of its operational lifespan, to ensure that it performs its role safely and efficiently.

There are also cross-border transmission lines to Namibia, Botswana, Zimbabwe, Mozambique, Swaziland, and Lesotho, allowing electricity to be traded with the rest of Southern Africa. It is one of Eskom Transmission Group's strategic objectives to increase the capacity of these interconnections to allow for greater volumes of electricity to be traded to reduce upward pressure on tariffs and improve security of electricity supply in South Africa in the longer term.

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.



***Thava Govender***

*Group Executive: Transmission / Acting Group Executive: Risk and Sustainability*

*October 2017*

# Executive summary

*This publication contains information about projects intended to extend or augment the transmission system that have been completed in the past year as well as about projects that are planned for the next ten (10) years. The transmission network is the primary network of interest covered in this publication. This covers electrical networks with voltages ranging from 220 kV to 765 kV and the transmission substations where these networks terminate. A few 88 kV and 132 kV electrical networks are included due to their strategic nature.*

The projects covered in this document include the generation integration projects required to ensure that the network is adequate to evacuate and dispatch power 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 comprises network expansions 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. Nersa is due to review Eskom's funding and revenue requirements during the first quarter of 2018 and announce Eskom's tariff determination for MYPD4 (fourth multi-year price determination) period, commencing 1 April 2018. The plan will have to be revised 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.

During the second quarter of 2015 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 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 include the 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.

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# 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 system***

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***

***RE – Renewable energy***

***REBID – Renewable energy bids programme***

***REDZ – Renewable energy development zones***

***REIPP – Renewable energy independent power producer***

***REIPPPP – Renewable energy independent power producers procurement programme***

***RTS – Return to service***

A previously mothballed power station undergoing recommissioning.

***SEA – Strategic environmental assessment***

***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 the 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, which is 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 seventh TDP was published in October 2015; this is the eighth publication based on the TDP for the period 2018 to 2027.

## 1.2 Major factor changes from the 2015 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 2015. The two main factors include the capital constraints, followed by the potential generation scenarios. Other changes are as a result of the deferment of projects due to the lower load forecast, as well as the challenges in the acquisition of substation sites and servitudes for lines. Additional IPPs (conventional or renewable) have been assigned preferred bidder status and have either already been connected, or have been included in this publication.

### Capital constraints

Due to capital constraints experienced by Eskom, projects had to be reprioritised to fit within available budget. The reprioritised projects maximise the benefits accruing from the available capital, while minimising the risks to security and reliability of supply. The reprioritisation process will be repeated after each tariff increase ruling by Nersa to ensure optimal use of the available budget.

### Generation Assumptions

A number of generation projects that were assumed to be in place for the TDP studies for the period 2018 to 2027, 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, Independent power producer programme,** 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,** 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 Eskom..

**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. It deals with the different scenarios that can be expected for future generation in the different provinces and the planned corridors. This chapter follows on from the generation integration covered in Chapters 2 and 3.

**Chapter 8, Capital expenditure plan,** deals with the forecasted costs of implementing the TDP.

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

# **Chapter 2** Independent power programme

The DoE Independent Power Producer (IPP) programme has stimulated participation of the private sector in addressing the electricity needs of South Africa. The DoE IPPPP Unit has to date procured or initiated the process to procure energy from Independent Power Producers through the following programmes:

- Renewable Energy IPP Procurement Programme (REIPPPPP)
- Small Projects Renewable Energy IPP Procurement Programme
- Coal Baseload IPP Procurement Programme
- Cogeneration IPP Procurement Programme
- Gas IPP Procurement Programme
- The Solar Parks Project

The distribution of IPP technology for the announced procurement programmes to date, totalling 8 502 MW is as shown in figure 2.1.

Of the above mentioned IPP programmes, the Gas Peakers programme amounting to a total of 1 004.5 MW is the most advanced, with all projects commissioned and in commercial operation. These projects are located in Dedisa substation near Port Elizabeth and Avon Substation, approximately 30 km to the north of Durban.

The second most advanced programme is the REIPPPP with all projects in bid windows 1 and 2 connected and in commercial operation, while 14 of the 23 projects in bid windows 3 and 3.5 are commissioned and in commercial operation. The IPPs in bid windows 4 and 4B are at budget quotation phase. The Small REIPP, Coal Baseload IPP, Cogeneration IPP, the Solar Parks and the Gas to power projects are in the different phases of the development and concept stage.

## 2.1 Development plans to enable approved IPPs

The Renewable Energy Independent Power Producer (REIPP) programme has to date, procured around 6 401 MW of energy from 106 IPP projects. So far, a total of 61 projects are connected to the national grid, with 3 520 MW of renewable energy capacity in commercial operation..

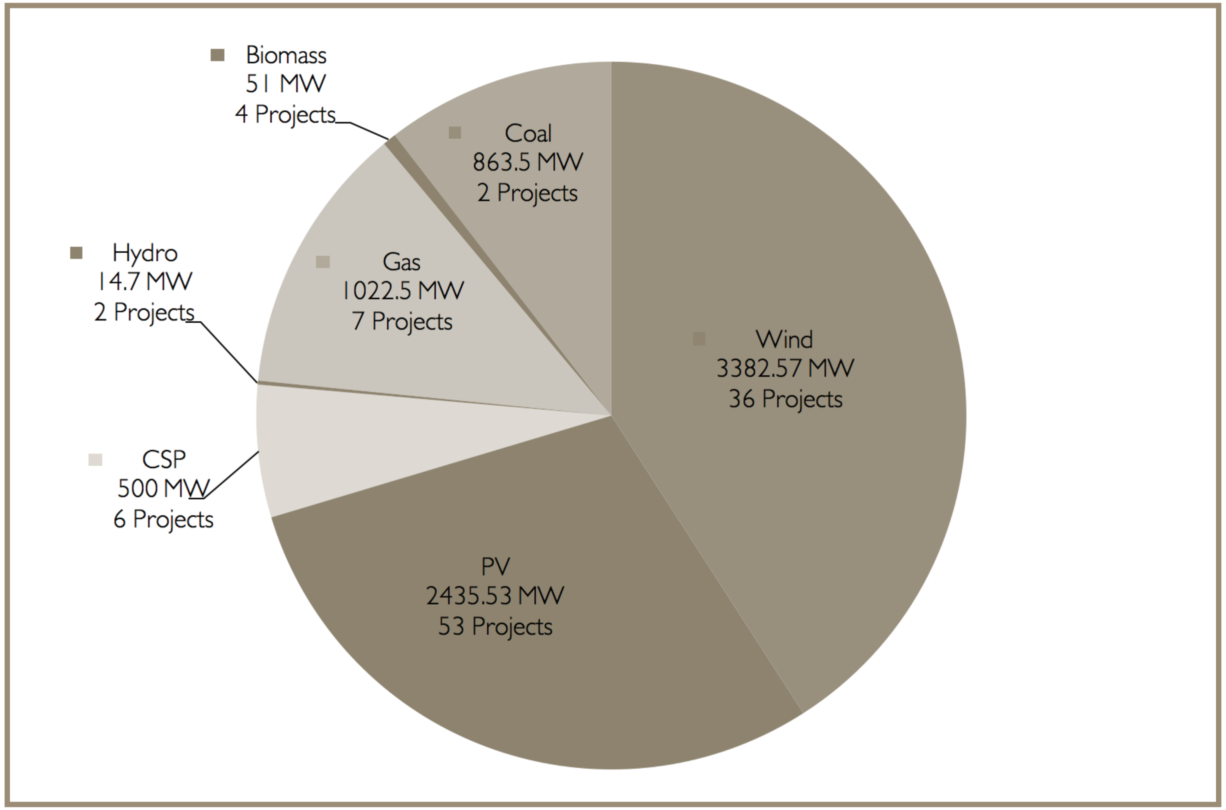



***Figure 2.1:*** Distribution IPP projects per technology

This new generation capacity is vital in meeting the needs of the economy as well as the objectives of the Integrated Resource Plan 2010 (IRP2010). The grid integration of these projects has exhausted the grid capacity that was previously available, particularly in the provinces of Northern Cape, Western Cape and Eastern Cape. Consequently, substantial grid infrastructure investments will be required to enable power evacuation from the majority of locations within these provinces to integrate additional IPPs.

The budget quotation process for 26 preferred bidder projects in REIPPPP bid windows 4 and 4B is currently in progress. These projects are expected to be connected to the national grid within the current TDP period. The bid window for small projects (1-5 MW), which is made up of 10 projects amounting to a total of 50 MW, is also in budget quotation phase and expected to be integrated within the current TDP period. Furthermore, the budget quotation phase for the two preferred bidders for Coal Baseload IPP Procurement Programme is also in progress.

| PROGRAM | NO. OF PROJECTS | MW CONTRIBUTION | CURRENT STATUS |
|---|---|---|---|
| *REIPPPP BW 1* | *28* | *1 436* | *All projects connected* |
| *REIPPPP BW 2* | *19* | *1 054* | *All projects connected* |
| *REIPPPP BW 3&3.5* | *23* | *1 656* | *14 projects connected, 8 in execution, 1 project in BW 3.5 awaiting financial close* |
| *REIPPPP BW 4* | *13* | *1 121* | *Budget quotation phase* |
| *REIPPPP BW 4B* | *13* | *1 084* | *Budget quotation phase* |
| *Smalls (1-5 MW)* | *10* | *50* | *Budget quotation phase* |
| *DoE Peakers* | *2* | *1 004.5* | *All projects connected* |
| *Coal Baseload* | *2* | *863.5* | *Budget quotation phase* |
| ***Total*** | ***110*** | ***8 269*** | |

***Table 2.1:*** Approved IPP projects status

Projects with the total allocated capacity of 863.5 MW are located in Mpumalanga and Limpopo Province. The expected connection to the grid for these projects is also likely to be within the current TDP period. The transmission integration scope of work for the integration of these projects has been finalised and funding for the upstream component of the scope of work to enable integration to the national grid has been included in the 2017 TDP funding requirements. The status of the IPP projects as at September 2017 is shown in Table 2 1.

The 2010 IRP calls for the diversification of electricity generating resources, particularly an increase in renewable energy resources, which will be spread across wider areas of the country. The Draft IRP that was released by the Department of Energy (DOE) in December 2016 also shows ambitions to integrate substantial RE generation in the country up to year 2050. Although the IRP outlines the total capacity per technology to be connected per year, it does not indicate the geographical location of the projects within South Africa. This spatial uncertainty makes it difficult to formulate plans for grid enhancements, particularly for REIPPPP. The location of potential Coal Baseload IPPs and Gas IPPs are relatively easy to predict compared to REIPPPP, which minimises the risk to development as the network-enabling activities can be initiated prior to the announcement of the preferred bidders. This is because the location of coal deposits nationally is known and the coal plants tend to be developed in close proximity to coal deposits, and the location of Gas IPPs and the Solar Parks projects are announced during the initial phases of a programme.

On the contrary, the location of the REIPPPP projects is only confirmed subsequent to the announcement of the preferred bidders, which presents a risk to timeous development of the enabling grid connection infrastructure, particularly long transmission lines and new substations. The process to implement major transmission infrastructure projects could take up to ten years from inception to commissioning. The key components of the transmission project development cycle resulting in this long project establishment timelines include planning, environmental authorisation, land acquisition, procurement and construction.

In contrast, the IPP plant infrastructure can be developed in relatively short periods at specific locations. The disjoint in the length of time between IPP plant development and establishment of back bone transmission infrastructure is thus of concern. If new transmission projects are required for the IPPs, it is difficult for such projects to be delivered within the desired target dates, which provides challenges for the future programmes.

These include:

- Establishment of the Grid Access Unit (GAU) and the Single Buyer Office to facilitate the connection requests of IPP developers and the buying of 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.
- Participation in the Grid Enablement Working Group to facilitate the development of the Transmission and Sub-transmission grid for future IPPs.

## 2.2 Strategic plans to enable future IPPs

Enabling successful integration of future energy from renewable sources in the current environment, which is characterised by diminishing connection capacity, connection location uncertainly and drawn-out network development, present a major challenge for a conventional planning philosophy. Thus, a major shift in the network planning approach for the future transmission grid has been adopted to ensure agility of the transmission development plans to adapt to the uncertainty of future load and generation locations. The development plans identify the critical power corridors and constraints on the transmission network and provide strategies to unlock and create a flexible and robust grid, which is 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-related 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. Amongst the more significant studies is the one conducted by the CSIR, in conjunction with DEA and Eskom, to identify suitable zones for the efficient and effective roll-out of wind and solar PV energy as part of the Government's 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. The identified REDZs were gazetted on 13 April 2017, in terms of the Government Notice (GN) 350.

Eskom has taken a twofold approach to strategically prepare the transmission grid for the creation of additional generation connection capacity. The first entails 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.

## The immediate to medium-term period

GCCA document, which indicates area with available connection capacity across the entire transmission grid and a set of transmission projects that could be implemented within a relatively short period over a number of phases, is used to provide indicative connection capacity in the immediate to medium-term period. 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 2. 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.

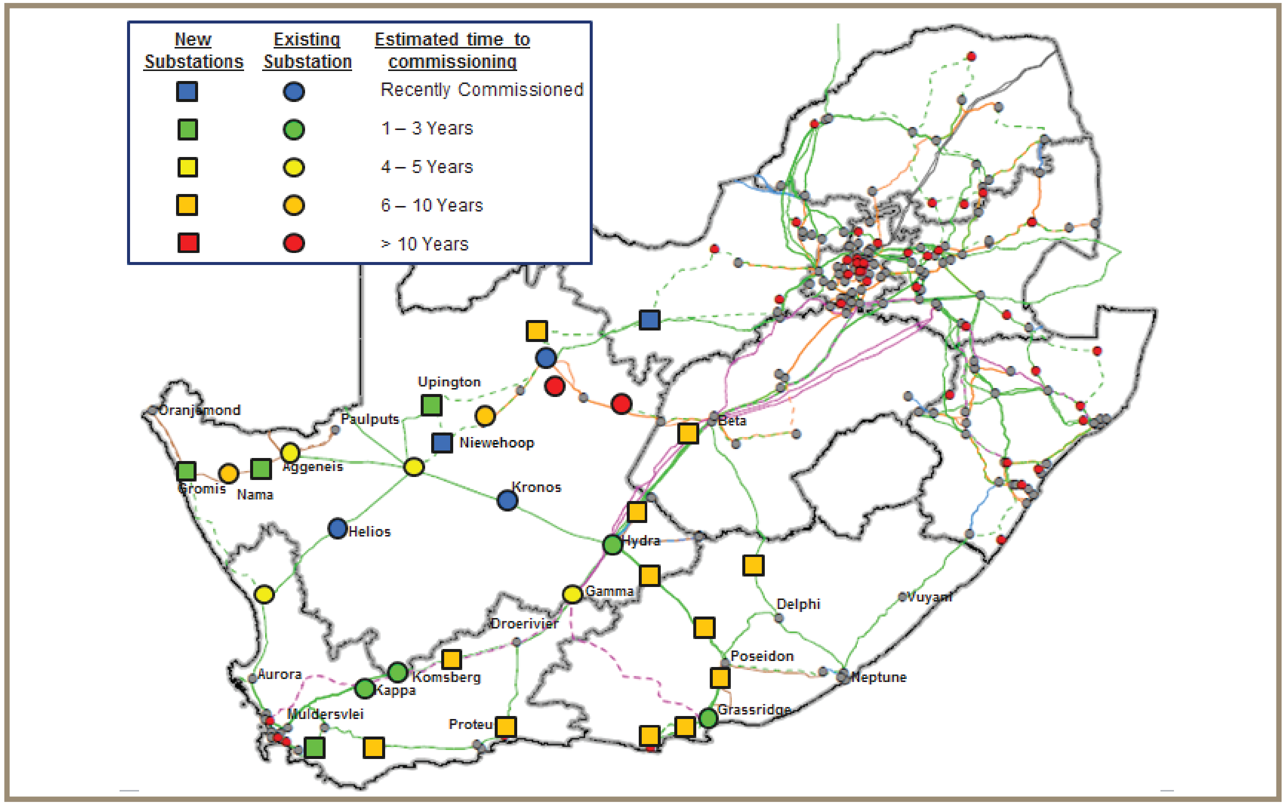



*Figure 2.2:* Generation connection capacity for the immediate to medium term

## 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 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.

These power corridors were gazetted for comment on 13 April 2017, in terms of the Government Notice (GN) 350.

The five transmission power corridors are shown on the map in Figure 2.3.

Furthermore, a study was commissioned by the Grid Enablement Working Group (under the auspices of Eskom and DoE IPP Office) to investigate the least-regret approach to effectively enable the integration of future energy from renewable sources in spite of the associated spatial dispersion and capacity challenges. This entails adopting a framework that favours the long-term transmission and distribution network development to facilitate optimal integration of future generation from renewable resources. The key objective of the study was to mitigate the potential risk of delays to grid connection by strategically initiating key grid enablement activities like environmental authorisation, land acquisition, licencing requirements and design. The main development infrastructure items identified were future distribution stations (collectors and satellites), transmission substations, as well as the power corridors for both transmission and distribution. The adopted network analysis criteria were in accordance with applicable distribution and transmission network codes and standards.

Information from previous IPP applicants, together with the IPP EIA applications database, was used to determine areas where the interest is likely to materialise in the future. This amounted to 35 076 MW of potential generation, which represents about 64% of the total generation from renewable sources in the Draft IRP of 2016. The study also took into account the work done previously to determine the Renewable Energy Development Zones (REDZ), as well as the subsequent SEAs.

Information from previous IPP applicants, together with

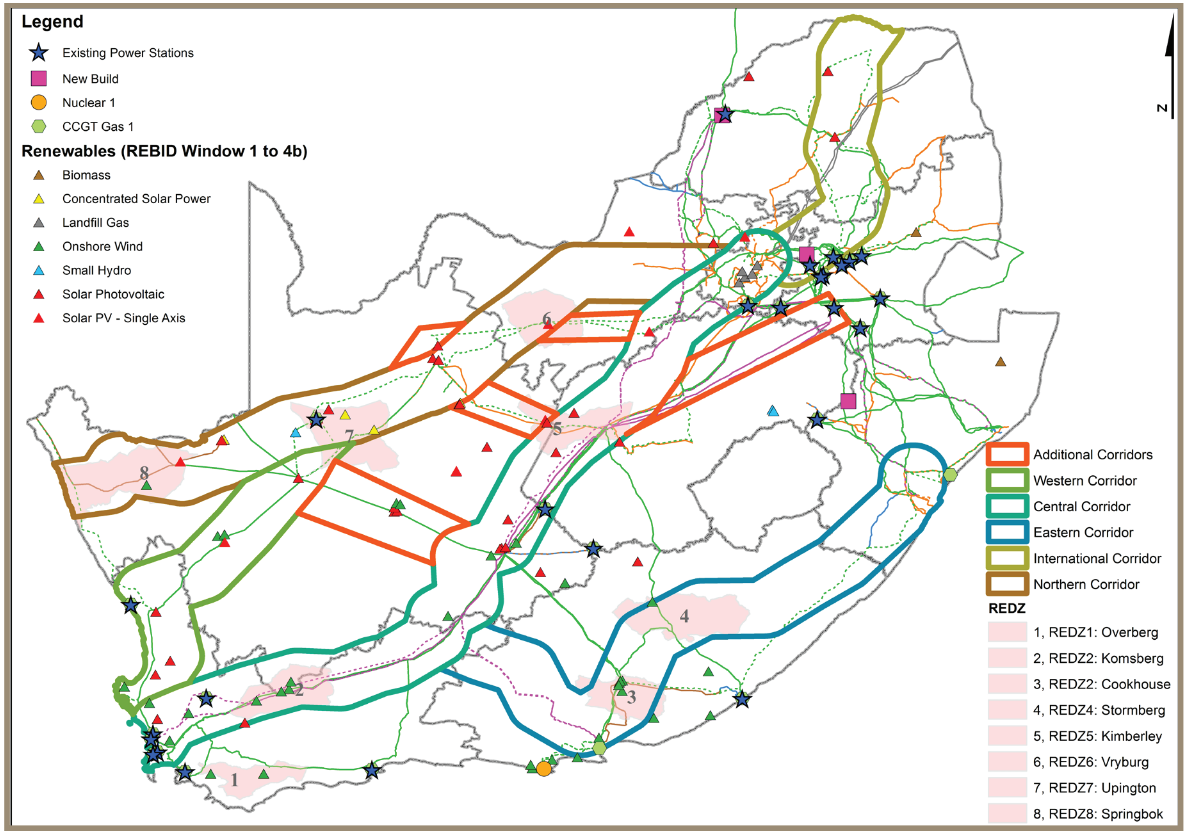



***Figure 2.3:*** Power corridors for the longer term

the IPP EIA applications database, was used to determine areas where the interest is likely to materialise in the future. This amounted to 35 076 MW of potential generation, which represents about 64% of the total generation from renewable sources in the Draft IRP of 2016. The study also took into account the work done previously to determine the Renewable Energy Development Zones (REDZ), as well as the subsequent SEAs.

The results of the study indicate that a number of main additional transmission strategic corridors need to be included in the Strategic Environmental Assessments over and above those already identified in the SEA study. The results also indicate that extensive transmission and distribution infrastructure will be required to enable future IPP connections. Eskom has secured technical approval of the strategic plan and the process is under way to engage stakeholders and identify the least impact approach to incorporating the identified additional corridors on to the SEA. Additional transmission corridor requirements to enable potential IPPs are shown in Figure 2.4.

This strategic plan will ensure that the spatial uncertainty to connect to the grid is mitigated for, which will result in the energy mix imperatives of the IRP being met more optimally. Further, the future network is optimised in terms of aggregate infrastructure requirements, cost effectiveness, grid accessibility to various IPPs, environmental impacts, and project delivery timelines.

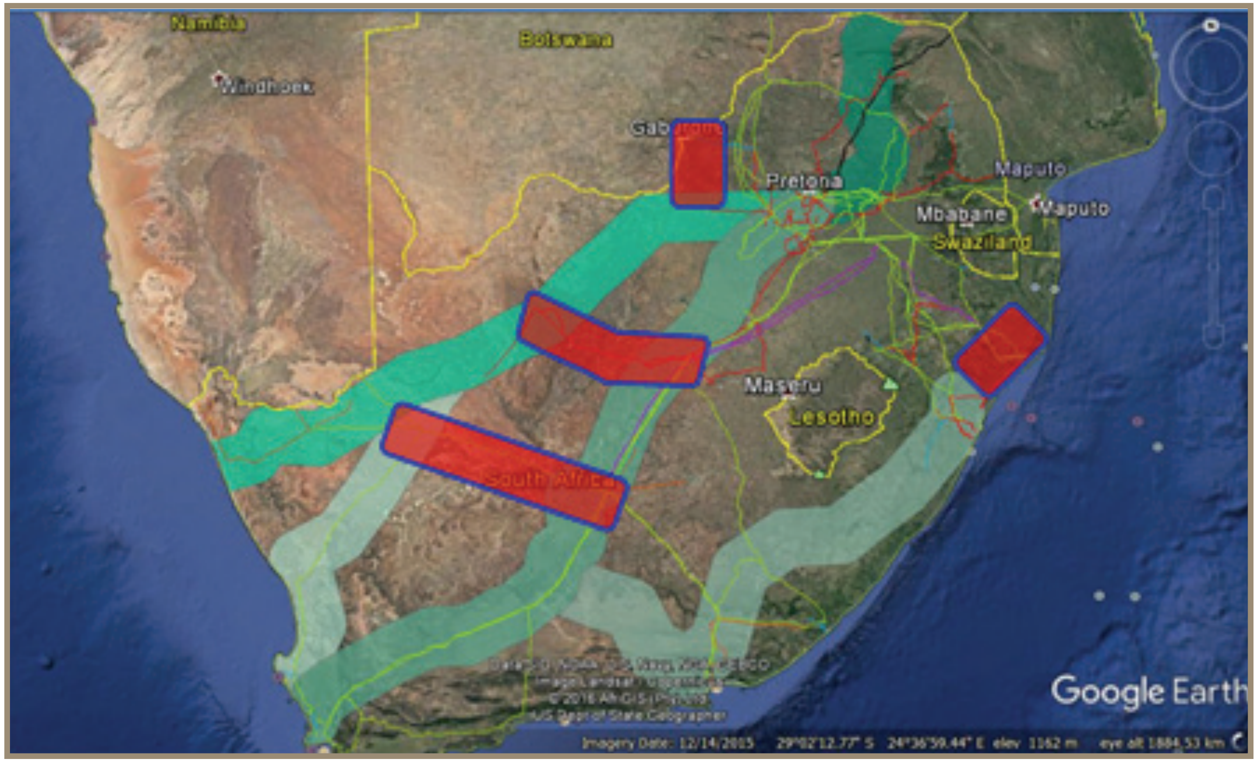



***Figure 2.4:*** SEA Corridors and additional strategic EIA for future REIPP

# Chapter 3
Load demand forecast and generation assumption

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 consists 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

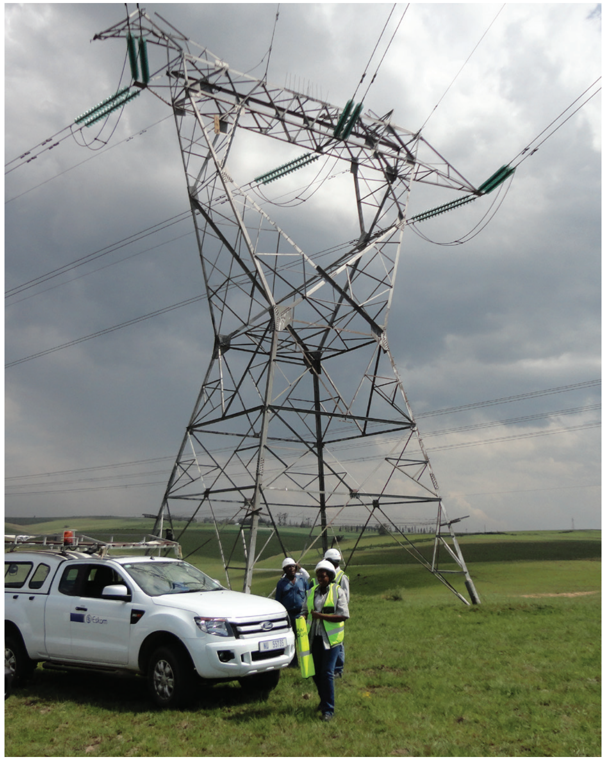
ELoad forecasting is a fundamental requirement in the Transmission planning cycle. The availability of sufficient transmission network capacity in any country is important for economic growth. Eskom's Grid Planning department, in consultation with the relevant Distribution operating units, Metros and Municipalities, compiles a forecast per point of supply for the network model.

A double S-curve methodology, combined with normative quantitative and qualitative techniques, is used to produce two national forecast scenarios. The two scenarios are described as Transmission High and Transmission Low forecast, respectively.

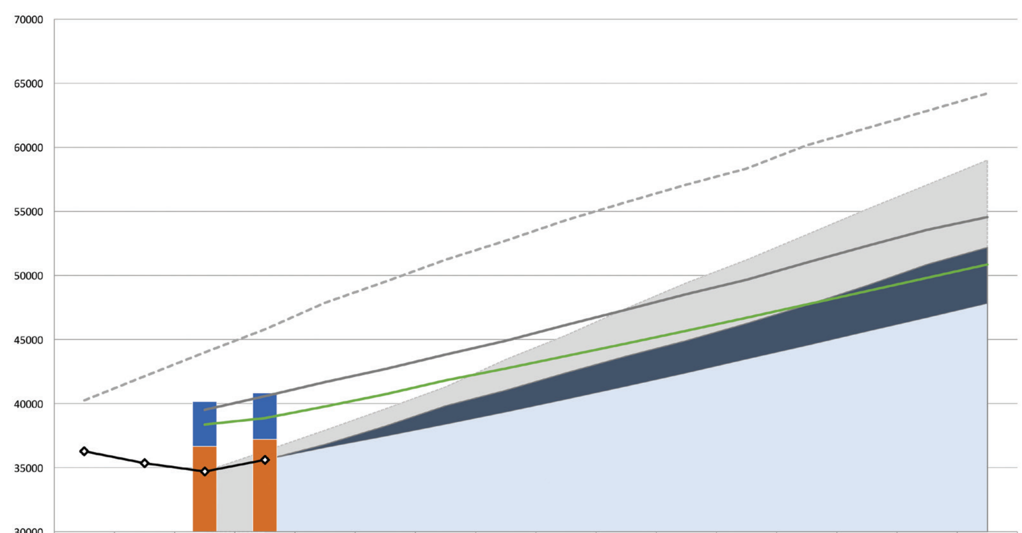
The Transmission High scenario is based on assumptions which will take South Africa from a developing country to a developed country and therefore indicates more optimistic growth figures. The high scenario is in line with the projected 3% GDP & GVA-R average year-on-year growth expected for the TDP period 2018 to 2027. This scenario assumes the return of current suppressed industries due to world economic conditions, and trade contracts influencing imports, exports and local production. The majority of large power users retained the allocated notified maximum demands, which is an indication that the return to full production within the TDP period is a likely prospect. The Transmission Low Scenario is based on assumptions that there will be a continued suppressed development rate in the country and most of the industries will not return to original status. However, this is a more pessimistic view with a year-on-year growth rate of just below 2%, and lower than the projected GDP & GVA-R Total industry figures.

These load forecasts, including the projected 2016 Draft IRP load forecast, can be seen in the graph in Figure 3 1. The Notified Maximum Demand (NMD) contractual values for 2015 and 2016 (Top and mid-sized customers) are indicated, demonstrating the commitment of the consumers beyond the economic downturn.

While the actual peak demand (indicated by the black line) has been on the decline over the past few years, mainly due to generation constraints, transmission development planning is based on meeting the high forecast. Therefore, the planning process still enables capacity to serve the base load throughout all feasible network operating conditions.



**National Demand Forecasts (MW) at Time of System Peak of the Transmission High and Low Forecast, shown with the IRP and ISEP forecasts for the TDP period 2018-2027**




| | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2015 TDP Demand (MW) - Constrained | | | 34695 | 36312 | 37928 | 39587 | 41294 | 43437 | 45322 | 47433 | 49408 | 51223 | 53188 | 55180 | 57070 | 58997 |
| 2016 TDP Demand (MW) - Transmission High | | | | 35608 | 36816 | 38245 | 39826 | 41051 | 42415 | 43708 | 44924 | 46255 | 47694 | 49232 | 50864 | 52182 |
| 2016 TDP Demand (MW) - Transmission Low | | | | 35608 | 36572 | 37452 | 38374 | 39333 | 40326 | 41347 | 42393 | 43458 | 44538 | 45627 | 46721 | 47815 |
| Mid Size Customer NMD (MW) | | | 3472 | 3621 | | | | | | | | | | | | |
| Top Customer NMD (MW) | | | 36676 | 37211 | | | | | | | | | | | | |
| Actual Peak Demand (MW) | 36276 | 35343 | 34695 | 35608 | | | | | | | | | | | | |
| 2010 IRP Demand (MW) | 40264 | 42129 | 43994 | 45786 | 47870 | 49516 | 51233 | 52719 | 54326 | 55734 | 57097 | 58340 | 60150 | 61500 | 62850 | 64200 |
| 2016 Base Draft IRP Demand (MW) | | | 39514 | 40589 | 41682 | 42702 | 43831 | 44916 | 46130 | 47336 | 48547 | 49656 | 51015 | 52307 | 53561 | 54567 |
| ISEP 2017 | | | 38370 | 38880 | 39770 | 40720 | 41810 | 42750 | 43710 | 44680 | 45680 | 46710 | 47750 | 48783 | 49818 | 50852 |

***Figure 3.1:*** The Eskom transmission system demand forecast

## 3.2 Generation assumptions

The Department of Energy (DoE) is accountable for the country's energy plan. This energy plan is termed the Integrated Resource Plan (IRP). The IRP is intended to drive all new generation capacity development for South Africa. Ministerial determinations on the connection volumes are made in different bid windows of the REIPPPP and Nersa licenses new generators according to these determinations.

The current official 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. A draft updated IRP version, which is referred to as the 2016 Draft IRP in this document was published on 22 November 2016 for comments. 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).

In June 2015 an agreement between Eskom Transmission and the IPP Office, representing the DoE, was reached that requires the TDP updates to take into consideration alternative generation scenarios. This section describes the alternative generation scenarios that were considered for this TDP update to assess their impact on the TDP baseline for this period. The different scenarios are listed below and each scenario is discussed on how to undertake the study in a separate section.

The TDP Generation Plan for the period 2018 to 2027 is based on the IRP 2010 report. There is a Generation Baseline Plan to be considered for this TDP update and associated network studies. This current installed and planned capacity is shown in Figure 4 below and indicates both the schedule for the conventional (dispatchable) generation plant and the renewable energy (variable/non-dispatchable) plant. Appendix A shows the Generation Baseline Plan allocation for the current TDP in tabular form.

The current forecast was focused at the lower end of the IRP's Cone of uncertainty. The generation roll out of the IRP, specifically the nuclear programme, which is unlikely to be delivered within the TDP period, was still included to test the impact on the TDP if critical corridors would be required. This is to enable aggregation of renewables, gas, and the nuclear considerations when identifying corridors.

In order to achieve the proposed IRP 2010 Plan, a number of assumptions regarding size and location of the future planned generation plant had to be made. These assumptions are discussed in detail in the sections that follow. The generation assumptions for the TDP period were fixed in February 2017 based on what was known and expected at the time, guided by the IRP 2010 and the 2016 Draft IRP, and are discussed below.are discussed below.

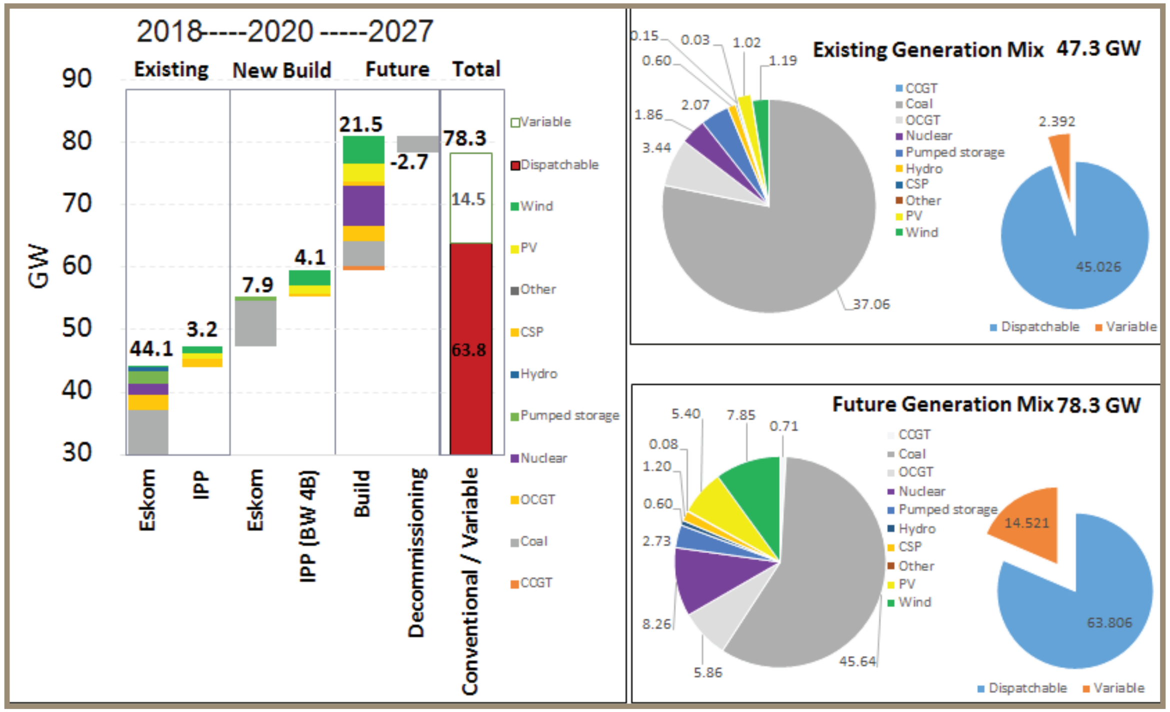



*Figure 3.2:* TDP Base Case Generation

## Existing and approved power stations

The existing generation fleet is assumed to be available over the 2018 to 2027 period, except for the units expected to be decommissioned at three power stations by 2026 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 846 MW units coal-fired – 794 MW sent out per unit

**Kusile:**
6 x 846 MW units coal-fired – 794 MW sent out per unit

**Ingula:**
4 x 333 MW units pumped-storage – 333 MW sent out per unit

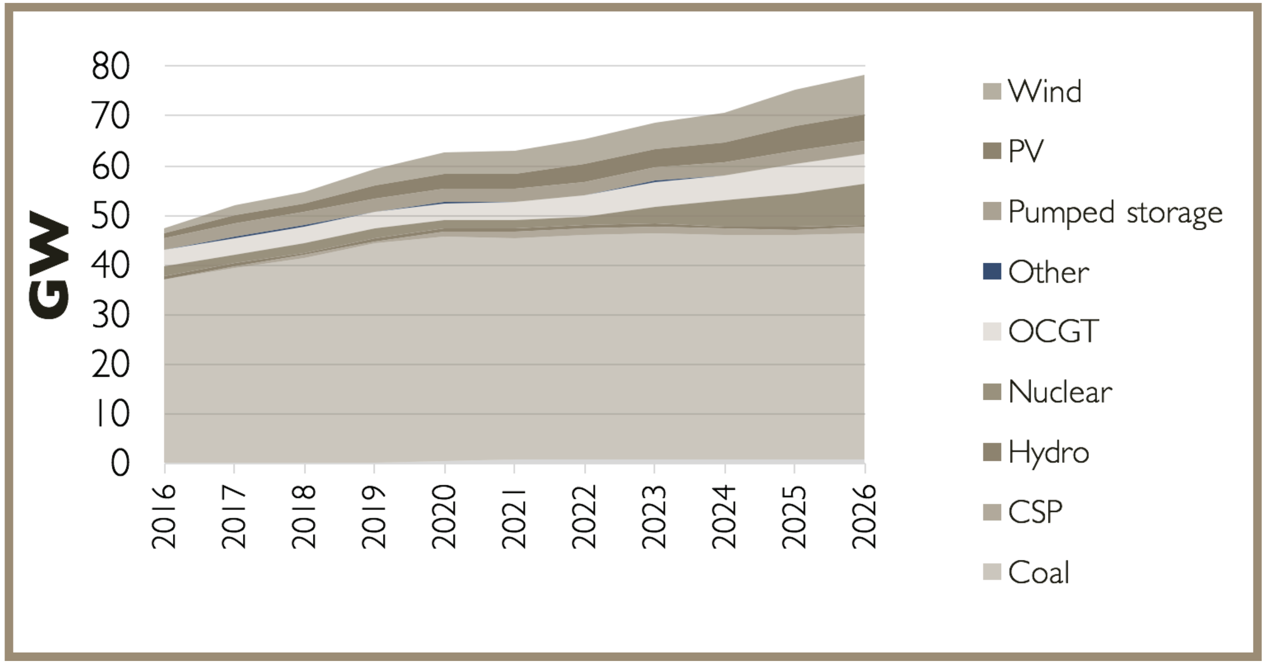



***Figure 3.3:*** Current and future assumptions on generation allocation

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.

The spatial allocation of the generation is provided in the following figures. This demonstrates the potential generation footprint from the current to the future.

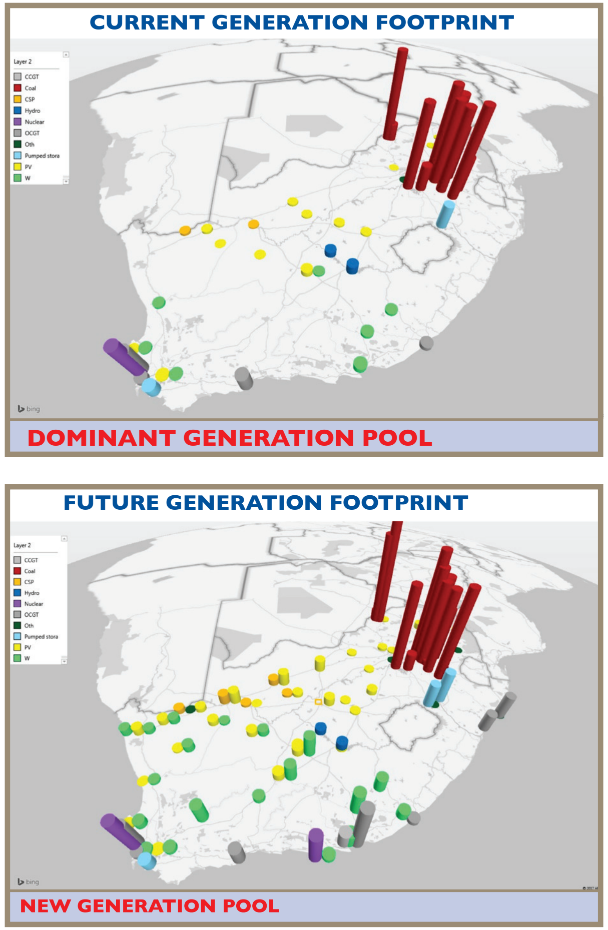



***Figure 3.4:*** Current and future generation spatial footprint

## DoE OCGT power stations

The two DoE OCGT plants (peaking) are assumed to be available for the 2017 system peak. These are modelled as follows:

- 2 x 167.5 MW units at Dedisa (335 MW)
- 4 x 167.5 MW units at Avon (670 MW)

These will be treated as peaking plant in the TDP studies where they will only be used during system peak or, if required, under contingency conditions. For provincial studies, they will be at full output under the local grid peak conditions and light load to ascertain that all the power can be evacuated.

## Ingula Pumped-storage

The Ingula pumped storage power station is an approved project. The project has been rescheduled with delays and it was assumed to have units 1 and 2 completed in time for the 2017 system peak with units 3 and 4 completed in time for the 2018 system peak.

## Coal generation

**Baseload coal (Medupi and Kusile)**

The base load coal power stations at Medupi and Kusile are approved projects. The first unit of Medupi is available and the last unit will be completed before the end of 2020. Kusile's first unit will be available in 2018 with the last unit in place before the end of 2022. For peak studies, the units were assumed to be available in the year subsequent to the scheduled completion dates in Table 3.1 below. No further large Eskom base-load coal-fired power stations are expected for the TDP period of 2018 to 2027.

| Year | Medupi | Kusile |
|---|---|---|
| 2016 | 846 | 0 |
| 2017 | 1692 | 0 |
| 2018 | 0 | 846 |
| 2019 | 1692 | 846 |
| 2020 | 846 | 846 |
| 2021 | 0 | 1692 |
| 2022 | 0 | 846 |
| 2023 | 0 | 0 |
| 2024 | 0 | 0 |
| 2025 | 0 | 0 |
| 2026 | 0 | 0 |
| 2027 | 0 | 0 |
| **Total** | **5 076** | **5 076** |

***Table 3.1:*** Medupi and Kusile completion schedules

## Co-generation projects and MTPPP

A total of 1 800 MW of co-generation plant has been allocated in the Ministerial Directive issued on 18 August 2015. There is no indication of what size plant and where these plants will be located. The MTPPP programme which offers PPA contracts to any generators that fall below a certain price level are not considered at Transmission level as most of the units were less than 20 MW in size. Co-generation plant will be located on existing industrial sites and will therefore have existing network in place which can be used for the evacuation of the power. Thus, based on the likelihood of existing network and the unknown locations, this co-generation is not considered in the TDP studies. Any large specific co-generation plant will be studied on submission of a generation connection application.

## New build coal options

In October 2016, the Minister of Energy approved approximately 900 MW of new coal generation. This consists of two power stations, Khanyisa (300 MW) and Thabametsi (600 MW). The IRP Update has no further provision for new coal-fired power stations beyond the allocated 900 MW.

A total of two new IPPs have been assumed, referred to as Coal IPP 1 and Coal IPP 2. Coal IPP 1, Khanyisa, will be in the Witbank area in 2021 with a capacity of 300 MW, a nd Coal IPP 2, Thabametsi is modelled as a 600 MW power station in 2021 in the Lephalale area probably at Massa Substation.

## Nuclear generation

There is no allocation for nuclear generation in the 2016 Draft IRP, however, due to the RFI and pending RFP that have been publicised, it has been decided that one unit should be tested in the TDP in 2027. The TDP tested for 1 600 MW in the Eastern Cape, Thuyspunt, in the base case and the same volume in the Western Cape as a scenario; this will cater for the possible approval of nuclear in either province within the TDP period.

Appendix A (Table A1) contains tables with the allocation of the conventional generation, including nuclear generation for the current TDP period.

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

The 2016 Draft IRP has a total of 3 300 MW of OCGT capacity in the TDP period. This is aligned with the DOE Preliminary Information Memorandum (PIM) which indicates a total of 3 000 MW of gas that is being earmarked (https://gaslng.ipp-gas.co.za/). Of the total 3 000 MW in the PIM, 1 000 MW has been allocated at Dedisa Substation in 2022 and 2 000 MW at Athene Substation split between 2024 and 2026. It is anticipated that the RFP for these gas projects will be issued in 2017.

The IRP Update proposes 4 400 MW of CCGT generation between 2025 and 2027. This coincides with higher generation decommissioning in the IRP update. Because of this, it was decided that the CCGT gas generation will be limited to approximately 700 MW in the TDP to be located in the Dedisa area. Because of the very high generation possibilities in the Port Elizabeth area, it is believed that there are sufficient tests in the area to cater for more CCGT should it be allocated in this area. This assumption will be revised as more information becomes available regarding decommissioning and nuclear generation in the Eastern Cape

## Imported hydropower

In the past, there was an assumption that about 1 200MW of imported hydro generation would materialise in the TDP period. The IRP Update has no imported hydro in the TDP period; the initial imports from Inga are anticipated in 2030, which is well outside the TDP period.

## Renewable energy IPP generation

The Government REIPPPP programme (known as the REBID programme) has gone out for procurement with windows 1, 2, 3, 3.5, 4 and 4B completed and the successful bidders confirmed or short-listed. The REBID allows IPPs to bid tariffs within maximum tariff limits for the following renewables:

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

## Successful and shortlisted RE bidders

For the purposes of the TDP planning studies it is assumed that the successful and short-listed IPPs for windows 1 to 4B will be in place in the year as per their submission up until 2021.

The renewable generators were modelled as discrete generators per project on the LV busbars (132 kV, 88 kV or 66 kV) of the MTS substation that either supplies the distribution network that they are connected into or is the point of connection as the case may be. The purpose is to determine how much the renewable generators offset the load being supplied by the MTS transformers. This modelling philosophy applies to all the types of renewable energy plants that are greater than 5 MW. Each different IPP unit is identified by the unique IPP ID number allocated by the DoE REBID process and grouped into the different types of generation.

## Future RE generation

From 2020 to 2027, the renewable energy generation as per the 2010 and Draft IRPs has been allocated in blocks of 100 MW units to various transmission substations per year to determine the overall impact on the transmission power flows. The even-spread of the RE allocation from 2020 to 2024 has been brought forward to bias a larger allocation in 2020 in line with the expectations of the IPP Office.

## Wind generation

In order to investigate the potential impact of wind generation, the successful wind plants from windows 1 to 4B of the REBID programme are modelled for 2018 to 2019 as well as proxy wind generators at the assumed allocation of future wind plants for 2020 to 2027.

The future wind generation has been assumed based on among others:

- the proposed REDZ areas from the Government SIP 8 project
- the Eskom study to map and quantify RE developer interest
- the Eskom proposals to DOE for phased transmission projects to increase grid connection capacity for RE generators
- assessment of RE generation connection applications received by Eskom for the various REIPPPP bid windows
- discussions with the IPP Office on potential sites and their report on IPP generation forecast input for the TDP process

Cumulatively the wind generation will have an impact on the power flows at transmission level under certain operating conditions. For the purposes of the TDP studies it is proposed that they be studied under the following operating conditions:

- 30% output at Time-of-System-Peak all (national - the base case)
- Zero output at Time-of-System-Peak load (national)
- 60% output at Time-of-System-Peak load (national)
- Zero, 30% and 60% output at the local Time-of-Grid peak (provincial)
- Zero, 30% and 60% output at system Low Load (national)
- Full 100% output at the local Low Load (provincial
- Zero and 30% output at the local Low Load (provincial)
- Zero, 30% and 60% output at Midday Load high (national and provincial)
- Zero, 30% and 0% output at local Midday Load low (national and provincial)

This is to determine the capacity and potential weakness under the extreme generation conditions based on the assumed connection at the MTS substations. For the normal Time of system peak (TOSP) modelling the wind generation is set at 30% of rated output, in line with the assumptions utilised for the 2010 IRP studies and recommendations.

Appendix A (Table A3) contains tables with the allocation of the wind generation for the current TDP period.



## PV solar generation

A significant amount of solar PV has been allocated under New Build options in the IRP Update with approximately 5 800 MW allocated by 2027. REIPPPP has resulted in many large PV solar plants in the grid. PV can only operate when there is sunlight and will therefore not be available for system peak. Effectively, PV does not contribute to meeting the peak system demand or add to the generation at the time of system minimum in the early hours of the morning. Thus, the PV can be excluded for studies of these two network conditions.

The cumulative effect of PV during the daylight hours will have an impact, particularly at peak output during low daytime loading and where they are connected to other generation within an MTS supply area. In order to investigate any potential impact, the successful PV plants from windows 1 to 4B of the REBID programme were modelled for 2017 to 2019 as well as at the assumed allocation of future PV plants for 2020 to 2027.

These generators were switched off during normal studies for the peak load and low load cases and only used when studying the daytime network condition. The following network conditions and PV output were studied:

**System wide**
Midday load high with PV at 95% output (Week day)
Midday load low with PV set at 95% output (Weekend)

**Province wide**
Midday load high with PV at 100% output (Week day)
Midday load low with PV set at 100% output (Weekend)

The objective is to identify the risk of network violations for high PV output, the magnitude of impact and whether new transmission lines or transformers would be required, especially for the assumed PV distribution after 2020. The allocation of PV, approved bidders, and future plant (Proxy PV), for the baseline generation schedule are shown in Appendix A (Table A2).

## Concentrated Solar Power (CSP) generation

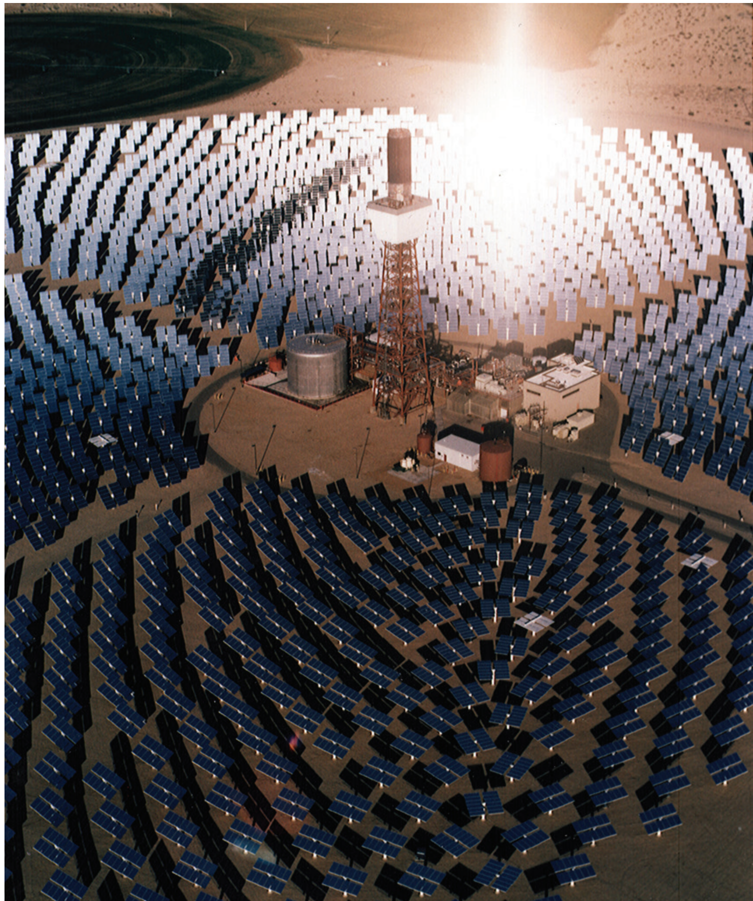
The total Concentrated Solar Power (CSP) generation has been set at 1 050 MW in the IRP Update. For the purposes of the TDP studies, the seven successful CSP projects amounting to 600 MW from the REBID programme have been allocated as follows:

- Ferrum 100 MW
- Garona 50 MW x 2
- Olien 100 MW
- Paulputs 100 MW x 2
- Upington 100 MW

It is assumed that the balance of the IRP allocation for CSP will be in the year 2020 based on 150 MW plants that will be connected at Ferrum (2020) and Upington (2020) as indicated in Appendix A (Table A4). These units will be run at maximum output during both the system peak and the local (provincial) peak as well as for the Midday load conditions. They will not be run during the low load conditions at night.

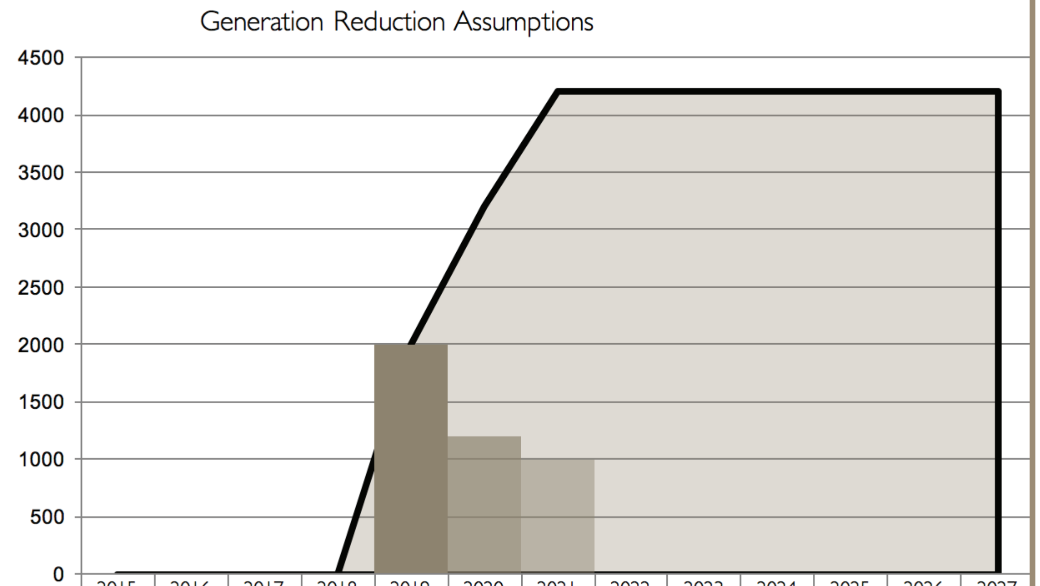
## Other RE IPP renewable generation

The majority of the REIPPPP is expected to be wind generation, PV and CSP with the balance made up of landfill gas, biomass and small hydro. The landfill and small hydro are a mixture of relatively small units and they are most likely to be connected to the Distribution networks (Eskom or municipal). These were not be modelled on the transmission system as it is believed that their impact will not be material.



## Assumed Generation Reduction

The 2016 Draft IRP indicates that the initial decommissioning of large coal units will start in 2020. However, the schedule for the decommissioning has not been finalised. As a result, decommissioning schedule assumptions were made in order to assess the impact on the transmission network pending the final decision. According to the assumption used in this TDP, generation reduction will start in 2019, with 2 000MW at Hendrina Power Station. This will be followed by 1 200 MW and 1 000 MW at Komati and Grootvlei respectively, in the subsequent two years as shown in Figure 3 5.


| | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Cummulative Decommissioning | 0 | 0 | 0 | 0 | 2000 | 3200 | 4200 | 4200 | 4200 | 4200 | 4200 | 4200 | 4200 |
| Hendrina | | | | | 2000 | | | | | | | | |
| Komati | | | | | | 1200 | | | | | | | |
| Grootvlei | | | | | | | 1000 | | | | | | |

***Figure 3.5:*** Power station decommissioning

## 3.3 Scenario sensitivities

The IRP is not specific about the spatial allocation of generators. This creates a problem in terms of the robustness of the plans. For that reason, an agreement was made with the IPP Office, representing the DoE, that the TDP updates would take into consideration alternative generation scenarios. The scenarios are generated by shifting generating units between provinces while maintaining the total generation by the end of the TDP period constant. Allocation of alternative sites and spread of the future generation is made from 2020 to 2027, but the main year of consideration will be 2027 when the full impact of these scenarios can be identified.

This section describes the alternative generation scenarios considered for this TDP Update to assess their impact on the TDP baseline for this period. The different scenarios are listed below:

The scenarios are as follows:

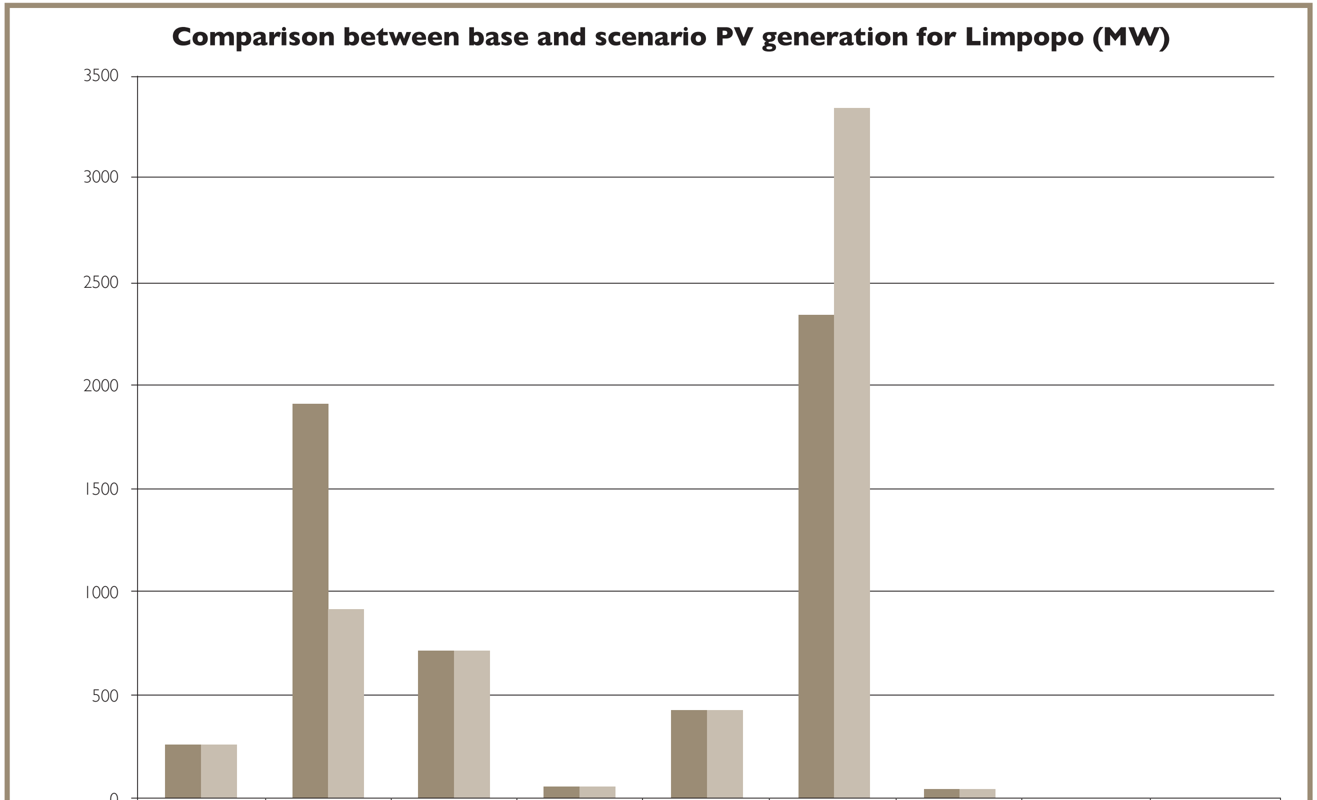
- Limpopo PV Scenario
- Northern Cape Wind Scenario
- Western Cape Wind, Gas and Nuclear Scenario

Figures 3.6, 3.7 and 3.8 show graphical representation of the allocation of the future RE generation using the above scenarios. They indicate the redistribution of the future generation to meet the three alternative generation scenarios.

## Scenario 1: Limpopo (Solar PV)

The purpose of this scenario is to determine the impact on the transmission network within Limpopo if 1 000 MW of solar PV generation is moved from the Northern Cape to Limpopo. As described, this is not new generation, but generation that is displaced from the Northern Cape to Limpopo. The Limpopo network study considered this scenario in addition to the base case to check if the network is still sufficient. Figure 3 6 shows the generation reallocation under this scenario. 1 000 MW of the future solar PV was allocated to the following locations in Limpopo as alternatives to the baseline allocation:

- Medupi: 200 MW
- Witkop: 100 MW
- Ndzhelele: 200 MW
- Tabor: 200 MW
- Spencer: 200 MW
- Foskor: 100 MW




| | FS | LM | NW | EC | WC | NC | GP | KZN | MP |
|---|---|---|---|---|---|---|---|---|---|
| PV Lim PV | 264 | 1918 | 725 | 60 | 434 | 2346 | 50 | 0 | 0 |
| PV Base | 264 | 918 | 725 | 60 | 434 | 3346 | 50 | 0 | 0 |

***Figure 3.6:*** Limpopo PV scenario generation comparison to base case

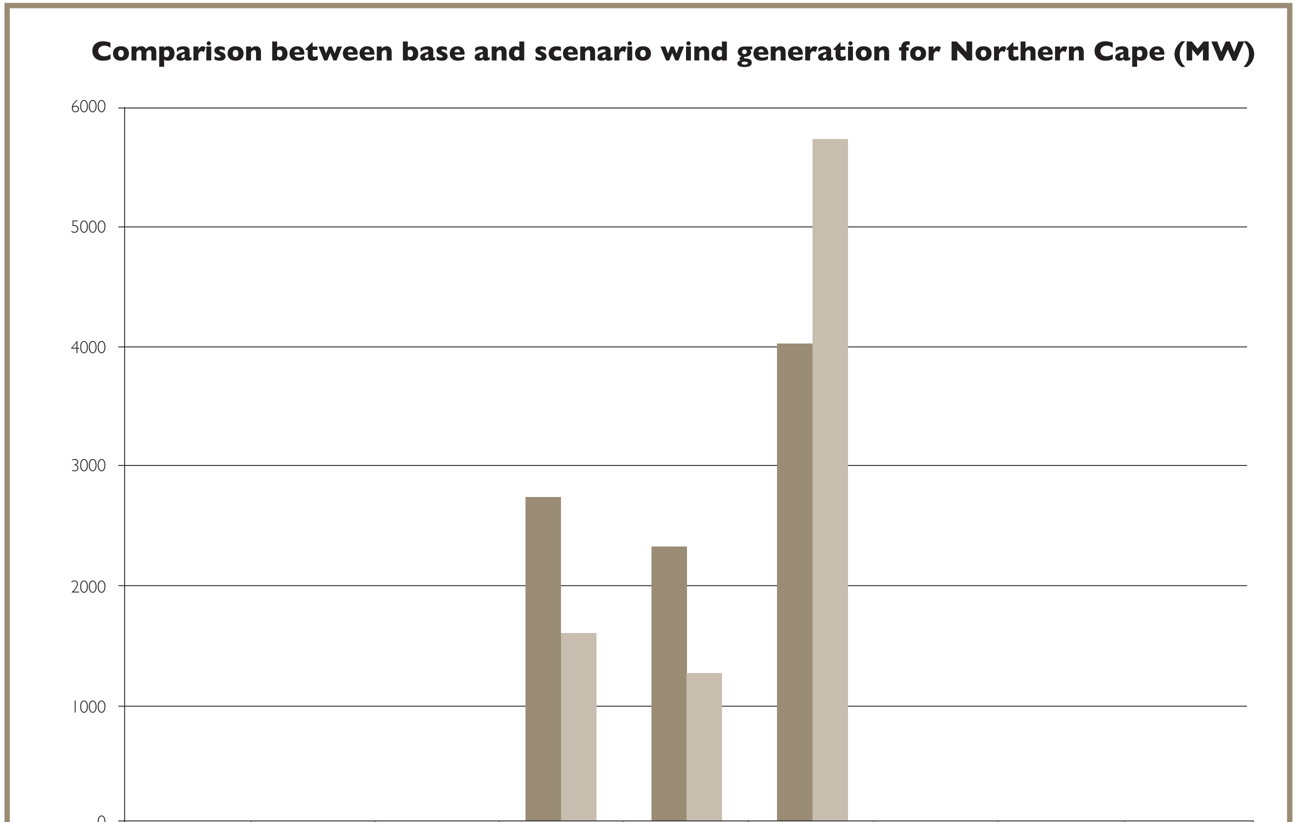
## Scenario 2: Northern Cape Wind Scenario

The purpose of this scenario is to determine the impact on the transmission network within Northern Cape if around additional 2 300 MW of wind generation is moved into the Northern Cape. The additional wind generation was added as listed below:

- Nama: 200 MW
- Gromis: 100 MW
- Aggeneis: 300 MW
- Oranjemund: 400 MW
- Kronos: 500 MW
- Gamma: 400 MW
- Aries: 400 MW

The Eastern Cape and Western Cape wind generation was left at the normal rated output of 30%, while the wind generation in the Northern Cape runs at full 100% output. Any network violations were noted and initial proposals made on how these violations are likely to be mitigated.

Figure 3.7 illustrates the scenario in a table as well as a summary graph.




| | FS | LM | NW | EC | WC | NC | GP | KZN | MP |
|---|---|---|---|---|---|---|---|---|---|
| W Base | 0 | 0 | 0 | 2832 | 2376 | 2638 | 0 | 0 | 0 |
| W NC W | 0 | 0 | 0 | 1632 | 1276 | 4938 | 0 | 0 | 0 |

***Figure 3.7:*** Northern Cape wind scenario comparison to base case generation

## Scenario 3: Western Cape wind, gas and nuclear

The purpose of this scenario is to determine the impact on the transmission network within the Western Cape if more gas, wind, and nuclear generation are to be relocated from other provinces to this province.

The studies were conducted at peak load and low load with all the generation in Western Cape switched as applicable to the generation type. Any network violations were noted and initial proposals made on how these violations are likely to be mitigated.

This scenario is modelled as follows:

### CCGT gas stations

732 MW of CCGT gas is relocated from Dedisa in the Eastern Cape to Ankerlig in the Western Cape.

### Nuclear

1 600 MW of nuclear generation is relocated from Thyspunt in the Eastern Cape to Duynefontein in the Western Cape. It must be noted that the amount of nuclear was already much lower than in the previous TDP.

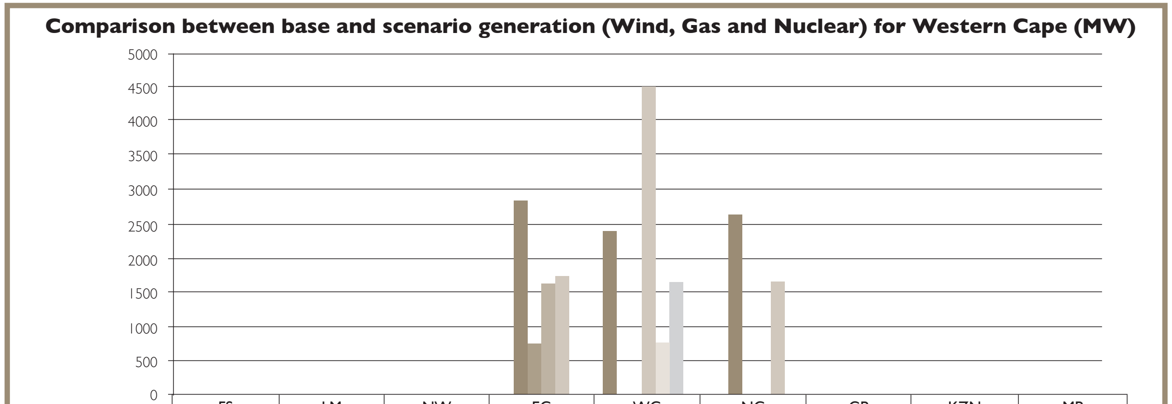
### Wind generation

A total of around 2100 MW of wind was moved from the Eastern Cape and Northern Cape to the Western Cape. Of this total, 1 000 MW was relocated from the Northern Cape, and 1 200 MW was relocated from the Eastern Cape. The additional Wind generation was added as listed below.

The Eastern Cape and Northern Cape Wind generation can be left at the normal rated output of 30% and the wind in the Western Cape run at full 100% output. This scenario is illustrated in Table 3.2 and Figure 3 8.

| | Total WC WGN Scenario (MW) | Total Base Case (MW) | Re-allocation (MW) |
|---|---|---|---|
| *Aurora* | *400* | *100* | *300* |
| *Droerivier* | *500* | *200* | *300* |
| *Juno* | *400* | *0* | *400* |
| *Asteria* | *300* | *0* | *300* |
| *Agulhas* | *300* | *0* | *300* |
| *Bacchus* | *300* | *100* | *200* |
| *Komsberg* | *600* | *400* | *200* |
| *Koruson* | *700* | *600* | *100* |
| **Total** | **3 500** | **1 400** | **2 100** |

***Table 3.2:*** Wind Re-allocation to the Western Cape




| | FS | LM | NW | EC | WC | NC | GP | KZN | MP |
|---|---|---|---|---|---|---|---|---|---|
| W Base | 0 | 0 | 0 | 2832 | 2376 | 2638 | 0 | 0 | 0 |
| CCGT Base | 0 | 0 | 0 | 732 | 0 | 0 | 0 | 0 | 0 |
| Nuclear Base | 0 | 0 | 0 | 1600 | 0 | 0 | 0 | 0 | 0 |
| W WCWGN | 0 | 0 | 0 | 1732 | 4476 | 1638 | 0 | 0 | 0 |
| CCGT WCWGN | 0 | 0 | 0 | 0 | 732 | 0 | 0 | 0 | 0 |
| Nuclear WCWGN | 0 | 0 | 0 | 0 | 1600 | 0 | 0 | 0 | 0 |

***Figure 3.8:*** Western Cape Wind, Gas and Nuclear Scenario comparison to Base Case generation

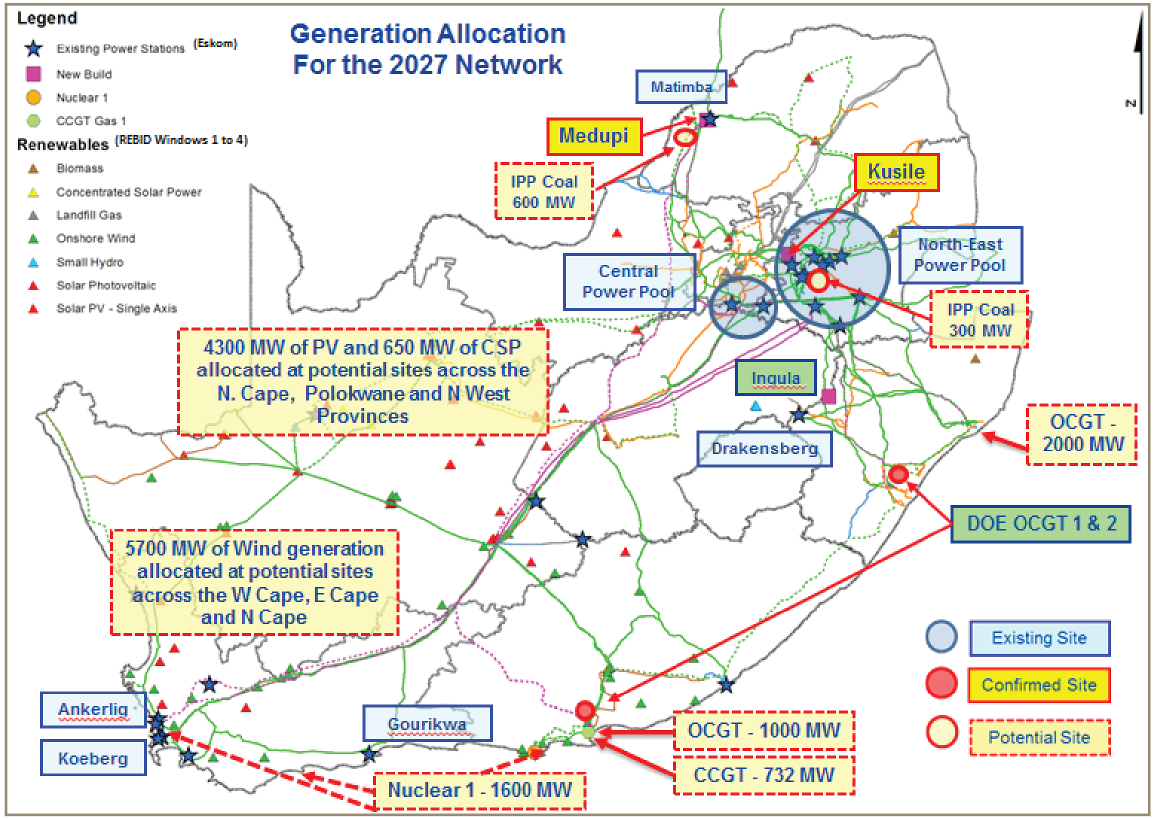



*Figure 3.9:* Planned power station capacity by 2027

# Chapter 4
# Project updates

## 4.1 Transmission reliability projects

This section shows the projects completed and nearing completion since the previous TDP publication in 2015. The project lists exclude feeder bay projects resulting from connection applications received.


***Table 4.1:*** Completed projects between FY2016/2017 and FY2017/18

| Province | Project name |
|---|---|
| **Gauteng** | *Waterberg Fault Level Project: Lulamisa Substation* |
| **KwaZulu Natal** | • *Avon 3rd transformers*<br>• *Mersey 3rd transformers*<br>• *Incandu 3rd transformers* |
| **Limpopo** | • *Acornhoek Upgrade Phase 1 - 2x125 MVA 275/132 kV transformers*<br>• *Foskor 3rd 250 MVA 275/132 kV transformer*<br>• *Spitskop 1 x 400/132 kV 500 MVA transformer*<br>• *Borutho 400/132 kV Substation (2x 500 MVA transformers)*<br>• *Borutho 400 kV Loop-in (Matimba-Witkop 1st 400 kV line)*<br>• *Medupi-Borutho 1st 400 kV line*<br>• *Borutho-Witkop 2nd 400 kV line* |
| **Mpumalanga** | • *Kruispunt strengthening project*<br>• *Kusile 400 kV HV Yard*<br>• *Kusile integration: Minerva-Duvha and Kendal-Apollo loop in/out*<br>• *Kusile integration: Vulcan bypass* |
| **North West** | • *Medupi Phase 1: Fault Level Plan – Ararat, Bighorn, Marang, Trident*<br>• *Mercury-Mookodi-Ferrum 400 kV line*<br>• *Mookodi 400/132 kV transmission substation*<br>• *Medupi-Marang 400 kV line*<br>• *Dinaledi-Spitskop lines*<br>• *Dinaledi 3rd 400/132 kV 500 MVA transformer*<br>• *Ngwedi 1st 400/132 kV 500 MVA transformer* |
| **Free State** | *Merapi transformation upgrade* |
| **Northern Cape** | • *Kronos 400/132 kV transformation*<br>• *Aries-Niewehoop 400 kV line*<br>• *Paulputs Ext 2nd 250MVA 220/132 kV transformer*<br>• *Nama MTS Transformers upgrade* |
| **Eastern Cape** | • *Dedisa OCGT*<br>• *Poseidon 500 MVA 400/132 kV transformer*<br>• *Vuyani Substation*<br>• *Eros-Vuyani 400 kV line*<br>• *Neptune-Vuyani 400 kV line* |
| **West Western Cape** | • *Muldersvlei 132 kV 72 Mvar capacitor bank*<br>• *Bacchus 132 kV and Proteus 132 kV 72 Mvar capacitor bank*<br>• *Acacia 3rd transformer*<br>• *Cape Corridor phase 2: Gamma-Kappa-Sterrekus 765 kV line* |

***Table 4.2:*** Projects in execution and planned to be completed by FY2022/2023

| Province | Project name |
|---|---|
| ***Gauteng*** | • *Vaal Strengthening South Phase 1*<br>• *Simmerpan 88 kV Establishment*<br>• *Glockner-Etna 1st and 2nd 400 kV line (operated @ 275 kV)*<br>• *Waterberg fault level project : Midas, Apollo, Pluto substations*<br>• *Lepini Ext 275kV 2 x 150MVAr capacitors*<br>• *Benburg MTS install 3rd 250 MVA 275/132 kV Transformer* |
| ***KwaZulu Natal*** | • *KZN 765kV Pinetown Strengthening: Ariadne substation*<br>• *Mbewu Substation*<br>• *Umfolozi Mbewu 765kV line*<br>• *Loop in/out Athene-Umfolozi & Umfolozi-Invubu 400kV Lines* |
| ***Limpopo*** | • *Waterberg Fault Level Project: Witkop Substation*<br>• *Dwaalboom (Dwarsberg) 132kV switching station*<br>• *Medupi-Ngwedi (Mogwase) 1st 400kV line*<br>• *Medupi-Ngwedi (Mogwase) 1st 765kV line (Energised at 400kV)* |
| ***Mpumalanga*** | • *Highveld South Reinforcement: Sasol 2 and 3 Series Reactors*<br>• *Waterberg Fault Level Project : Merensky Substation*<br>• *Highveld South Reinforcement Phase 1: Series Reactors*<br>• *Mpumalanga Underrated Equipment*<br>• *Kusile PS Integration*<br>• *Normandie MTS 2nd 400/132 KV Transformer* |
| ***North West*** | • *Watershed Strengthening*<br>• *Medupi Phase 1: Fault Level Plan - Spitskop*<br>• *Waterberg Fault Level Project: Hermes and Lomond substations*<br>• *Ngwedi 400/132 kV substation* |
| ***Free State*** | • *Waterberg Fault Level Project: Perseus Substation*<br>• *Harrismith Strengthening Phase 1*<br>• *Everest-Merapi 400 kV line (operated at 275 kV)* |
| ***Northern Cape*** | • *Kronos-Cuprum 1st & 2nd 132kV feeder bays*<br>• *Niewehoop-Upington 1st 400kV line and Upington substation*<br>• *Namaqualand strengthening*<br>• *Northern Cape Strengthening: Ferrum-Nieuwehoop 400kV line*<br>• *Groeipunt 220/132 kV substation*<br>• *Northern Cape Strengthening: Aries 400MVar SVC Reactor* |
| ***Eastern Cape*** | • *Southern Grid TX Transformer Normalisation: Buffalo & Pembroke substations*<br>• *Grassridge-Dedisa 132 kV line*<br>• *PE Strengthening Phase 3: Poseidon; Delphi; Grassridge; Dedisa Shunt Capacitors* |
| ***West Western Cape*** | • *Muldersvlei 3rd 500 MVA 400/132 kV Transformer & 132 kV Series Reactors*<br>• *Ankerlig-Sterrekus 400kV lines*<br>• *Pinotage Substation (Firgrove Transmission Substation)*<br>• *Koeberg 400kV busbar reconfiguration (Risk Reduction)* |

## 4.2 Grid connection applications

Table 4 3 outlines the number of Cost Estimate letters / indicative cost estimates (ICEs) and budget quotations (BQs) that were processed during the 2017 financial year (April 2016 to March 2017). These were as a result of applications for grid connections, as per the Grid Code.

As shown in Table 4 3, ICEs/BQs were issued for all transmission connection applications received during the 2017 financial year. The number of connection applications received during the 2017 financial year (87) was substantially lower than a total of 211 and 200 applications that were received in 2015 and 2016, respectively. The decline in the number of connection requests is mainly attributable to the reduced number of applications for DoE's REIPPPP. The identities of individual applicants are not reported on in order to protect the confidentiality of the parties involved.

***Table 4.3:*** Connection applications received / issued and accepted

| Indicative cost estimates | | Budget quotations | |
|---|---|---|---|
| **Received / Issued** | **Accepted** | **Received / Issued** | **Accepted** |
| *72* | *7 (9.72%)* | *15* | *1 (6.67%)* |

# 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 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 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.

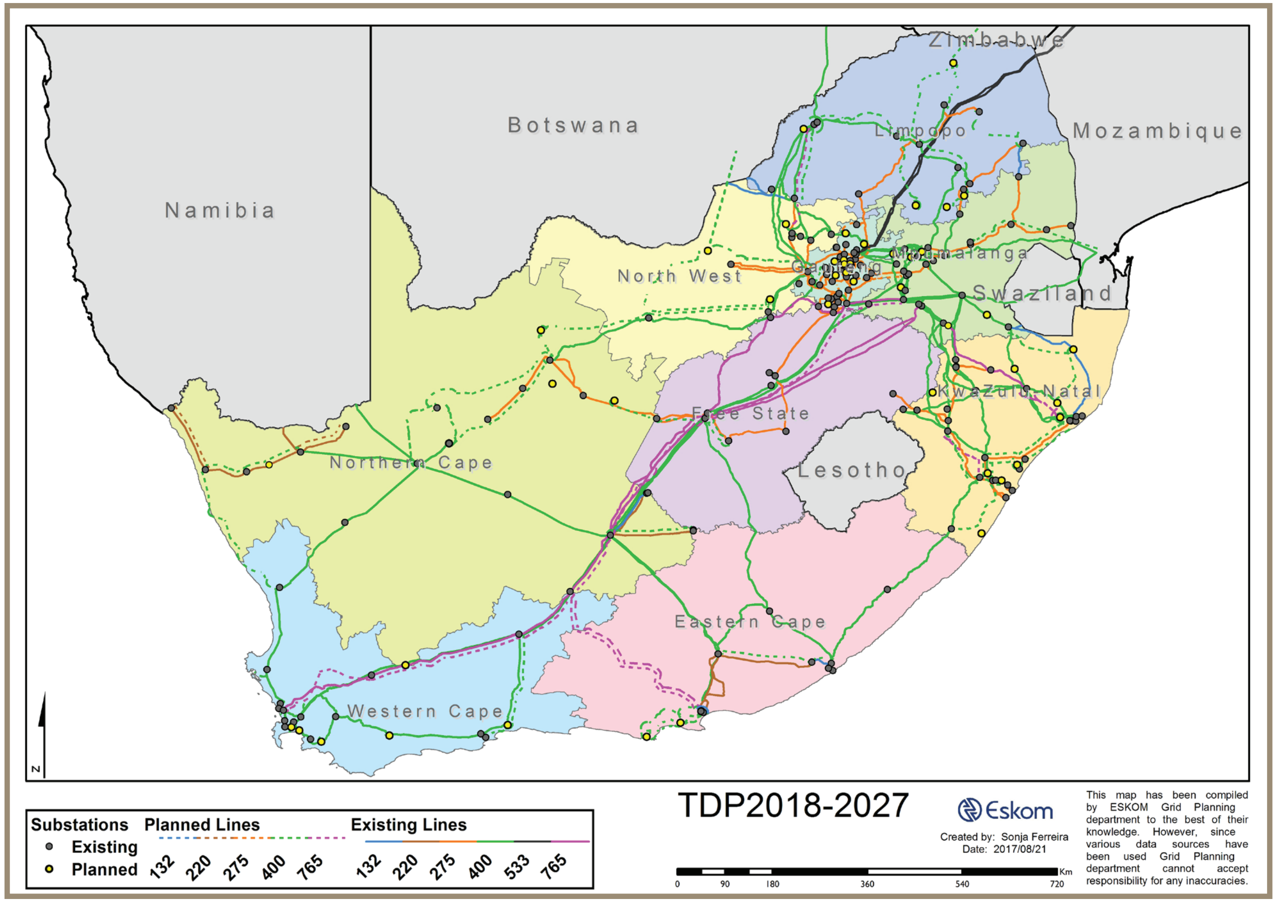



***Figure 5.1:*** Map showing relative location of the major TDP scheme projects

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 overvoltage 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.

| Transmission assets for National View | New assets expected in 2018 to 2022 | New assets expected in 2023 to 2027 | Total new assets |
|---|---|---|---|
| **Power lines (km)** | | | |
| *765 kV* | *98* | *350* | *448* |
| *400 kV* | *2 311* | *3 513* | *5 824* |
| *275 kV* | *40* | *226* | *266* |
| **Total length (km)** | **2 449** | **4 089** | **6 538** |
| **Transformers** | | | |
| *Number of units* | *55* | *54* | *109* |
| **Total capacity (MVA)** | **17 600** | **29 435** | **47 035** |
| **Capacitors** | | | |
| *Number of banks* | *17* | *18* | *35* |
| **Total capacity (MVar)** | **1 102** | **1 044** | **2 146** |
| **Reactors** | | | |
| *Number of banks* | *22* | *8* | *30* |
| **Total capacity (MVar)** | **1 560** | **1 050** | **2 610** |

***Table 5.1:*** Major TDP transmission assets expected to be installed

# Chapter 6
# Breakdown of the TDP projects by province

## 6.1 Gauteng province

### Background

Gauteng is the smallest province by landmass and the most populated province in South Africa. Gauteng province is the hub of economic activity in South Africa and accounts for about 27% of electricity consumption in the country. The province houses major financial institutions, including the Johannesburg Stock Exchange (JSE), as well as large commercial and industrial establishments. It is the home to large industrial areas such as Eastrand, Midrand and Vanderbijlpark, along with South Africa's largest cities, Johannesburg and Pretoria which are the respective capitals of Gauteng Province and South Africa. Large municipalities (redistributors) are the dominant players, accounting for about 75% of electricity consumption in the province.

The provincial load peaked at 10 488 MW in 2016 and it is expected to increase to about 16 560 MW by 2027. The Gauteng transmission network is predominantly connected at the 275 kV level, with a few transmission stations connected at 400 kV as shown in Figure 6.1. The Gauteng Province comprises six Customer Load Networks (CLNs), namely West Rand, Johannesburg South, Tshwane, East Rand, Johannesburg North and the Vaal.

The East Rand, Johannesburg North, West Rand and the Vaal CLNs consume approximately 61% of the demand in the province, while the Johannesburg South and Tshwane CLNs account for the remaining 39% of the provincial demand.

There is a steady increase in demand for electricity supply in the Gauteng province, which is mainly attributable to commercial and residential developments.

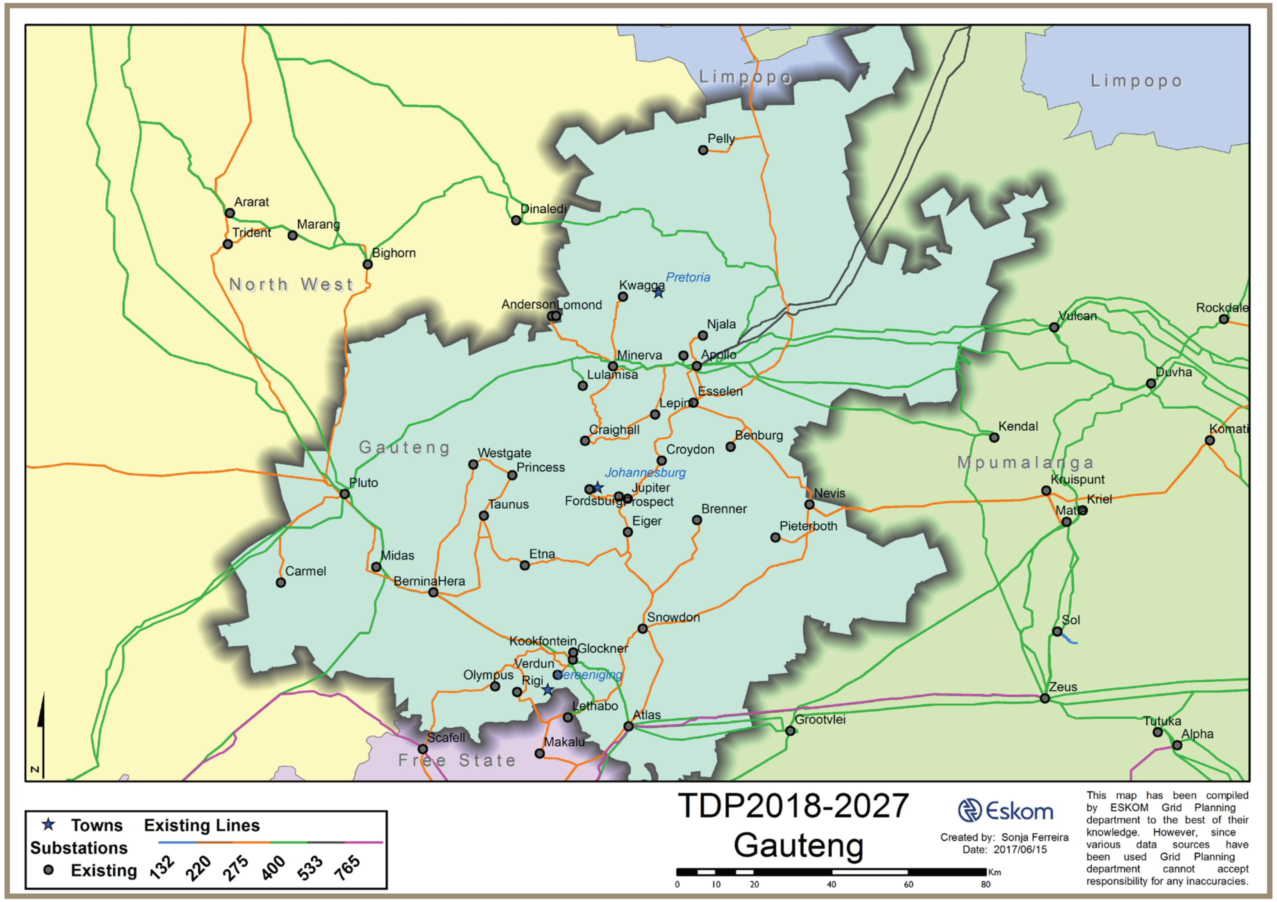



***Figure 6.1:*** Current Gauteng province network diagram

## Generation

Kelvin Power Station (in Johannesburg) and Rooiwal Power Station (in Tshwane) are currently the only large scale Independent Power Producers that lie within the Gauteng province. In addition, five small IPP projects with a total capacity of 22.7 MW from Landfill Gas were approved as part of the DoE REIPP Bid Round 3 programme.

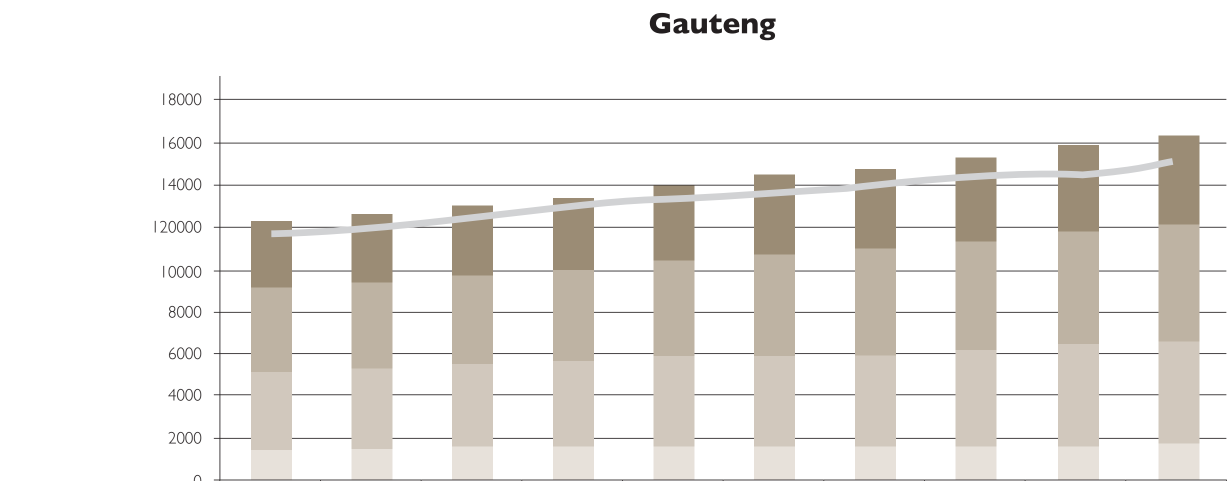
Most of the power consumed within the Gauteng province is sourced from the power stations in neighbouring Limpopo and Mpumalanga provinces, as well as from Cahora Bassa in Mozambique. The power supply to the Gauteng province is primarily transported though the Apollo-Cahora Bassa HVDC lines, as well as the HVAC transmission lines from Lethabo, Matla, Kendal, Duvha, Grootvlei, Kusile and Matimba power stations.

## Load forecast

The load forecast for the Gauteng province is shown in Figure 6 2. The economic mix in the Gauteng province comprises redistributors, gold mines, commercial and industrial consumers. The load in the Gauteng province is forecasted to grow steadily at about 2.8% annually, from 11 716 MW in year 2018 to 16 560 MW by year 2027. In the current TDP review period, the Gauteng customer load networks reduced from six to four CLNs namely: East Rand, Johannesburg, Vaal and West Rand CLNs for load forecasting purposes.

Most of the substations in the Tshwane Johannesburg North and South CLNs were incorporated into a new CLN called Johannesburg. Fordsburg and Prospect were incorporated into the West Rand CLN and Eiger was incorporated into the Vaal CLN. The new Johannesburg CLN which comprises the former Johannesburg North and Tshwane CLNs are expected to experience the highest rate of load growth, followed by the East and West Rand CLNs. The rate of load growth in the Vaal CLN is expected to be the lowest load in the province.

The major TDP schemes planned in the Gauteng province are as follows:




| | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 |
|---|---|---|---|---|---|---|---|---|---|---|
| West Rand @ Grid Peak | 3110 | 3217 | 3326 | 3424 | 3515 | 3722 | 3829 | 3948 | 4061 | 4173 |
| JHB @ Grid Peak | 3935 | 4051 | 4186 | 4271 | 4600 | 4783 | 4988 | 5125 | 5378 | 5596 |
| East Rand @ Grid Peak | 3825 | 3906 | 3969 | 4098 | 4207 | 4317 | 4435 | 4517 | 4785 | 4925 |
| Vaal @ Grid Peak | 1391 | 1431 | 1543 | 1558 | 1571 | 1597 | 1609 | 1651 | 1658 | 1682 |
| Gauteng @ TOSP | 11716 | 12095 | 12505 | 12982 | 13290 | 13592 | 14012 | 14351 | 14557 | 14925 |

**Figure 6.2:** Gauteng province load forecast

## 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 voltage constraints in the Johannesburg North CLN and supports future loads in the Midrand and Tembisa areas. Currently two 150 Mvar capacitor banks are being installed at the Lepini substation 275 kV busbar, and this will be followed by construction of the Apollo-Lepini 275 kV line to increase capacity.

**Johannesburg East Strengthening: Jupiter B integration**
This scheme provides a new power corridor into the Johannesburg South CLN and entails construction of the 2 x 400 kV lines from Matla Power Station to the new transmission switching station in the Germiston area, named Jupiter B (near the existing Jupiter transmission substation). At least five transmission lines will be connected to the Jupiter B station, which will increase thermal capacity in the Johannesburg South area.

**Johannesburg East Strengthening: North Rand integration**
This scheme addresses network constraints in the East Rand and the Johannesburg South CLN. The planned upgrade of the existing North Rand distribution substation into a transmission substation (named Mesong) and the construction of two Apollo–Mesong 400 kV lines will result in increased transfer limits in the East Rand and Johannesburg South CLNs. The Sebenza-Mesong corridor comprising two 400 kV lines (energised at 275 kV) might be developed faster than the Apollo-Mesong corridor due to environmental and land acquisition challenges. Furthermore, the Sebenza substation that City Power is building will de-load Prospect substation and create more capacity in the East Rand.

**Simmerpan Strengthening: Simmerpan 275 kV integration**
Simmerpan Strengthening addresses unfirm transformation at Jupiter substation in the Germiston area and alleviates constraints at the Simmerpan 88 kV distribution substation, which are attributed to load growth in the Ekurhuleni and East Rand area. The Simmerpan 275 kV substation will be energised from the planned new switching substation, Jupiter B, via the existing Jupiter-Simmerpan 275 kV lines (currently energised at 88 kV). A provision will be made during construction for potential future expansion of the Simmerpan substation to accommodate 2 x 250 MVA 275/132 kV transformers, subject to load growth in the Croydon 132 kV network.

**Vaal Strengthening**
The scheme entails the construction of two Glockner–Etna 400 kV lines and the uprating of under-rated terminal equipment in order to de-load the overloaded lines in the Vaal and West Rand CLN. These lines will be energised at 275 kV voltage level until the need for integrating a 400 kV line at Etna substation materialises.

**Johannesburg Central Strengthening**
The main purpose of this transmission infrastructure investment scheme is to ensure Grid Code compliance for Taunus and Fordsburg substations, as well as to address the expected thermal constraints in the distribution network. The scope of work includes establishing new the Quattro substation which will cater for four 315 MVA 275/88 kV transformers belonging to City Power and two 500 MVA 275/132 kV transformers belonging to Eskom. Two 400 kV lines, energised at 275 kV will also be built from Etna to Quattro.

### West Rand Strengthening

This scheme addresses future thermal and voltage constraints of the transmission network, as well as the distribution network constraints in the West Rand area. The project entails establishing a 400 kV line at Westgate, building the Hera-Westgate 400 kV line and installing a 500 MVA 400/132 kV transformer at Westgate.

### Tshwane Reinforcement

The Tshwane reinforcement schemes address the transmission substation's firm capacity constraints due to load increases in the Tshwane CLN. The project entails establishing two new transmission substations in Tshwane CLN; one to the north (near Soshanguve) and the other east of Tshwane (near Mamelodi).

The transmission development plans for Gauteng Province are shown in Figure 6.3.

## New substations

The following new substations will be established in the Gauteng Province in order to address load growth:

Load growth in the East Rand CLN will necessitate the introduction of the following 400/132 kV substation:

- Lesokwana substation in the Ekurhuleni area

Load growth in the Johannesburg CLN will necessitate the introduction of the following 400/132 kV substation:

- Sesiu substation in the Dalkeith area

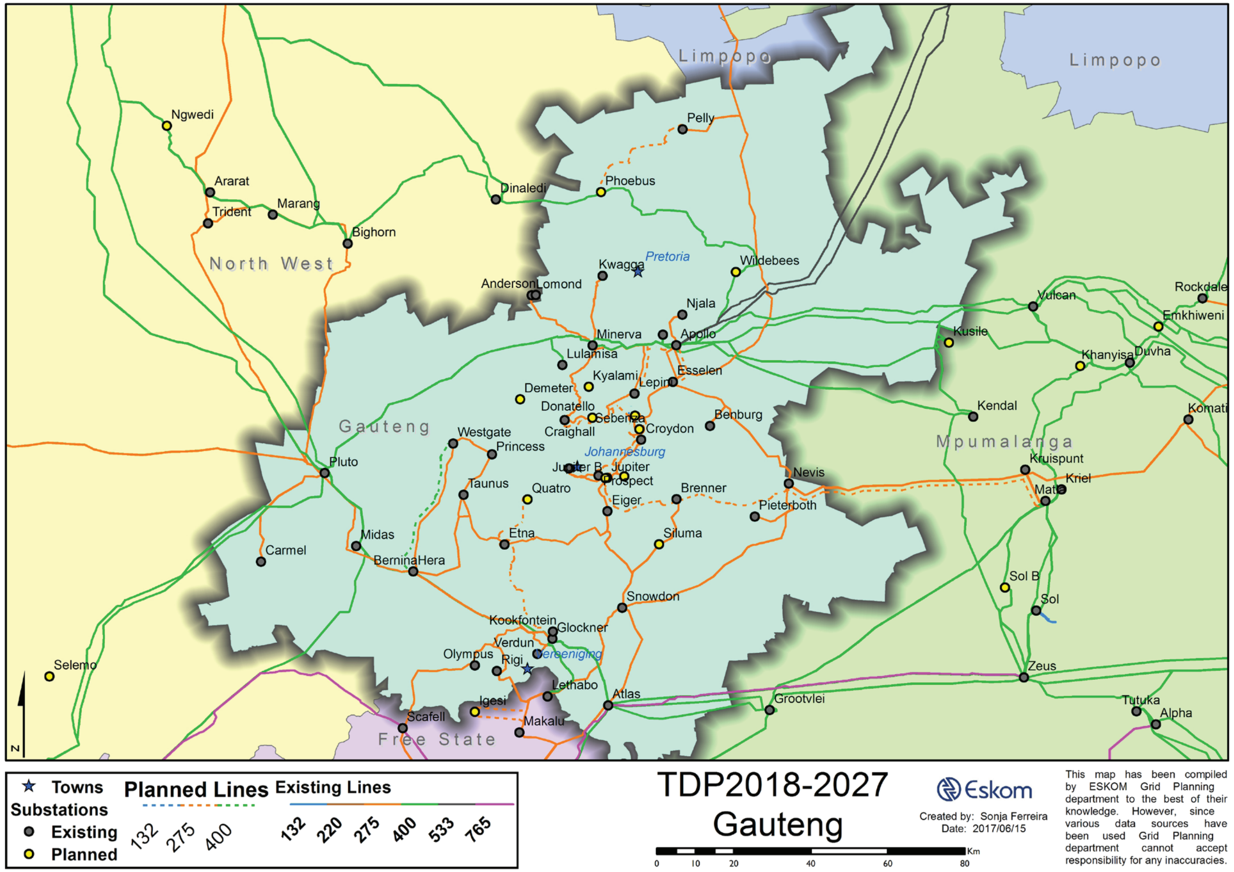



*Figure 6.3:* Future Gauteng province network diagram

## Reactive power compensation

The following capacitor banks will be installed for voltage support in the Gauteng province:

- 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
- 2 x 150 MVar capacitor bank at Lepini 275 kV

## Provincial summary

The planned increases in transmission assets by the end of 2022 and the end of 2027, along with the total number of new assets, are shown in Table 6 1. A summary of all projects and scheme planned for this province is provided in Table 6-2..

***Table 6.1:*** Cumulative TDP transmission assets for Gauteng province

| Transmission assets for Gauteng Province | New assets expected in 2018 to 2022 | New assets expected in 2023 to 2027 | Total new assets |
|---|---|---|---|
| **Power lines (km)** | | | |
| *765 kV* | *0* | *0* | *0* |
| *400 kV* | *117* | *111* | *228* |
| *275 kV* | *0* | *36* | *36* |
| **Total length (km)** | **117** | **147** | **264** |
| **Transformers** | | | |
| *Number of units* | *8* | *8* | *16* |
| **Total capacity (MVA)** | **3 195** | **3 630** | **6 825** |
| **Capacitors** | | | |
| *Number of banks* | *4* | *4* | *8* |
| **Total capacity (MVar)** | **396** | **264** | **660** |
| **Reactors** | | | |
| *Number of banks* | *0* | *0* | *0* |
| **Total capacity (MVar)** | **0** | **0** | **0** |

**Table 6.2:** Gauteng province – summary of projects and timelines

| TDP Scheme | Project Name | Expected CO Year |
|---|---|---|
| **Benburg 3rd Transformer** | Benburg Ext 275/132 kV 250 MVA 3rd transformer | 2017 |
| **JHB North Strengthening Phase 1** | Lepini Ext 275 kV 2 x 150 MVAr capacitors (project currently in construction) | 2017 |
| **Brenner Strengthening Phase 1** | Brenner 2 x 88 kV 48 MVAr capacitors | 2019 |
| **Waterberg Fault Level Project** | Waterberg Fault Level Project : Midas Substation | 2019 |
| | Waterberg Fault Level Project :Apollo Substation | |
| | Waterberg Fault Level Project : Pluto Substation | 2021 |
| **Vaal Strengthening Phase 2** | Glockner-Etna 1st and 2nd 400 kV line (operate @ 275 kV) | 2020 |
| **Tshwane Reinforcement: Diphororo Phase 1** | Diphororo Ext 400/132 kV substation (1st and 2nd 500 MVA transformers) | 2021 |
| | Diphororo 400 kV loop-in (Apollo-Dinaledi 400 kV line) | |
| **Tshwane Reinforcement – Wildebees Phase 1** | Wildebees 400/132 kV (Customer 2 x 315 MVA transformers) and Apollo-Dinaledi 400 kV line into Wildebees | 2021 |
| **Johannesburg Central Strengthening** | Etna-Quattro 1st and 2nd 400 kV Lines (energised @ 275 kV) | 2021 |
| | Quattro 275/88 kV substation (400/88 kV construction) (City Power 1st and 2nd 315 MVA transformers) | |
| | Quattro 275/132 kV substation (400/132 kV construction) (1st and 2nd 500 MVA transformers) | |
| **JHB North Strengthening: Demeter 400kV Integration** | Loop in Pluto-Thuso 400 kV into Demeter | 2022 |
| | Demeter 400/88kV transformation (1st, 2nd and 3rd 315 MVA transformers and 400kV busbar) | |
| **Simmerpan 275 kV Integration Phase 1** | Jupiter B-Simmerpan 1st and 2nd 275 kV lines (uprate of 88 kV lines) | 2023 |
| | Simmerpan 275/88 kV substation (expand existing Distribution substation) (2 x 315 MVA transformers) | |
| **JHB North Strengthening Phase 2** | Apollo-Lepini 1st 275 kV line | 2024 |
| **West Rand Strengthening Phase1** | Westgate 400/132 kV substation (1st 500 MVA transformer) | 2025 |
| | Hera-Westgate 1st 400 kV line | |
| **West Rand Reactive Power Project** | 1 x 48 MVAr Cap Banks at Princess 88 kV | 2026 |
| | 1 x 72 MVAr Cap Bank at Taunus 132 kV | |
| | 1 x 72 MVAr Cap at Quattro 132 kV | |
| | 1 x 72 MVAr Cap at Westgate 132 kV | |

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

| | | |
|---|---|---|
| ***JHB East Strengthening: North Rand Integration*** | North Rand Ext 2 x 500 MVA 275/132 kV transformers | 2027 |
| | North Rand-Sebenza lines (to be energised at 275 kV) | |
| | North Rand-Chloorkop 1st and 2nd 132 kV lines | |
| | Connect Esselen-North Rand 1st 275 kV line (currently operated at 132 kV) to the North Rand 275 kV busbar. | |
| | By-Pass Chloorkop S/S 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 two 275 kV lines to form two Apollo-North Rand 275 kV lines. | |
| ***JHB East Strengthening: Jupiter B integration*** | Jupiter B 275kV switching station | 2024 |
| | Matla-Jupiter B 1st and 2nd 400 kV line (operated at 275kV) | 2027 |
| | Jupiter B 275 kV Loop-ins (Prospect-Sebenza 1 & 2, Jupiter-Prospect 1, Jupiter-Fordsburg 1) | 2028 |
| ***Brenner Strengthening Phase 2*** | Lesokwana (Brenner B) 275/88 kV (built at 400 kV) | 2027 |
| | Loop-in and out Snowdon-Brenner and Matla-Jupiter B 275kV lines into Lesokwana | |
| ***Tshwane Reinforcement: Phoebus Phase 2*** | Phoebus/Diphororo 400/275kV substation (1st and 2nd 400 MVA 400/275 kV transformers) | 2027 |
| | Phoebus (Diphororo)-Kwagga 1st 275 kV line | |
| | Pelly-Phoebus/Diphororo 1st 275 kV line (energise Hangklip-Pelly 132 kV line) | |

# 6.1 KwaZulu-Natal (KZN) province

## Background

The KwaZulu-Natal (KZN) province is situated on the eastern seaboard of South Africa, along the Indian Ocean. The capital of KwaZulu-Natal is Pietermaritzburg with its largest city being Durban. The provincial economy is mainly driven by activities concentrated around the port of Durban and the capital, Pietermaritzburg, with significant contributions in the Richards Bay-Empangeni, the Ladysmith-Ezakheni and the Newcastle-Madadeni regions.

The provincial load peaked at around 6 287 MW in 2016 which represents a 2.5% increase on 2015 loads, and it is expected to increase to about 7 682 MW by 2027. The main transmission supply network to KwaZulu-Natal is predominantly connected at a 400 kV voltage level, with the local transformation stations to 275 kV as shown in the existing network overview in Figure 6 4. The KwaZulu-Natal province comprises four Customer Load Networks (CLNs), namely Empangeni, Ladysmith, Newcastle and Pinetown. The Empangeni and Pinetown CLNs are the two main load centres in the province, consuming approximately 29.2% and 53.74% of the load respectively. Ladysmith and Newcastle CLNs make up the remaining 17.06% of the demand in the province.

The province has a number of development plans, which include the Dube Trade Port at La Mercy, upgrading 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. There are also various projects for public infrastructure

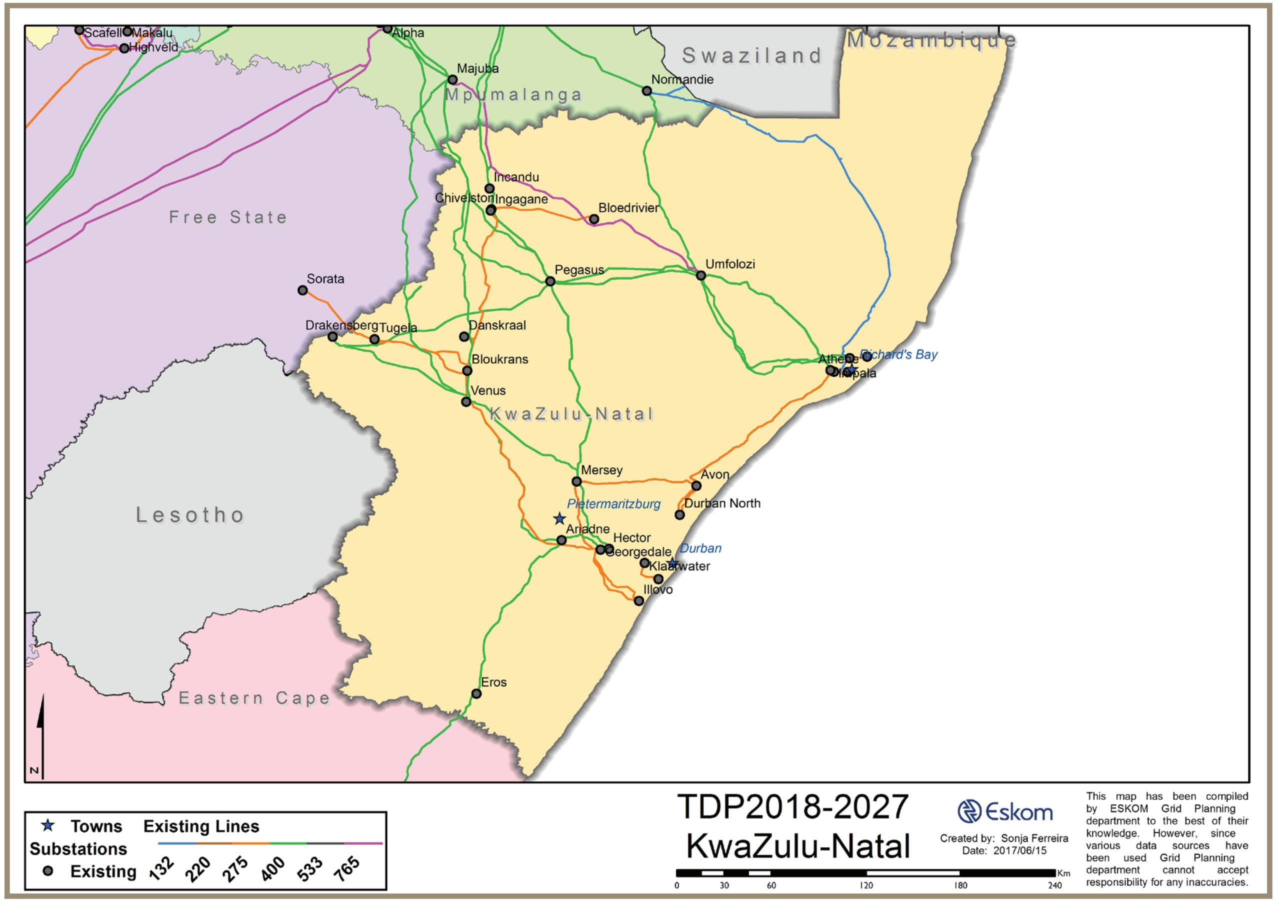



***Figure 6.4:*** Current KZN transmission network

delivery such as 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.

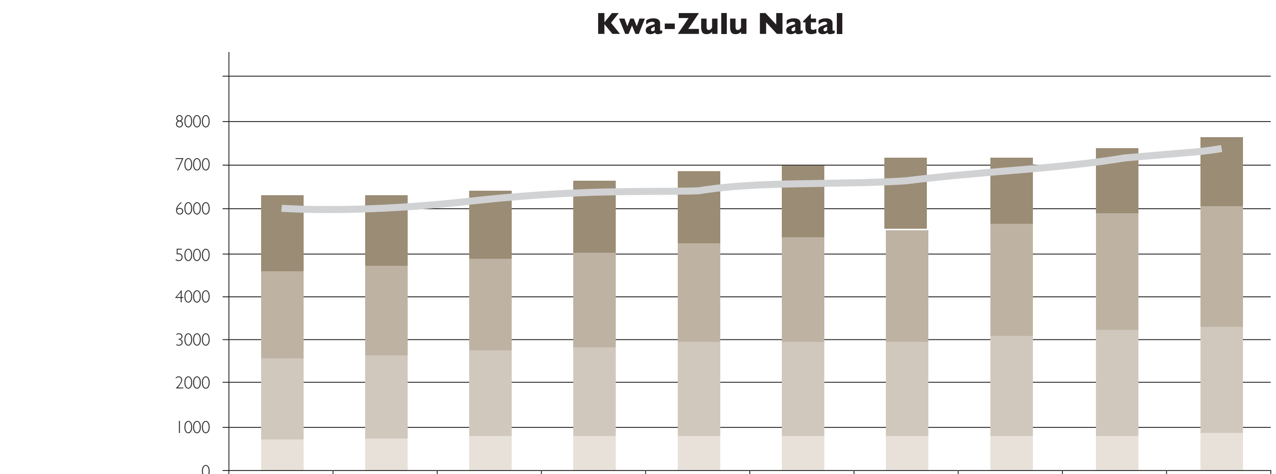
## Generation

Drakensberg and Ingula Pumped-storage Schemes were historically the only power stations that lie within the defined KwaZulu-Natal province. The DoE peaking power station was commissioned at Avon transmission substation, about 30 km to the north of Durban in 2016. Most of the power consumed within this province is sourced from the power stations in the Mpumalanga province.

The 2016 Draft Integrated Resource Plan (IRP) has identified Richards Bay harbour as a potential site for a 2 000 MW gas plant. This is part of the 3 000 MW gas-to-power government initiative as per the DoE gas programme.

## Load forecast

The economic mix in the KwaZulu-Natal province comprises redistributors, commercial customers and industrial customers. The load in KwaZulu-Natal province is forecasted to grow steadily at about 2% annually, from 6 532 MW in year 2018 to 7 682 MW by year 2027. The highest provincial load growth is expected in the Pinetown and Empangeni CLN due to industrial, commercial and residential developments. The load forecast for the KwaZulu-Natal province is shown in Figure 6 5.




| | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 |
|---|---|---|---|---|---|---|---|---|---|---|
| Pinetown @ Grid Peak | 3316 | 3392 | 3470 | 3550 | 3632 | 3715 | 3800 | 3888 | 3977 | 4069 |
| Empangeni @ Grid Peak | 2123 | 2206 | 2234 | 2225 | 2237 | 2253 | 2259 | 2270 | 2282 | 2283 |
| Newcastle @ Grid Peak | 642 | 658 | 673 | 688 | 702 | 717 | 732 | 746 | 760 | 773 |
| Ladysmith @ Grid Peak | 210 | 213 | 217 | 300 | 305 | 309 | 313 | 317 | 322 | 326 |
| Kwa-Zulu Natal @ TOSP | 6045 | 6221 | 6347 | 6528 | 6648 | 6765 | 6868 | 6974 | 7057 | 7130 |

***Figure 6.5:*** KZN province load forecast

## Major schemes

The major schemes for KZN province are as follows:

**KZN 765 kV Strengthening**
The KZN 765 kV Strengthening project entails establishing 765 kV MTS in the Pinetown and Empangeni areas, supplied via 765 kV lines from the power pool in the north and integrated into the local 400 kV network in both areas. The Pinetown and Empangeni 765 kV load centres will also be linked via two 400 kV lines. The project will be executed in various stages. The trigger for each stage will be dependent on the demand growth (generation and/or load) in both areas.

**South Coast Strengthening: St. Faiths 2 x 500MVA 400/132kV substation**
This includes construction of the 2nd Ariadne-Eros 400 kV line, 132 kV multi-circuit line and the establishment of the St. Faiths 400/132kV substation near Port Shepstone. The trigger for the St. Faiths substation will be the demand growth along the South Coast.

**eThekwini Electricity Network Strengthening**
This project involves:

- 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 the Hector 400/275 kV transformers, the Hector-Klaarwater 275 kV lines and Klaarwater substation.

- The establishment of Inyaninga the 2 x 500 MVA 400/132 kV substation by looping into one of the planned Isundu-Mbewu 400 kV lines to form the Isundu-Inyaninga 400 kV line and Inyaninga-Mbewu 400 kV line.

**NKZN Strengthening: Iphiva 2 x 500 MVA 400/132 kV substation**

This project involves the establishment of Iphiva 400/132 kV substation around Candover-Mkuze to address supply constraints around Pongola, Makhatini Flats and iSimangaliso (Greater St. Lucia) Wetland Park. The planned Iphiva Substation will be supplied by two 400kV lines, namely Normandie-Iphiva and Duma-Iphiva 400 kV lines. Duma substation is part of the planned Ermelo-Richards Bay Coal-link upgrade project.

**Ariadne Substation Strengthening**

Grid Planning is currently investigating options to increase the transformation capacity at Ariadne substation or to strengthen the 132 kV network interconnector between Mersey and Ariadne substations, and provide backup for transformer outages at the Ariadne substation.

The transmission development plans for the KwaZulu-Natal province are shown in Figure 6 6.

## New substations

The following new 400/132 kV substations will be established in the KwaZulu-Natal province in order to support load growth as well as strengthening the existing network:

- Iphiva Substation in the Northern KwaZulu-Natal (NKZN) area
- St. Faith Substation in the South Coast area of KwaZulu-Natal
- Shongweni Substation around Hillcrest in the Western part of eThekwini Municipality
- Inyaninga Substation in the Northern part of eThekwini Municipality

**Reactive Power Compensation**

Within the KwaZulu-Natal province, there are plans to:

- Refurbish the Athene Static Var Compensator (SVC) at Athene Substation
- Decommission the SVC at Impala Substation
- Reconfigure the Illovo SVC to retain the 100MVar Capacitor bank

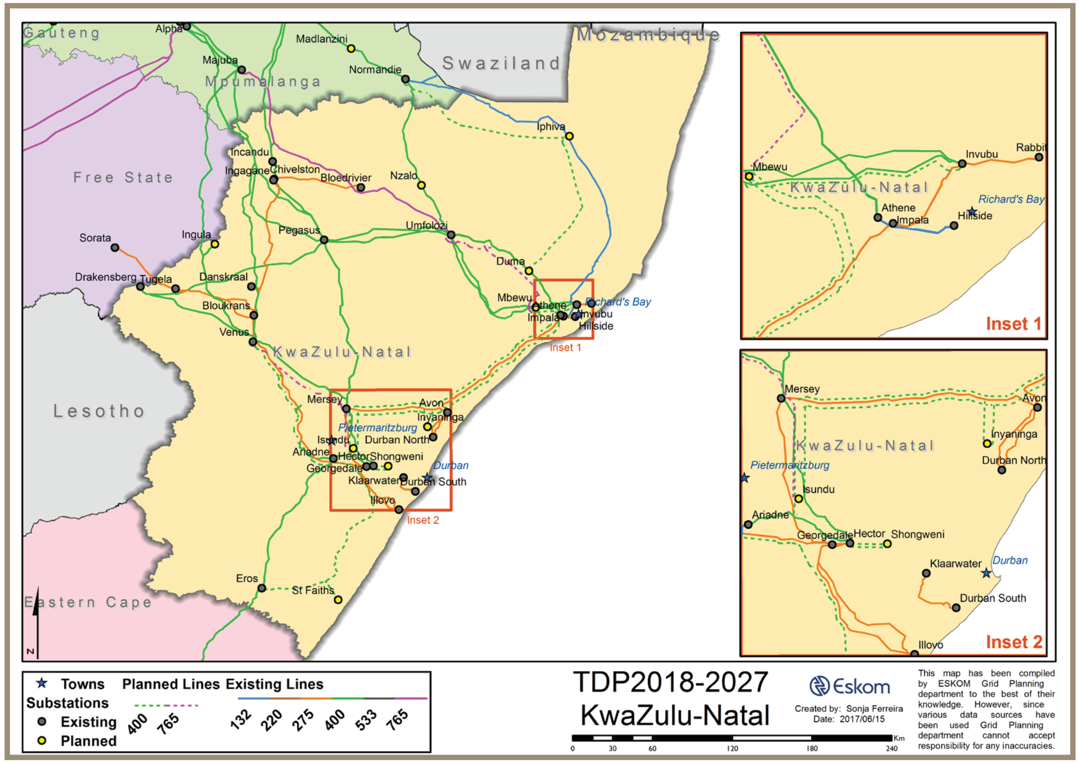



***Figure 6.6:*** Future KZN province network diagram

## New substations

The following new 400/132 kV substations will be established in the KwaZulu-Natal province in order to support load growth as well as strengthening the existing network:

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- St. Faith Substation in the South Coast area of KwaZulu-Natal
- Shongweni Substation around Hillcrest in the Western part of eThekwini Municipality
- Inyaninga Substation in the Northern part of eThekwini Municipality

**NKZN Strengthening: Iphiva 2 x 500 MVA 400/132 kV Substation**

The KZN 765 kV Strengthening project entails establishing 765 kV MTS in the Pinetown and Empangeni areas, supplied via 765 kV lines from the power pool in the north and integrated into the local 400 kV network in both areas. The Pinetown and Empangeni 765 kV load centres will also be linked via two 400 kV lines. The project will be executed in various stages. The trigger for each stage will be dependent on the demand growth (generation and/or load) in both areas.

**South Coast Strengthening: St. Faiths 2 x 500 MVA 400/132 kV Substation**

This includes construction of the 2nd Ariadne-Eros 400 kV line, 132 kV multi-circuit line and the establishment of the St. Faiths 400/132kV substation near Port Shepstone. The trigger for the St. Faiths substation will be the demand growth along the South Coast.

**eThekwini Electricity Network Strengthening**

This project involves:

- 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 the Hector 400/275 kV transformers, the 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 the Isundu-Inyaninga 400 kV line and Inyaninga-Mbewu 400 kV line.

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This project involves the establishment of Iphiva 400/132 kV substation around Candover-Mkuze to address supply constraints around Pongola, Makhatini Flats and iSimangaliso (Greater St. Lucia) Wetland Park. The planned Iphiva Substation will be supplied by two 400kV lines, namely Normandie-Iphiva and Duma-Iphiva 400 kV lines. Duma substation is part of the planned Ermelo-Richards Bay Coal-link upgrade project.

**Ariadne Substation Strengthening**

This project involves the establishment of Iphiva 400/132 kV substation around Candover-Mkuze to address supply constraints around Pongola, Makhatini Flats and iSimangaliso (Greater St. Lucia) Wetland Park. The planned Iphiva Substation will be supplied by two 400kV lines, namely Normandie-Iphiva and Duma-Iphiva 400 kV lines. Duma substation is part of the planned Ermelo-Richards Bay Coal-link upgrade project.

## Reactive power compensation

Within the KwaZulu-Natal province, there are plans to:

- Refurbish the Athene Static Var Compensator (SVC) at Athene Substation
- Decommission the SVC at Impala Substation
- Reconfigure the Illovo SVC to retain the 100MVar Capacitor bank

## Provincial summary

The increase in transmission assets by the end of 2022 and the end of 2027 and the total new asset added is shown in Table 6-3. A summary of all projects and scheme planned for this province is provided in Table 6-4.

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

| Transmission Assets for Kwa-Zulu Natal Province | New Assets expected in 2018 - 2022 | New Assets expected in 2023 – 2027 | Total New Assets |
|---|---|---|---|
| **Power lines (km)** | | | |
| 765 kV | 98 | 0 | 98 |
| 400 kV | 474 | 1 066 | 1 540 |
| 275 kV | 0 | 16 | 16 |
| Total length (km) | 572 | 1 082 | 1 654 |
| **Transformers** | | | |
| *Number of units* | 4 | 8 | 12 |
| Total capacity (MVA) | 980 | 5 500 | 6 480 |
| **Capacitors** | | | |
| *Number of banks* | 0 | 0 | 0 |
| Total capacity (MVar) | 0 | 0 | 0 |
| **Reactors** | | | |
| Number of banks | 0 | 1 | 1 |
| Total capacity (MVar) | 0 | 200 | 200 |

***Table 6.4:*** KZN province – summary of projects and timelines

| TDP Scheme | Project | Expected CO Date |
|---|---|---|
| Transnet Coal-Line Upgrade | 3 of 1 x 160MVA 400/88 kV substations | Customer Dependent |
| | Loop-in Camden-Normandie 1 400 kV line, Normandie-Umfolozi 1 400 kV line & Pegasus-Athene 1 400 kV line respectively. | |
| Ariadne-Venus 2nd 400 kV Line | Ariadne-Venus 2nd 400 kV line (recycle Georgedale-Venus 1 or 2 275 kV line) | 2020 |
| KZN 765 kV Strengthening - Empangeni Integration | Mbewu 400kV Switching Station | 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), operate at 400 kV | |
| | Invubu-Mbewu 2nd 400 kV line | |
| | Establish 400kV feeder bay for Mbewu-Umfolozi 765kV line | |
| KZN 765 kV Strengthening -Pinetown Integration | Isundu 400 kV switching station | 2027 |
| | Isundu-Venus 765 kV line (operated at 400 kV) | |
| | Ariadne-Isundu 400 kV line | |
| | Hector-Isundu 400 kV line | |
| KZN 765 kV Strengthening - Isundu-Mbewu 1st & 2nd 400kV Lines | Isundu-Mbewu 1st & 2nd 400 kV lines | 2027 |
| eThekwini Electricity Network Strengthening | Inyaninga 2 x 500 MVA 400/132kV Substation | 2028 |
| | Loop-in Isundu-Mbewu 1 400kV line into Inyaninga Substation | |
| | Shongweni 2 x 500 MVA 400/132 kV Substation | 2025 |
| | 2 x Hector-Shongweni 1st and 2nd 400 kV lines | |
| South Coast Strengthening | Ariadne-Eros 2nd 400 kV line | 2021 |
| | St. Faiths 2 x 500 MVA 400/132 kV Substation | 2027 |
| | Loop-in Ariadne-Eros 2 400 kV line into St. Faiths Substation | |
| NKZN Strengthening Phase 1 | Iphiva 400 kV busbar | 2024 |
| | Normandie-Iphiva 1st 400 kV line | |
| | Iphiva 1 x 500 MVA 400/132 kV transformer | |
| NKZN Strengthening Phase 2 | Duma-Iphiva 1st 400 kV line | 2026 |
| | Iphiva 1 x 500 MVA 400/132 kV transformer | |
| Ariadne 3rd 500 MVA 400/132 kV transformer | Ariadne 3rd 500 MVA 400/132 kV transformer | 2025 |

## 6.3 Limpopo province

### Background

The Limpopo Province is situated on the most northern part of South Africa and is named after the Limpopo River. The largest city in the province is Polokwane, and the province shares international borders with Botswana, Mozambique and Zimbabwe. The provincial economy is mainly driven by mining, exporting primary products and importing manufactured goods.

The Northern Grid consists of three Customer Load Networks (CLN), namely Lephalale, Polokwane, and Phalaborwa. Each CLN is made up of a number of main transmission substations. The transmission substations are interconnected through 400 kV, 275 kV as well as through the 132 kV underlying distribution network. The Polokwane CLN is the main load centre in the Northern Grid, consuming approximately 41% followed by Phalaborwa, consuming 40%. The 2016 peak load for the Northern Grid was 2 854 MW. This is 3.6% (106 MW) lower than the demand of 2 960 MW recorded for the previous year.

Lephalale CLN is the only CLN to see a load growth in this period. The load in this CLN increased by 4.4% when compared to last year's CLN peak. Phalaborwa CLN peak loading decreased from 1 179 MW to 1 135 MW, a total reduction of 3.7%. Polokwane CLN peaked at 1 180 MW, which was 4 MW less than last year's peak of 1 184 MW.

Growth in Limpopo is primarily due to the platinum group metals (PGM), 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 underway throughout Limpopo Province.

Figure 6 7 shows the geographical diagram of the existing Northern Grid transmission network.

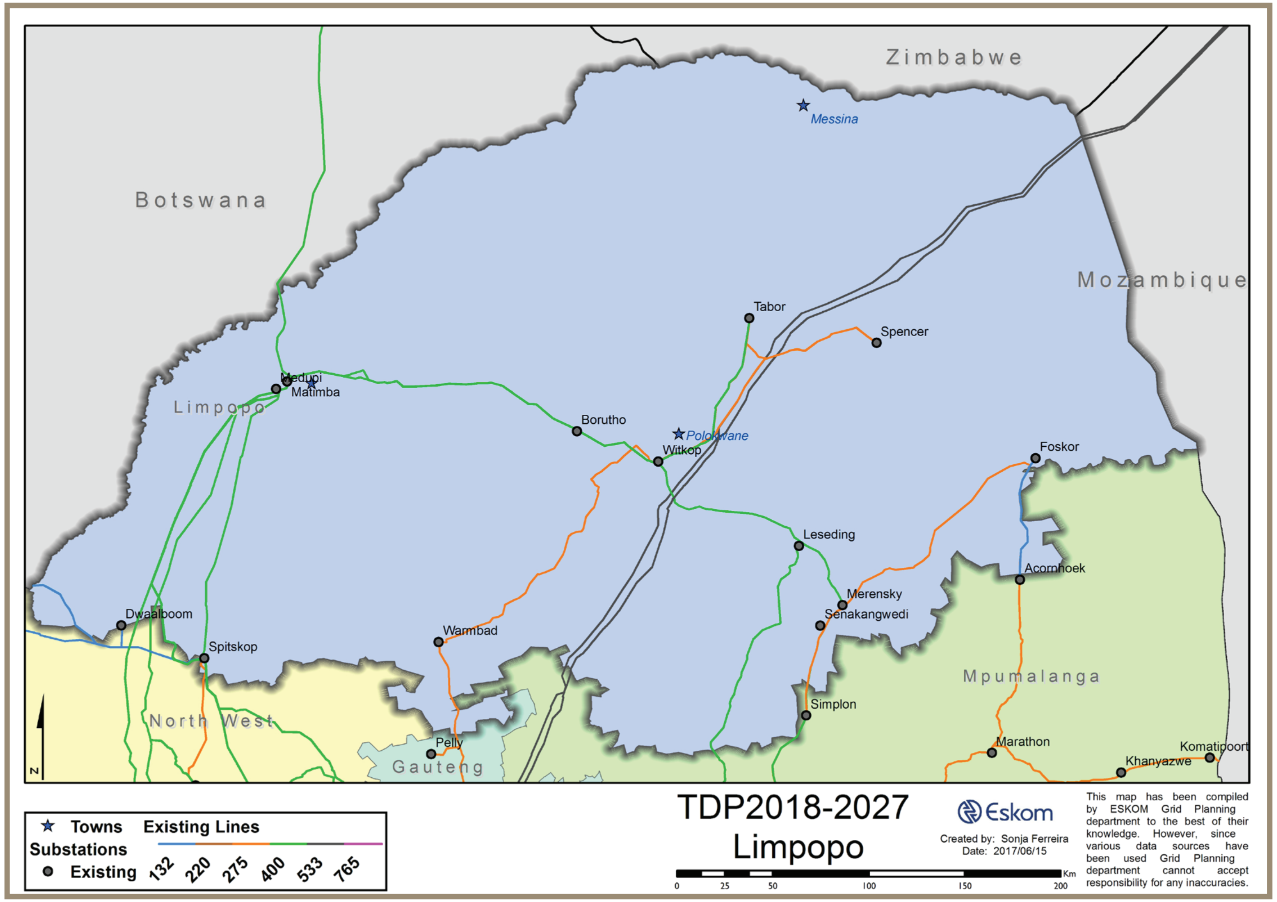



***Figure 6.7:*** Current Limpopo province network diagram

## Generation

The base load generation in Limpopo province is located in the Lephalale area, which is rich in coal reserves. There are two coal-fired power stations located in this area, namely the Medupi Power Station (under construction) and the existing Matimba Power Station. On completion, Medupi together with the Matimba coal-fired power station will provide almost 8.5 GW of generation to the South African grid.

### Matimba Power Station

The coal-fired power station is designed to generate 3 990 MW; Matimba – the Tsonga word for "power" – is the largest direct dry-cooled power station in the world, with six 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 5 076 MW (6 x 846 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.

### Thabametsi Power Station

Thabametsi Power Station is one of the two preferred coal IPPs for the first round of the DoE coal IPP programme. It will have a nominal generating capacity of 630 MW (2 x 315 MW units), with the total export capacity of 600 MW.

Table 6.5 shows a summarised list of generation capacity in Limpopo province.

| Scenario Description | Number of units in specified operating mode at each power station | | |
|---|---|---|---|
| | Matimba Power Station | Future Medupi Power Station | Future Thabametsi Power Station |
| Type | Base-load | Base-load (By year 2020) | Base-load (By year 2022) |
| Total Capacity (MW) | 3 990 MW | 5 076 MW | 630 MW |
| Normal operation for Planning load flow studies | 6 x 665 MW | 6 x 846 MW | 2 x 315 MW |

## Renewable Generation

Two Photo-Voltaic (PV) Renewable Energy Plants were commissioned and integrated into Witkop Substation (30 MW) and Tabor Substation (28MW) in the Polokwane area in year 2014.

Tom Burke – 60 MW Photo-Voltaic (PV) Renewable Energy Plant was integrated to Matimba Substation in the Lephalale area in year 2016.

## Load forecast

The CLNs (Customer Load Networks) in the Northern Grid are expected to experience positive growth over the next ten years. The Lephalale CLN will have a steady growth rate at 8.9%. This can be attributed to the heavy industry expected and the resulting light industry together with commercial and residential developments as spin-offs.

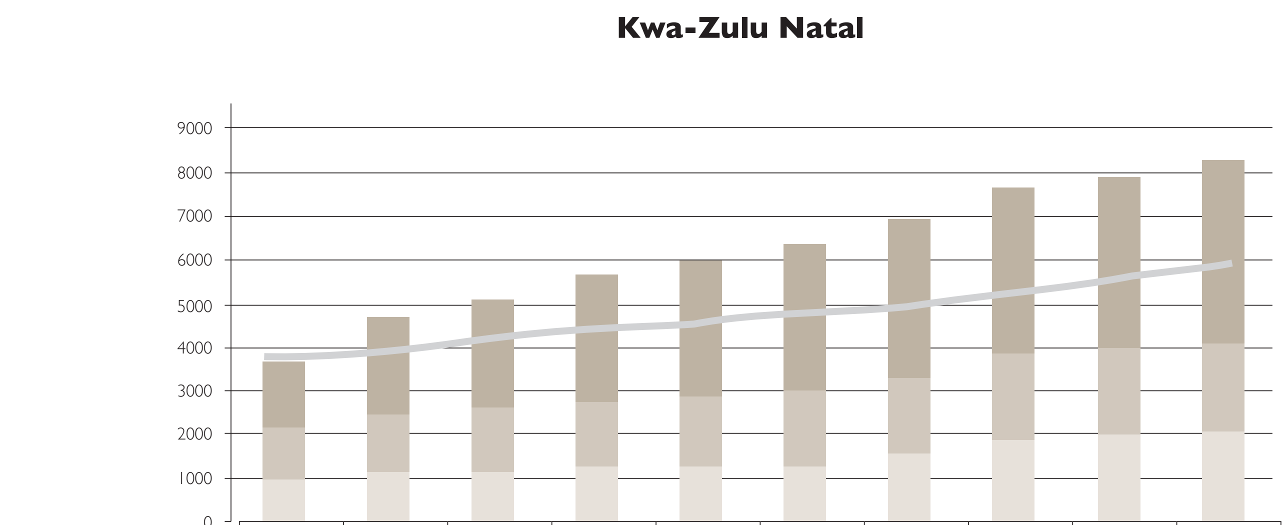
Mining activities are also expected in the areas of the Lephalale CLN, the introduction of the Borutho transmission substation will cater for these expected new mining loads in the surrounding areas of Mokopane town.

Polokwane CLN is expected to experience a load growth at 7.54%. The introduction of Nzhelele transmission substation will provide capacity for the new mines, electrification and residential developments which are expected in the area.

The Phalaborwa CLN will have a highest growth rate at 10.27%. This can be attributed to increase in mining activities and possible smelting operations near Leseding Substation.

The load in the Limpopo province is forecasted to grow steadily at about 6.95%, from 3 681 MW in year 2018 to 6 610 MW by year 2027.

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




| | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 |
|---|---|---|---|---|---|---|---|---|---|---|
| Phalaborwa @ Grid Peak | 1534 | 2243 | 2583 | 2847 | 3144 | 3426 | 3670 | 2270 | 4032 | 4204 |
| Lephalale @ Grid Peak | 1252 | 1371 | 1457 | 1584 | 1671 | 1801 | 1889 | 746 | 2075 | 2113 |
| Polokwane @ Grid Peak | 895 | 1041 | 1059 | 1161 | 1170 | 1197 | 1406 | 317 | 1894 | 1991 |
| Limpopo @ TOSP | 3659 | 3875 | 4069 | 4271 | 4496 | 4741 | 4970 | 6974 | 5330 | 5518 |

***Figure 6.8:*** Limpopo province load forecast

## Major schemes

The major schemes for the province are as follows:

**Medupi Transmission Integration (400 kV and 765 kV)**
The project is part of the original scope for Medupi Power Station integration into the grid. It entails the construction of 400 kV and 765 kV lines from the vicinity of Medupi Power Station to bulk power evacuation points in the Polokwane CLN and North West province.

**Waterberg Generation 400kV stability enhancement**
The following projects were later recommended due to future planned generation projects around the Waterberg area. The projects were raised to ensure compliance with the Grid Code in terms of transient stability.

- Construct 1 x 400 kV line from Medupi to Witkop (~200 km)
- Construct 1 x 400 kV line from Borutho to Silimela (~100 km)

**Nzhelele 400 kV Integration**
The integration of the 400 kV line into Nzhelele is required to de-load Tabor substation and Spencer substation. The 400 kV supply to enable this project will be sourced from the Tabor and Borutho substations through two 400 kV lines.

**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 at Spencer substation. The project will also require the 2nd Merensky-Foskor 275 kV line to be operated at 400 kV. A new 400/275 kV transformation will be established at Foskor substation.

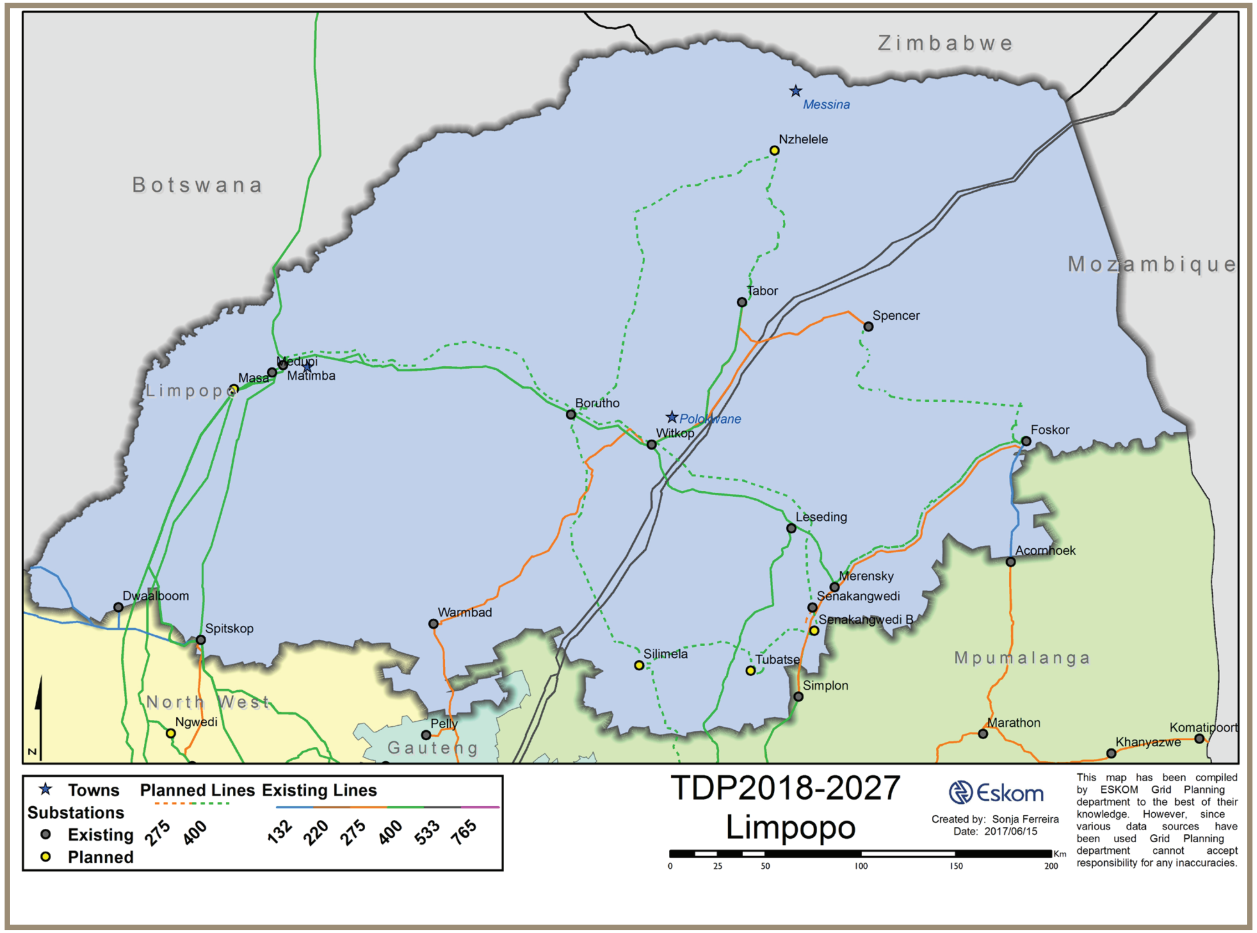
**Silimela (Marble Hall) Transmission Substation**
A new transmission substation will be constructed next to the existing Wolwekraal distribution substation to mitigate network constraints in the Mapoch and Kwaggafontein areas beyond 2018. This new transmission substation will deload Simplon substation and also supply the future load growth in the south-western part of the Phalaborwa CLN.

**Maphutha (Senakakgwedi B) Transmission Substation**
A new transmission substation will be constructed next to Uchoba distribution substation to create additional transmission network capacity for forecasted future load growth in the Steelpoort area.

**Dwarsberg (Dwaalboom) 132 kV Switching Station**
A 132kV switching station will be established to improve performance of the supply to existing Eskom customers in the Dwaalboom area, as well as the supply to the Gaborone area in Botswana.

The transmission development plans for Limpopo province are shown in Figure 6.9.

***Figure 6.9:*** Future Limpopo province network diagram




## New substations

The transmission substations to be established in Limpopo province over the TDP period are included in Section 6.3.4.

## Reactive power compensation

The following capacitor banks will be installed for voltage support in the Limpopo province:

- 2 x 36 MVar capacitor banks on the 132 kV busbar with associated bays at Tabor substation
- 2 x 36 MVar capacitor banks on the 132 kV busbar with associated bays at Spencer substation
- 2 x 36 MVar capacitor banks on the 132 kV busbar with associated bays at Nzhelele substation

## Provincial summary

The increase in transmission assets by the end of 2022 and the end of 2027 and the total new assets are shown in Table 6-6.

***Table 6.6:*** Cumulative TDP transmission assets for Limpopo province

| Transmission Assets for Limpopo Province | New Assets expected in 2018 - 2022 | New Assets expected in 2023 – 2027 | Total New Assets |
|---|---|---|---|
| **Power lines (km)** | | | |
| 765 kV | 0 | 0 | 0 |
| 400 kV | 664 | 817 | 1481 |
| 275 kV | 0 | 165 | 165 |
| Total length (km) | 664 | 982 | 1646 |
| **Transformers** | | | |
| Number of units | 5 | 4 | 9 |
| Total capacity (MVA) | 1 510 | 2 200 | 3 710 |
| **Capacitors** | | | |
| Number of banks | 6 | 0 | 6 |
| Total capacity (MVar) | 216 | 0 | 216 |
| **Reactors** | | | |
| Number of banks | 19 | 0 | 19 |
| Total capacity (MVar) | 1 360 | 0 | 1 360 |

The following projects are planned for the 2018 to 2027 period:

***Table 6.7:*** Limpopo province – summary of projects and timelines

| Scheme | Project | Expected CO Date |
|---|---|---|
| Nzhelele 400 kV Integration | Nzhelele 400/132 kV substation (1st & 2nd 250 MVA) | 2022 |
| | Tabor-Nzhelele 400 kV line | |
| | Borutho-Nzhelele 1st 400 kV line | |
| Tubatse Strengthening Scheme Phase 1 | Senakangwedi B (Maphutha) 400/275 kV Substation (1st 800 MVA 400/275 kV transformer), | 2022 |
| | Arnot–Merensky 400 kV loop in-out into Senakangwedi B (Maphutha) Substation | |
| | Tubatse (Manogeng)-Senakangwedi B (Maphutha) 1st 400 kV line | |
| | Senakangwedi B (Maphutha)-Senakangwedi 1st 275 kV line | |
| | Senakangwedi B (Maphutha) 400/132 kV Substation (1st and 2nd 500 MVA 400/132kV transformers) | |
| | Witkop-Senakangwedi B (Maphutha) 1st 400 kV line | 2025 |
| Highveld North-West and Lowveld North Reinforcement-Phase 2 | Silimela 400/132 kV substation | 2019 |
| | Tubatse (Manogeng) 400 kV switching station | |
| | Turn in Duvha-Leseding 400 kV line into Tubatse (Manogeng) switching station | |
| | Tubatse (Manogeng)-Silimela (Marble Hall) 400 kV line | |
| Highveld North-West and Lowveld North Reinforcement-Phase 1 | Emkhiweni (Rockdale B)-Silimela 400 kV line | 2022 |
| Foskor & Acornhoek 275/132kV Transformation Upgrades | Foskor-Merensky 2nd 275 kV Line | 2021 |
| | Acornhoek Upgrade Phase 1: 2x125 MVA 275/132 kV transformers | Commissioned |
| | Foskor 3rd 250 MVA 275/132 kV transformer | |
| Dwaalboom (Dwarsberg) 132kV Switching Station | Dwaalboom (Dwarsberg) 132 kV switching station | 2018 |

***Table 6.7:*** Limpopo province – summary of projects and timelines (continued)

| | | |
|---|---|---|
| Medupi Transmission Integration | Medupi-Spitskop 1st 400 kV line | Commissioned |
| | Medupi-Spitskop 2nd 400 kV line | |
| | Medupi-Spitskop 3rd 400 kV line | |
| | Spitskop-Dinaledi 1st 400 kV line | |
| | Spitskop-Dinaledi 2nd 400 kV line | |
| | Medupi-Marang 1st 400 kV | |
| | Medupi-Ngwedi (Mogwase) 1st 400 kV line | Commissioned |
| | Medupi-Ngwedi (Mogwase) 1st t 765 kV line (Energised at 400 kV) | |
| | Borutho 400/132 kV substation (2x 500 MVA transformers) | Commissioned |
| | Borutho 400 kV Loop-in (Matimba-Witkop 1st 400 kV line) | |
| | Medupi-Borutho 1st 400 kV line | |
| | Borutho-Witkop 2nd 400 kV line | |
| | Medupi 400/132 kV 2x250 MVA substation | |
| Waterberg Generation 400 kV Stability Enhancement | Borutho-Marble Hall (Silimela) 1st 400 kV line | 2023 |
| | Medupi-Witkop 1st 400 kV line | 2020 |
| Limpopo East Corridor Strengthening | Foskor-Spencer 1st 400 kV line (110km) | 2024 |
| | 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 400/132kV 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 |
| Waterberg Fault Level Project | Waterberg Fault Level Project: Witkop Substation | 2019 |
| Borutho 3rd 500MVA 400/132 kV transformer | Borutho 3rd 500 MVA 400/132 kV transformer | 2027 |
| Leseding 3rd 500 MVA 400/132 kV transformer | Leseding 3rd 500 MVA 400/132 kV transformer | 2027 |
| Warmbad 3rd 125 MVA 275/132 kV transformer | Warmbad 3rd 125 MVA 275/132 kV transformer | 2027 |

## 6.4 Mpumalanga province

### Background

Mpumalanga is a province located in the north-eastern part of South Africa, which shares international borders with Mozambique and Swaziland. The capital of Mpumalanga is Nelspruit, the major city in the Mbombela Local Municipality. The provincial economy is mainly driven by farming, mining, heavy industry and, viz. the Kruger National Park, Sudwala Caves and Blyde River Canyon

The provincial load peaked at around 3 934 MW in 2016 which represents a 3% decrease on 2015 loads, and it is expected to increase to about 4 915 MW by 2027. The Mpumalanga province comprises four Customer Load Networks (CLNs), namely Highveld South, Lowveld, Middleburg and Witbank. The transmission network in Mpumalanga province is predominantly connected at a 400 kV voltage level, with minor transmission stations connected at 275 kV as shown in Figure 6 10. The load growth in Mpumalanga province during this TDP period is attributable to commercial development, electrification and the establishment of the industrial development zone (IDZ).

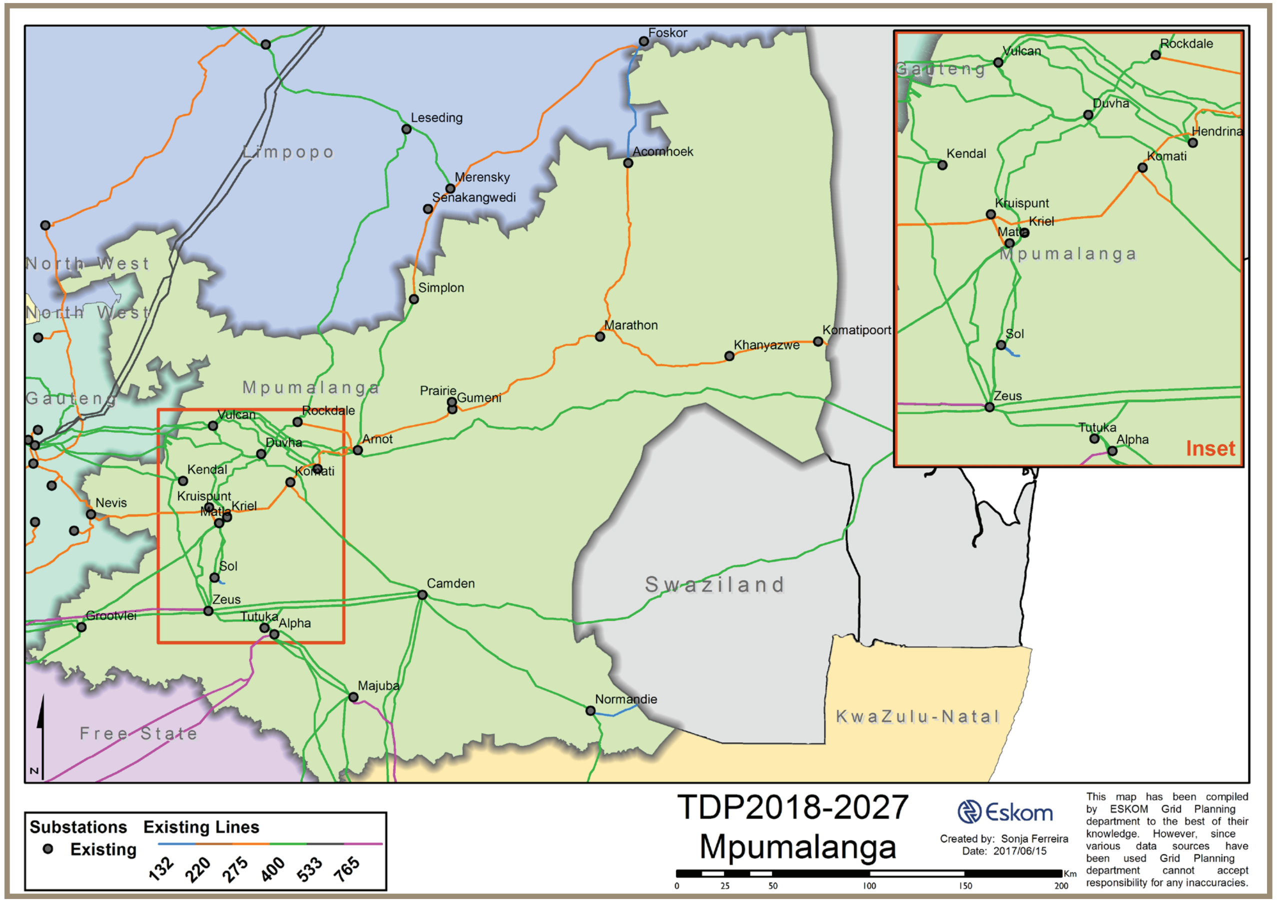



***Figure 6.10:*** Current Mpumalanga province network diagram

## Generation

The Mpumalanga province is considered the power generation hub of South Africa due to the high concentration of power stations in the province. 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 total capacity of Kusile Power Station on completion is expected to be 5 076 MW.

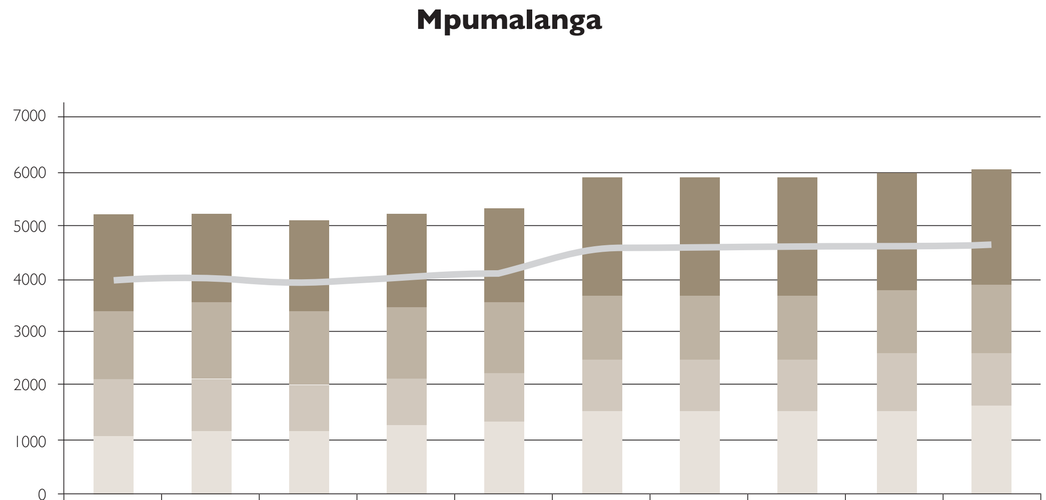
One of the two preferred coal IPPs for the first round of the DoE coal IPP programme, known as Khanyisa power station is also located in Mpumalanga province. The allocated export capacity for this power station is 306 MW.

Furthermore, the draft IRP proposes the decommissioning of some of the units at Eskom's coal-fired power stations. Since the decommissioning schedule has not been finalised, generation reduction was assumed at Hendrina, Grootvlei and Komati during this TDP period in order to evaluate the transmission network impacts thereof.

## Load forecast

The economic mix in the Mpumalanga province comprises redistributors, mining, commercial customers and industrial consumers. The load in Mpumalanga province is forecasted to grow steadily at about 2% annually, from 4 173 MW in year 2018 to 4 915 MW by year 2027. The highest provincial load growth is expected in the Highveld South CLN due industrial developments near Secunda.

The load forecast for the Mpumalanga province is shown in Figure 6 11.




| | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 |
|---|---|---|---|---|---|---|---|---|---|---|
| Highveld South @ Grid Peak | 1723 | 1729 | 1739 | 1750 | 1760 | 2236 | 2171 | 2179 | 2186 | 2194 |
| Witbank @ Grid Peak | 1312 | 1324 | 1333 | 1351 | 1364 | 1175 | 1179 | 1185 | 1189 | 1194 |
| Lowveld @ Grid Peak | 992 | 1017 | 883 | 4098 | 912 | 1009 | 1027 | 1007 | 1024 | 1042 |
| Middelburg @ Grid Peak | 1084 | 1144 | 1219 | 1558 | 1276 | 1462 | 1485 | 1505 | 1539 | 1621 |
| Mpumalanga @ TOSP | 3975 | 4047 | 4054 | 12982 | 4130 | 4560 | 4547 | 4560 | 4605 | 4681 |

***Figure 6.11:*** Mpumalanga province load forecast

## Major schemes

Several projects and schemes that aim to address the long-term requirements of the province have been initiated in order to accommodate the forecasted load and generation integration in the province. The main schemes planned in the Mpumalanga province are as follows:

**Highveld North-West and Lowveld North Reinforcement – Phase 1: Emkhiweni Integration**
This scheme entails the establishment of the new Emkhiweni 400/132 kV substation which is required to address both Vulcan and Rockdale substation transformation constraints.

**Highveld South Reinforcement Phase 2: Mulalo Integration**
This scheme entails the establishment of the new Mulalo 400/132 kV substation which is required to mitigate transformation capacity and fault level constraints at Sol Substation.

**Kusile Power Station Integration**
This is a project required to integrate Kusile Power Station into the transmission network. The scheme comprises the construction of three new transmission lines as well as the reconfiguration of the local network to enable power evacuation. The new transmission lines to be constructed as part of this scheme are Kusile-Lulamisa, Kusile-Zeus and Kendal-Zeus 400 kV lines.

**Lowveld Strengthening Phase 2B**
This scheme is required to increase the transformation capacity at Marathon substation near Nelspruit, and mitigate the expected low voltages in the 275 kV network under N-1 in the Lowveld area.

The transmission development plans for Mpumalanga Province are shown in Figure 6 12.

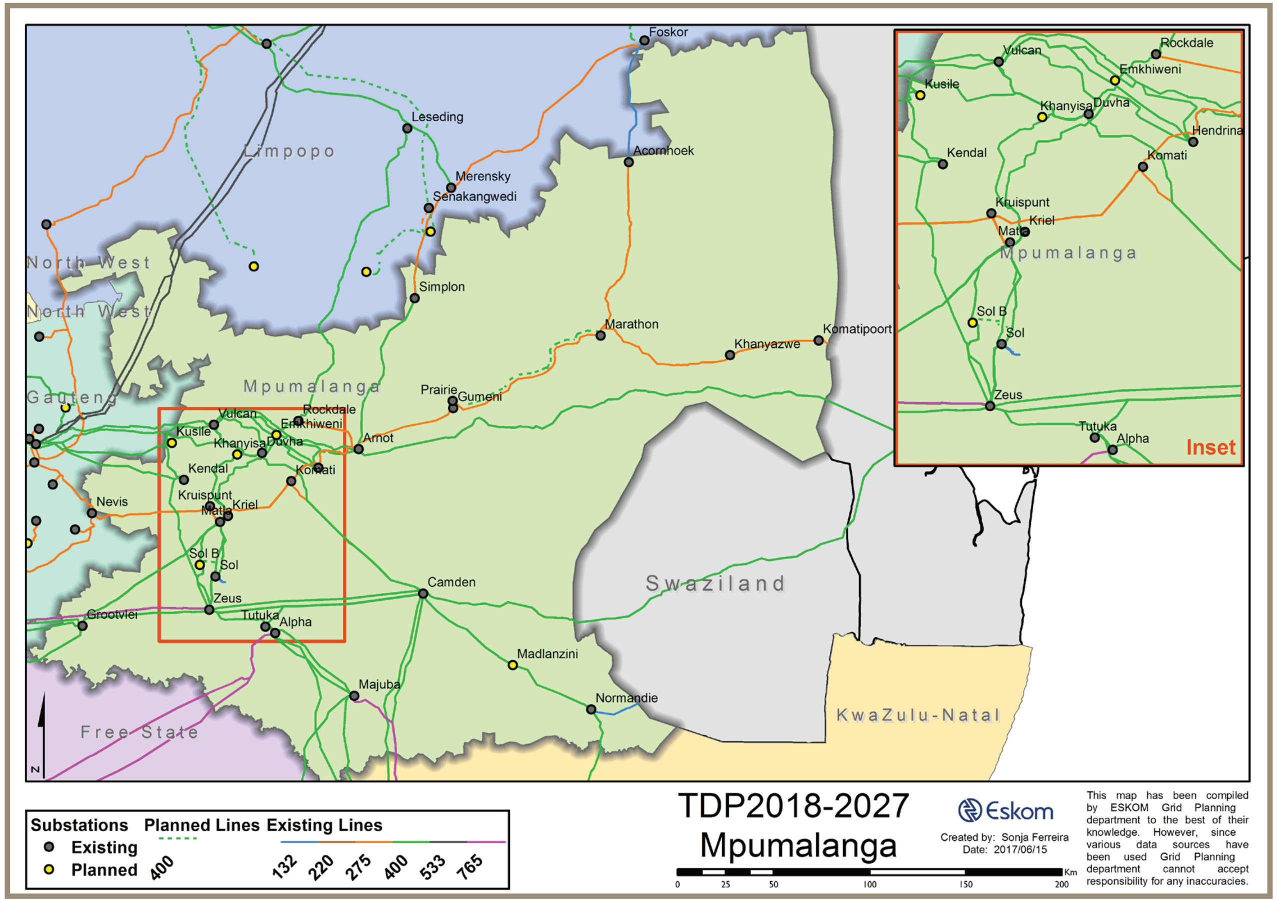



**FIGURE 6.12:** FUTURE MPUMALANGA PROVINCE NETWORK DIAGRAM

## New substations

The following new substations will be established in the Mpumalanga province in order to address load growth as well as IPP integration:

Load growth in the industrial, mining and commercial sectors of the Middleburg CLN will necessitate the introduction of the following 400/132 kV substation:

- Emkhiweni 2 x 500 MVA 400/132 kV substation between Emalahleni and Middleburg

Load growth in the Highveld South CLN will necessitate the introduction of the following 400/132 kV substation:

- Mulalo 5 x 500 MVA 400/132 kV substation in the Secunda area

Load growth in the Lowveld CLN will necessitate the introduction of the following 400/132 kV substation:

- Marathon 1 x 500 MVA 400/132 kV substation in the Nelspruit area

The Khanyisa Power Station integration in the Witbank CLN will necessitate the introduction of the following 400kV substation:

- Benella switching station in the Emalahleni area

## Reactive power compensation

There are no reactive power compensation projects in the Mpumalanga Province.

## Provincial Summary

The increase in transmission assets by the end of 2022 and the end of 2027 and the cumulative total are shown in Table 6 8.

**Table 6.8:** Cumulative TDP transmission assets for Mpumalanga province

| Transmission Assets for Mpumalanga Province | New Assets expected in 2018 - 2022 | New Assets expected in 2023 - 2027 | Total New Assets |
|---|---|---|---|
| **Power lines (km)** | | | |
| *765 kV* | *0* | *0* | *0* |
| *400 kV* | *383* | *100* | *483* |
| *275 kV* | *10* | *0* | *10* |
| *Total length (km)* | *393* | *100* | *493* |
| **Transformers** | | | |
| *Number of units* | *8* | *1* | *9* |
| *Total capacity (MVA)* | *3 750* | *500* | *4 250* |
| **Capacitors** | | | |
| *Number of banks* | *0* | *0* | *0* |
| *Total capacity (MVar)* | *0* | *0* | *0* |
| Reactors | | | |
| *Number of banks* | *0* | *0* | *0* |
| *Total capacity (MVar)* | *0* | *0* | *0* |

***Table 6.9:*** Mpumalanga province – summary of projects and timelines

| Scheme name | Project name | Expected CO Date |
|---|---|---|
| ***Normandie transformation Upgrade*** | *Normandie Ext. 2nd 250 MVA 400/132 kV transformer* | *2018* |
| ***Kusile PS integration*** | *Kusile 400 kV HV Yard* | *Commissioned* |
| | *Kusile integration: Minerva-Duvha and Kendal-Apollo loop in/out* | *Commissioned* |
| | *Kusile integration: Vulcan bypass* | *Commissioned* |
| | *Kusile Integration Phase 3B: Kusile 400 kV loop-in (Apollo-Kendal 1st 400 kV line)* | *Commissioned* |
| | *Kusile Integration Phase 3A: Kusile 400 kV bypass Duvha (to form Kusile-Vulcan 400 kV line)* | *2018* |
| | *Kusile Integration Phase 4A: Kendal-Zeus 1st 400 kV line* | *2018* |
| | *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)* | *2018* |
| | *Kusile Integration Phase 4B: Kendal-Zeus 2nd 400 kV line* | *2018* |
| | *Kusile 400 kV bypass Duvha (to form Kusile-Vulcan 400 kV line)* | *2018* |
| | *Kusile 400 kV bypass Kendal (Kendal bypass required to form the Kusile-Zeus 400 kV line from Kusile-Kendal and Kendal-Zeus lines)* | *2018* |
| | *Kendal-Zeus 1st 400 kV line* | *2019* |
| | *Kendal-Zeus 2nd 400 kV line* | *2019* |
| | *Kusile Integration Phase 2: Kusile-Lulamisa 1st 400 kV line* | *2019* |

**Table 6.9:** Mpumalanga province – summary of projects and timelines (continued)

| | | |
|---|---|---|
| ***Highveld South Reinforcement 1*** | *Highveld South Reinforcement: Series Reactors* | *2019* |
| ***Waterberg Fault Level Project*** | *Waterberg Fault Level Project: Merensky Substation* | *2020* |
| ***Mpumalanga Underrated Equipment*** | *Mpumalanga Underrated Equipment* | *2020* |
| ***Highveld North-West and Lowveld North Reinforcement – Phase 1*** | *Turn in Kendal-Arnot 400 kV line into Emkhiweni 400/132 kV Substation* | *2022* |
| | *Emkhiweni 400/132 kV Substation* | |
| ***Highveld South Reinforcement 2*** | *Turn in Kriel-Tutuka 400 kV line into Mulalo substation* | *2022* |
| | *New Mulalo 400/132 kV substation* | |
| | *Turn in Kriel-Zeus 400 kV line into Mulalo substation* | |
| | *Mulalo Ext. equip 8 x 132 kV feeder bays* | *2022* |
| ***Khanyisa Power Station Integration*** | *Benella 400 kV switching station* | *2019* |
| | *Turn in Kusile-Vulcan 400 kV line into Benella Switching Station* | |
| ***Lowveld Strengthening Phase 2B*** | *Gumeni-Marathon 400 kV line* | *2024* |
| | *Marathon 400/132 kV substation* | |

# 6.5 North West province

## Background

The North West province of South Africa, also known as the platinum province, is bounded on the north by Botswana, and domestically on the south by the provinces of Free State and the Northern Cape, and on the northeast as well as east by the Limpopo and Gauteng. Much of the province consists of flat areas of scattered trees and grassland.

The North West province is endowed with various mineral riches such as platinum group metals, dimensions stone, fertile and vast agriculture soil, a strong manufacturing sector and potential opportunities for renewable energy and agro processing. The North West province is home to the largest platinum refinery and two of the largest platinum mines as well as the 4th largest integrated ferrochrome producer. In addition, tourism activities and investment opportunities thrive in the province, boasting among others internationally renowned tourism hubs such as the Big 5 Pilanesberg located in the crater of an extinct volcano, and Madikwe Game Reserves, Sun City Entertainment and Golf complex, the Taung Skull heritage site and the popular Hartebeespoort dam. The Magaliesberg mountain range in the northeast extends to about 130 km from Pretoria to Rustenburg. The Vaal River flows along the southern border of the province.

In addition to record high levels of sunshine all year round, ideal for solar and green energy projects, the North West province offers an outstanding quality of life in its smaller cities and developing towns.

The mainstay of the economy of the North West province is mining, which generates more than half of the province's gross domestic product. The chief minerals are gold, mined at Orkney and Klerksdorp; uranium, mined at Klerksdorp; platinum, mined at Rustenburg and Brits; and diamonds, mined at Lichtenburg, Christiana, and Bloemhof. The northern and western parts of the province have many sheep farms and cattle and game ranches. The eastern and southern parts are crop-growing regions that produce maize (corn), sunflowers, tobacco, cotton, and citrus fruits. The entertainment and casino complex at Sun City and 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 and extend into the Carletonville customer load networks. There is a need and determination to extend to untapped areas waiting to be explored, hence the need to have adequate expansion network plans in place to meet the demand in load growth. In addition to this, a need to unlock capacity for electrification and to create a platform for integration of renewable energy.

The provincial load peaked at around 3 171 MW in 2016 which represents an 8% decrease on 2015 loads. The load within the province is projected to be approximately 4 600 MW by 2027. The North West comprises of two Customer Load Networks (CLNs), namely Rustenburg and Carletonville. Rustenburg CLN consumes approximately 63% of the load, with Carletonville CLN making up the remaining 37% of the demand in the province. The North West province comprises of a predominantly 400 kV connected transmission network, with an underlying 275 kV network. The integration of Medupi Power Station (situated in Limpopo province will further enhance the major power corridors into Rustenburg, extending into the Carletonville Customer Load Network.

The current transmission network is shown in Figure 6.13.

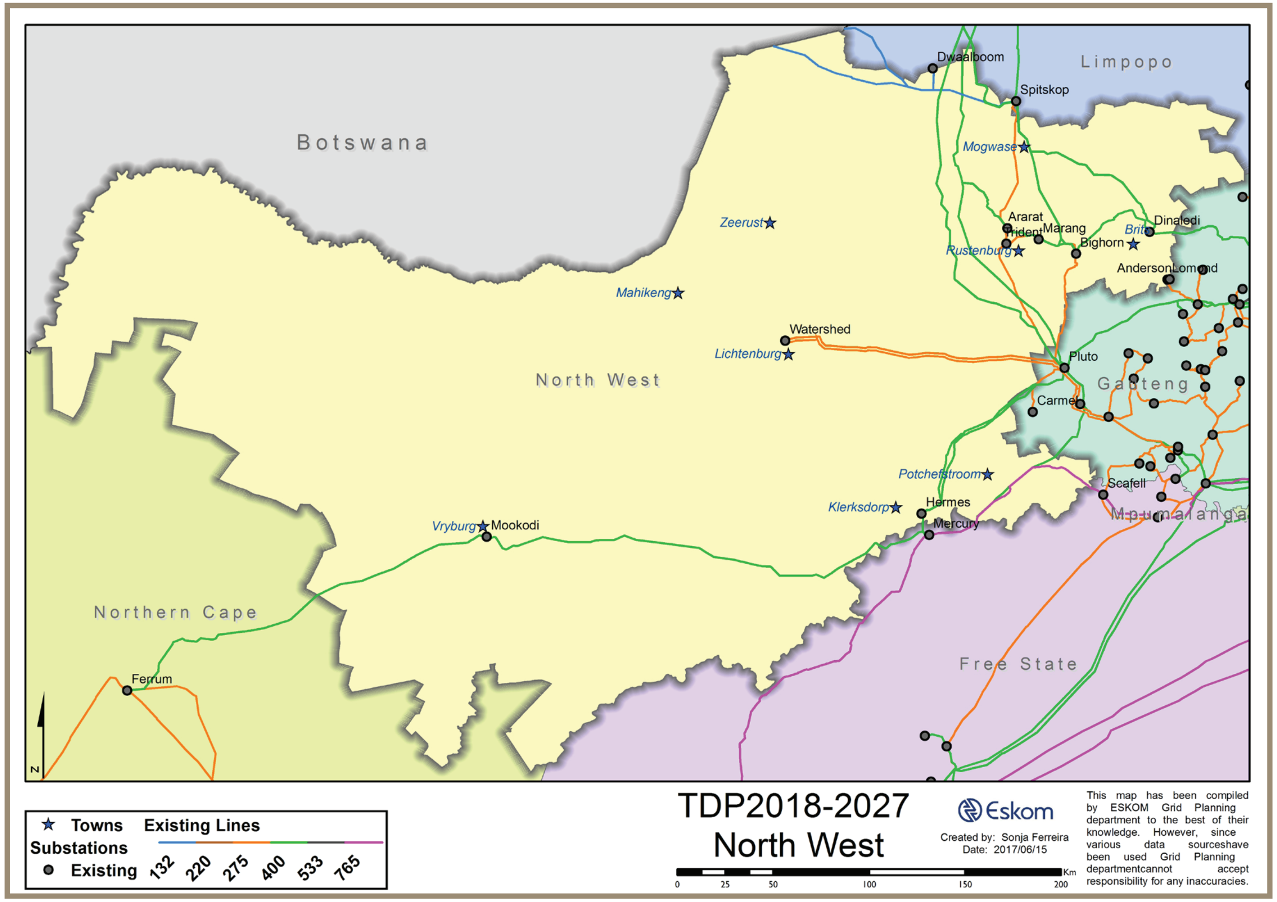



***Figure 6.13:*** Current North West province network diagram

## Generation

There are no power stations within the North West Province. All the power consumed within this province is sourced from power stations in the Limpopo province and Mpumalanga province. The load flows will change after the integration of the Medupi power station and most of the power into the North West Province will be supplied from the Limpopo Province.

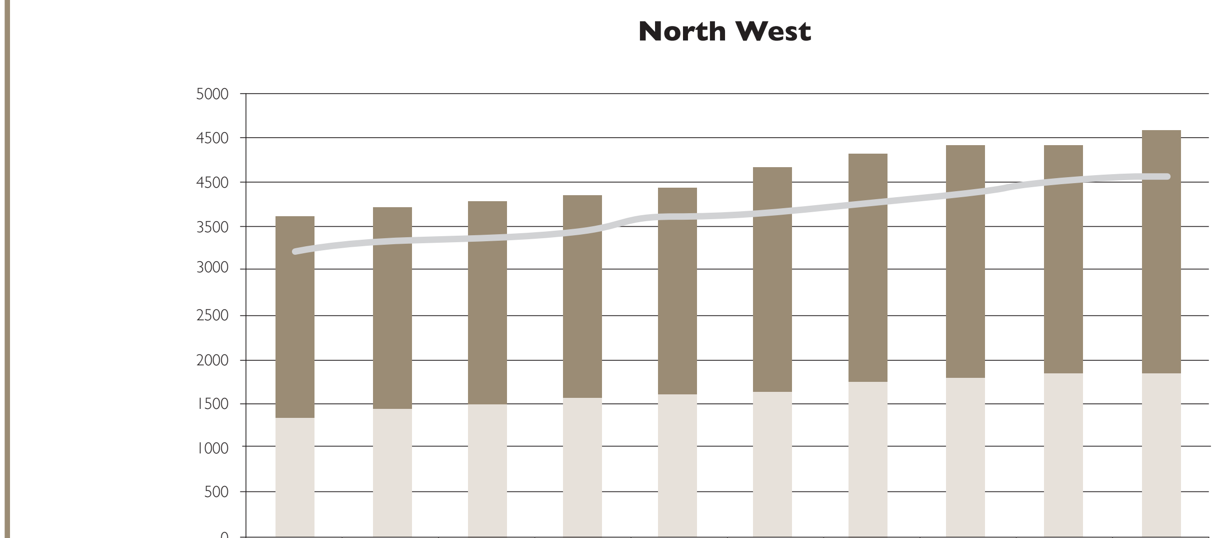
## Renewable generation

There has been an interest in renewable energy generation, particularly near Vryburg and neighbouring towns, i.e., Lichtenburg, which lies in the Carletonville CLN.

The planned Mahikeng Substation which lies approximately 60 km west of Watershed has been identified as a potentially optimal location for connecting some of the new renewable plants, and a possible strategic connection corridor to the SADC region through Botswana as a first point of entry.

## Load forecast

The load forecast for the North West province is shown in Figure 6.14.




| | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 |
|---|---|---|---|---|---|---|---|---|---|---|
| Rustenburg @ Grid Peak | 2302 | 2270 | 2300 | 2333 | 2366 | 2526 | 2572 | 2621 | 2590 | 2716 |
| Carletonville @ Grid Peak | 1336 | 1451 | 1500 | 1536 | 1587 | 1644 | 1750 | 1799 | 1830 | 1883 |
| North West @ TOSP | 3120 | 3170 | 3225 | 3284 | 3465 | 3540 | 3619 | 3720 | 3863 | 3941 |

***Figure 6.14:*** North West province load forecast

## Major schemes

Several projects and schemes have been initiated to meet and cater for the forecasted load demand and generation integration in the province. The following major schemes are planned for the 2018 to 2027 period on the North West province:

- Integration of Ngwedi Substation
- Rustenburg Strengthening Phase 2
- Rustenburg Strengthening Phase 3
- Watershed Strengthening
- Watershed (Backbone) Strengthening Phase 3

### Rustenburg Strengthening Phase 2

Rustenburg Strengthening Phase 2 refers to the extension of Marang Substation which will introduce a 132 kV voltage level at Marang substation. The Distribution network will also be upgraded from 88 kV to 132 kV in conjunction with the introduction of a 132 kV line at Marang Substation.

### Ngwedi 400/132 kV Integration

Ngwedi substation is planned to de-load Ararat Substation and create additional capacity to supply load between Spitskop and Ararat. This will establish an evacuation path for power from Medupi power station into the Rustenburg CLN and shift load from Ararat to Ngwedi. One of the planned Medupi-Ngwedi lines will be built according to the 765 kV standards, however it will be operated at 400 kV.

### Rustenburg Strengthening Phase 3

The scheme is expected to address low voltages in the Rustenburg CLN under the N - 1 loss of the Medupi-Marang 400 kV line. The low voltages at Marang, Bighorn and Dinaledi substations will be addressed by installing shunt capacitors at those respective substations which will also provide reactive power support in the Rustenburg CLN.

### Watershed Strengthening Phase 3

The current network constraints at Watershed Substation are capacity shortages and poor voltage regulation, emanating from the N - 1 of 275 kV in-feeds into Watershed Substation. Approximately 180 MVA will be shifted from Watershed Substation to Mookodi and Ngwedi Substation. Furthermore, a new Mahikeng (Watershed B)
2 x 500 MVA 400/88 kV substation is planned approximately 60 km west of Watershed Substation to create additional capacity for future load growth. The substation in-feeds will comprise the construction of the Pluto-Mahikeng 200 km 400 kV line and Mookodi-Mahikeng 160 km 400 kV line.

The transmission development plans for North West province are shown in Figure 6.15.

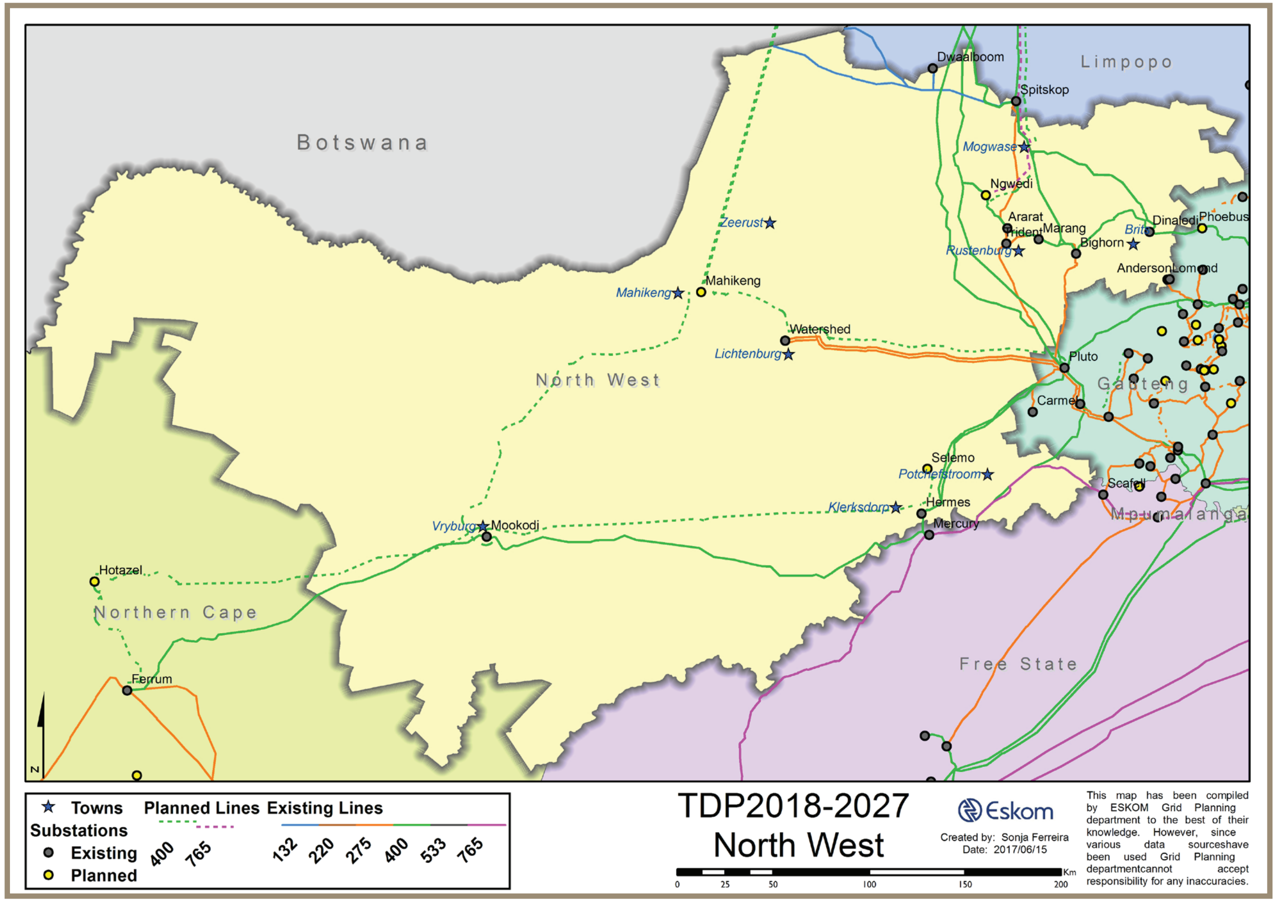



***Figure 6.15:*** Future North West province network diagram

## New substations

The transmission substations to be established in North West province over the TDP period are included in Section 6.5.4.

## Reactive power compensation

The following capacitor banks will be installed for voltage support in the North-West Province:

- 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)

## Provincial summary

The increase in transmission assets by the end of 2022 and the end of 2027 and cumulative total are shown in Table 6 10.

***Table 6.10:*** Cumulative TDP transmission assets for North West province

| Transmission Assets for North West Province | New Assets expected in 2018 - 2022 | New Assets expected in 2023 – 2027 | Total New Assets |
|---|---|---|---|
| **Power lines (km)** | | | |
| 765 kV | 0 | 0 | 0 |
| 400 kV | 0 | 180 | 180 |
| 275 kV | 0 | 0 | 0 |
| Total length (km) | 0 | 180 | 180 |
| **Transformers** | | | |
| Number of units | 1 | 5 | 6 |
| Total capacity (MVA) | 1750 | 1945 | 3695 |
| **Capacitors** | | | |
| Number of banks | 3 | 13 | 16 |
| Total capacity (MVar) | 90 | 744 | 834 |
| **Reactors** | | | |
| Number of banks | 0 | 0 | 0 |
| Total capacity (MVar) | 0 | 0 | 0 |

**Table 6.11:** North West province – summary of projects and timelines

| Scheme | Project | Expected CO Date |
|---|---|---|
| *Ngwedi Substation* | *Ngwedi 400/132 kV substation* | *2020* |
| *Watershed Strengthening* | *Watershed MTS 132 kV Reactive power compensation (2x30 MVAr Capacitors)* | *2021* |
| | *Watershed MTS 88 kV Reactive power compensation (1x30 MVAr Capacitors)* | |
| | *Watershed 275/132 kV substation 250 MVA 275/132 kV transformer* | *2021* |
| *Kimberley Strengthening Phase 2* | *Mercury-Mookodi (Vryburg) 1st 400 kV line,* | *Commissioned* |
| | *Mookodi-Ferrum 400 kV line, and Establishment of Mookodi 2x 250 MVA 400/132 kV MTS,* | |
| | *Distribution 132 kV integration at Mookodi Substation (Distribution lines)* | *2016-2019* |
| *Watershed (Backbone) Strengthening Phase 3* | *Pluto-Mahikeng 400 kV* | *2024* |
| | *Mahikeng 1st 315MVA 400/88 kV transformer* | |
| | *Mahikeng 2nd 315MVA 400/88 kV transformer* | *2029* |
| | *Mookodi-Mahikeng 400 kV* | |

**Table 6.11:** North West province – summary of projects and timelines (continued)

| | | |
|---|---|---|
| *Kimberley Strengthening Phase 3* | *Hermes-Mookodi (Vryburg) 1st 400kV line* | *2026* |
| *Rustenburg Strengthening Phase 1* | *Bighorn 2 x 500 MVA 400/132 kV transformer* | *2027* |
| *Rustenburg Strengthening Phase 2* | *Marang Extension 2 x 500 MVA 400/132 kV substation* | *2028* |
| *Rustenburg Strengthening Phase 3* | *Bighorn Reactive Compensation (2 x 72 MVAr 132kV and 3 x 48 MVAr 88 kV Shunt Capacitors)* | *2028* |
| | *Marang Reactive Compensation (5 x 48 MVAr 88kV Shunt Capacitors)* | |
| | *Dinaledi Reactive Compensation (3 x 72MVAr 88kV Shunt Capacitors)* | |
| *Medupi Integration Phase 2A: Mogwase* | *Ngwedi 2 x 500 MVA 400/132 kV Substation* | *2017-19* |
| | *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 400kV)* | |
| *Trident /Ararat / Marang network optimization study* | *1x 88 kV feeder bay and associated Distribution scope of work. (Customer related)* | *2020* |
| *Trident 3rd Transformer* | *Trident 3rd transformer* | *2022* |
| *Carmel 275/88 kV Capacity Upgrade* | *Carmel 275/88 kV Capacity Upgrade* | *2022* |

# 6.6 Free state province

## Background

The Free State province is South Africa's most centrally located province with Bloemfontein as its capital. It has borders with most other provinces and has Lesotho as its eastern neighbour. Mining and agriculture are the bedrock of the economy in the province. 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, the promotion of manufacturing, warehousing and storage opportunities. The Harrismith Logistics Hub (HLH) on the N3 is at the centre of these plans.

The provincial load peaked at around 1 707 MW in 2016 which represents a 2% increase on the 2015 loads, and it is expected to increase to about 2 461 MW by 2027. The Free State province comprises three Customer Load Networks (CLNs), namely Sasolburg, Bloemfontein and Welkom. The Welkom CLN consumes approximately 47% of the load. Sasolburg and Bloemfontein CLNs make up the remaining 53% of the demand in the province. The province has a number of development proposals which include various projects for 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. There is also an interest by IPPs to establish PV plants in the western parts of the province.

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

The current transmission network is shown in Figure 6.16.

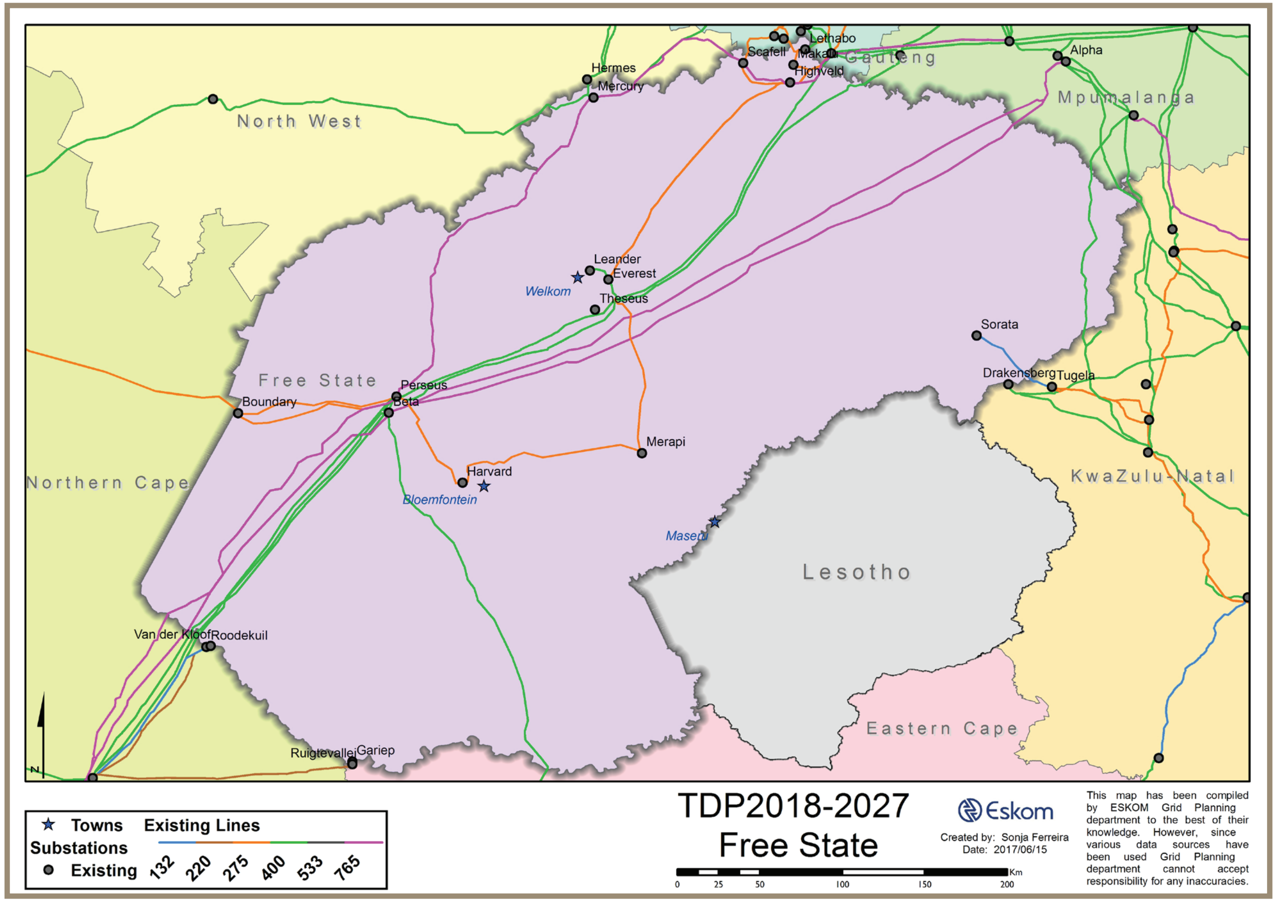



***Figure 6.16:*** Current Free State province network diagram

## Generation

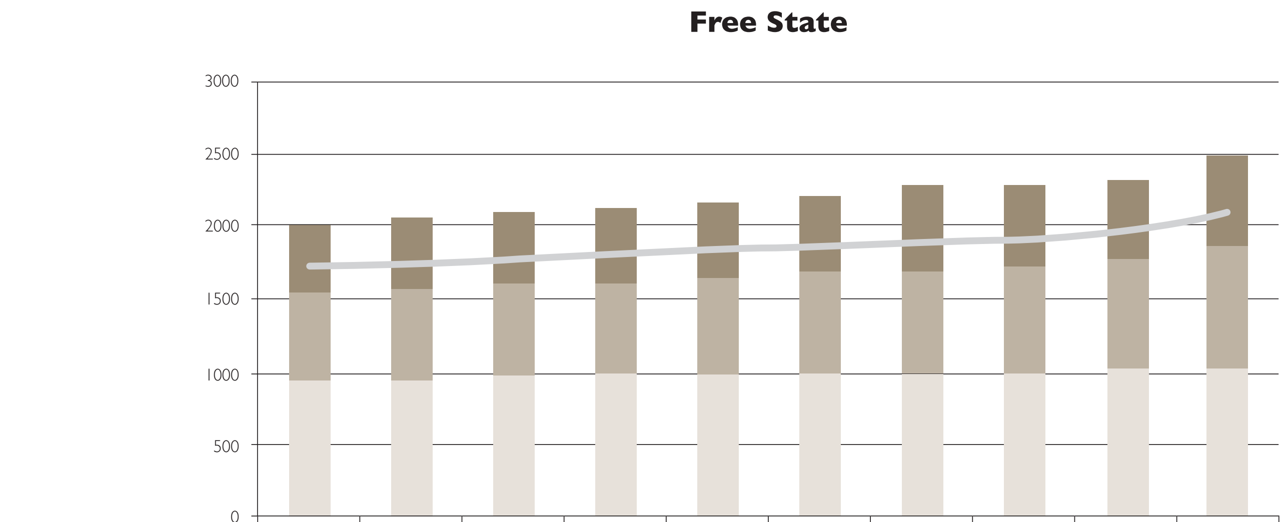
The power supply into the province is predominantly sourced from Lethabo Power Station and Mpumalanga province through 400 kV and 275 kV transmission lines. Lethabo Power Station is a coal-fired power station located in the Vaal Triangle area of the Free State, and designed to generate a total capacity of 3 558 MW.

## Renewables

There has been interest shown in the Free State Province by Independent Power Producers (IPPs) for solar power generation, mainly in the Dealesville and Welkom areas.

## Load forecast

The economic mix in the Free State province is predominantly mining, commercial customers and residential customers. The load in the Free State province is forecasted to grow steadily at about 2% annually, from 2 001 MW in the year 2018 to 2 461 MW by the year 2027. The highest provincial load growth is expected in the Sasolburg CLN. The load forecast for the Free State province is shown in figure 6-19.




| | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 |
|---|---|---|---|---|---|---|---|---|---|---|
| Sasolburg @ Grid Peak | 463 | 481 | 488 | 495 | 503 | 510 | 517 | 524 | 532 | 593 |
| Bloemfontein @ Grid Peak | 593 | 611 | 619 | 635 | 662 | 689 | 699 | 710 | 764 | 845 |
| Welkom @ Grid Peak | 945 | 952 | 973 | 980 | 988 | 996 | 1003 | 1011 | 1019 | 1023 |
| Free State @ TOSP | 1695 | 1731 | 1762 | 1788 | 1824 | 1859 | 1880 | 1902 | 1961 | 2084 |

***Figure 6.17:*** Free State province load forecast

## Major schemes

Several projects and schemes have been identified to accommodate the forecasted load and generation integration in the province. The following major schemes are planned for the 2018 to 2027 period in the Free State province:

**Bloemfontein Strengthening Phase 1B**
The project involves establishing a 275 kV line from Everest substation to Merapi substation, built at 400 kV specifications and operated at 275 kV.

**Bloemfontein Strengthening Phase 2**
The project involves acquiring servitudes for future 400 kV lines i.e. Beta- Harvard and Harvard- Merapi lines and the introduction of 400 kV at Harvard and Merapi substations.

**Harrismith Strengthening Phase 1**
This project addresses network capacity constraints in the Harrismith region which includes Tugela substation in the KwaZulu-Natal province and Sorata 132 kV switching station in the Free State province. The Sorata 132 kV switching station will be extended to a 275/132 kV substation to deload Tugela substation. Sorata substation will be supplied by the existing Tugela-Sorata 275 kV line which is currently operated at 132 kV.

**Sorata Substation Strengthening**
This project will involve recycling the servitude for the Groenkop-Tugela 132 kV line and the construction of the 2nd Sorata-Tugela 275 kV line, as well as installing a 2nd 275/132 kV transformer at Sorata Substation.

**Makalu Substation Strengthening**
The new Igesi 275/88 kV substation will be established in the Sasolburg area in the Free State province. This project involves establishing the Igesi 275/88 kV substation and to loop into one of the Lethabo-Makalu 275 kV lines to form Lethabo- Igesi and Igesi- Makalu 275 kV lines. The Igesi Substation will deload Makalu Substation, assist in reducing network fault levels around Makalu Substation as well as support load growth in the area.

The transmission development plans for Free State province are shown in Figure 6.18.

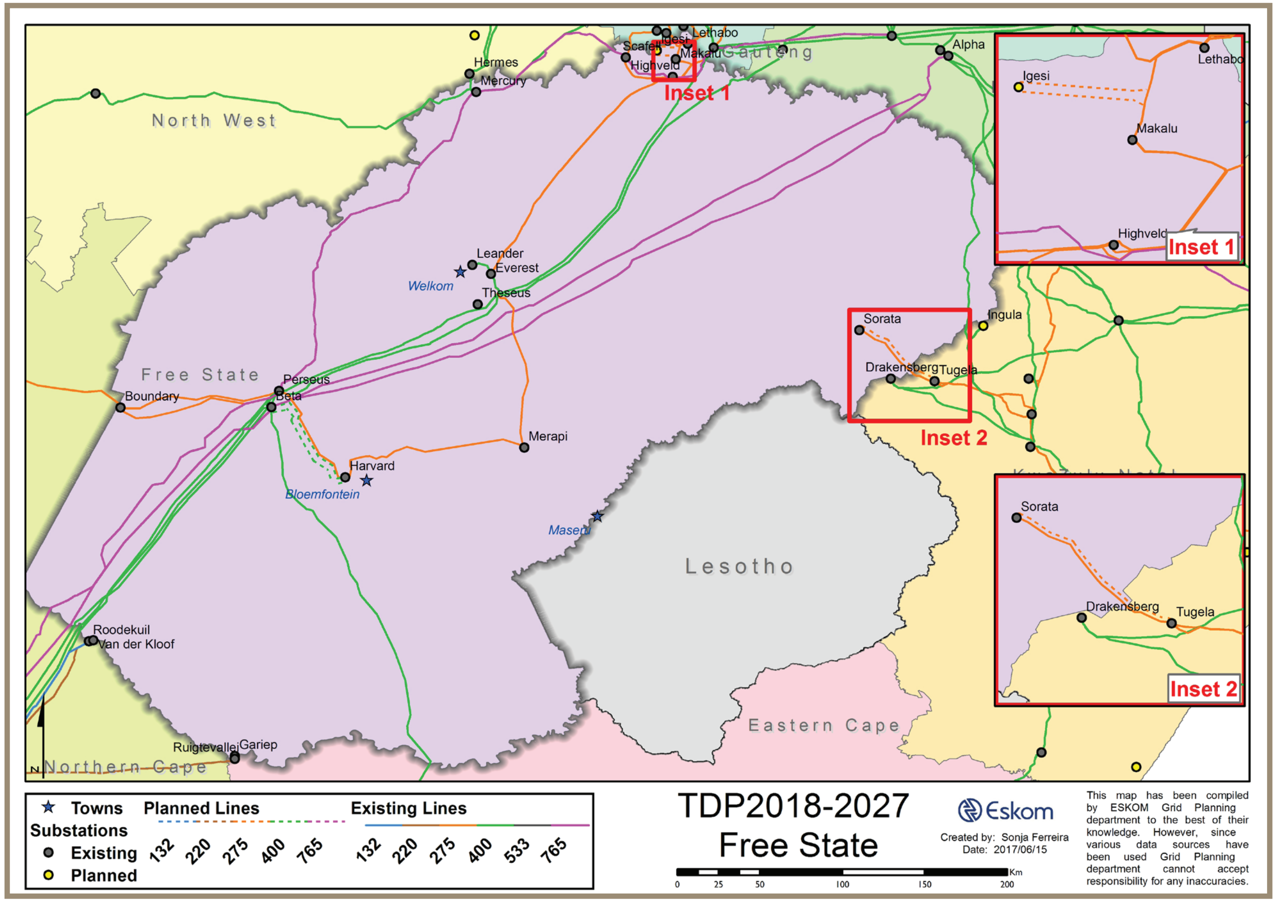



***Figure 6.18:*** Future Free State province network diagram

## New substations

The transmission substations to be established in North West province over the TDP period are included in Section 6.6.4.

## Reactive power compensation

There are no reactive power compensation projects within the Free State province.

## Provincial summary

The increase in transmission assets by the end of 2022 and the end of 2027 and a cumulative total are shown in Table 6 12.

***Table 6.12:*** Cumulative TDP transmission assets for Free State province

| Transmission Assets for Free State Province | New assets expected in 2018 to 2022 | New assets expected in 2023 to 2027 | Total new assets |
|---|---|---|---|
| **Power lines (km)** | | | |
| *765 kV* | *0* | *0* | *0* |
| *400 kV* | *0* | *190* | *190* |
| *275 kV* | *30* | *9* | *39* |
| **Total length (km)** | **30** | **199** | **229** |
| **Transformers** | | | |
| *Number of units* | *2* | *6* | *8* |
| **Total capacity (MVA)** | **500** | **2 630** | **3 130** |
| **Capacitors** | | | |
| *Number of banks* | *0* | *0* | *0* |
| **Total capacity (MVar)** | **0** | **0** | **0** |
| **Reactors** | | | |
| *Number of banks* | *0* | *0* | *0* |
| **Total capacity (MVar)** | **0** | **0** | **0** |

***Table 6.13:*** Free State province – summary of projects and timelines

| TDP Scheme | Project name | Expected CO year |
|---|---|---|
| ***Waterberg Fault Level Project*** | *Everest - Merapi 400 kV line (operated at 275 kV)* | *2019* |
| ***Bloemfontein Strengthening Phase 1B*** | *Waterberg Fault Level Project: Perseus Substation* | *2019* |
| ***Bloemfontein Strengthening Phase 2*** | *2 x Beta-Harvard 400 kV lines* | *2023* |
| | *Harvard 2 x 500 MVA 400/132 kV substation* | *2023* |
| | *Harvard-Merapi 400 kV line* | *2023* |
| | *Merapi 2 x 500 MVA 400/132 kV substation* | *2023* |
| ***Harrismith Strengthening Phase 1*** | *Sorata 1st 275/132 kV 250 MVA transformer, operate Tugela-Sorata line at 275 kV* | *2020* |
| | *Sorata 400 kV busbar (operated at 275 kV)* | *2020* |
| ***Makalu Strengthening*** | *Establish 2 x 315 MVA 275/88 kV Igesi substation* | *2023* |
| | *Loop in one of Lethabo-Makalu 275 kV lines into Igesi Substation* | *2023* |
| | *Refurbishment of existing Makalu Substation* | *2023* |
| ***Sorata Substation Strengthening*** | *Recycle Groenkop-Tugela 132 kV line 1 and construct Sorata-Tugela 400 kV line (operated at 275 kV). Estimated line length is 60km* | *2027* |
| | *Sorata 2nd 275/132 kV 250 MVA transformer* | *2027* |

## 6.7 Northern Cape province

### Background

Northern Cape is situated in the northwest part of South Africa and is the largest province by landmass as well as it is the most sparsely populated province in South Africa with Kimberley as its capital. The majority of economic activity is concentrated in Kimberly and Upington, which are located to the east and northern region of the province respectively. The Northern Cape landscape provides the perfect environment for the world's largest telescope, the Square Kilometre Array (SKA). It also 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 in South Africa. Furthermore, the increased interest in mining operations in the Kimberley area is expected to increase the demand for electricity in the province.

The provincial load peaked at 1 090 MW in 2016 and it is expected to increase to about 1 510 MW by 2027. The Northern Cape Province comprises four Customer Load Networks (CLNs), namely Kimberley, Karoo, Namaqualand and West Coast. The Kimberley CLN is the main load centre in the province, consuming approximately 33% of the load. Karoo, Namaqualand and West Coast CLNs make up the remaining 18% of the demand in the province. Kimberley is supplied by means of the 275 kV network from Ferrum and Namaqualand by a radial 275 kV network supported by the 400 kV line from the North West province. The traditionally weak radial transmission network, high demand growth together with the high potential for the development of generation from Renewable Energy Sources (RES) makes the Northern Cape the centre of network development activities within this planning horizon.

The current transmission network is shown in Figure 6 19.

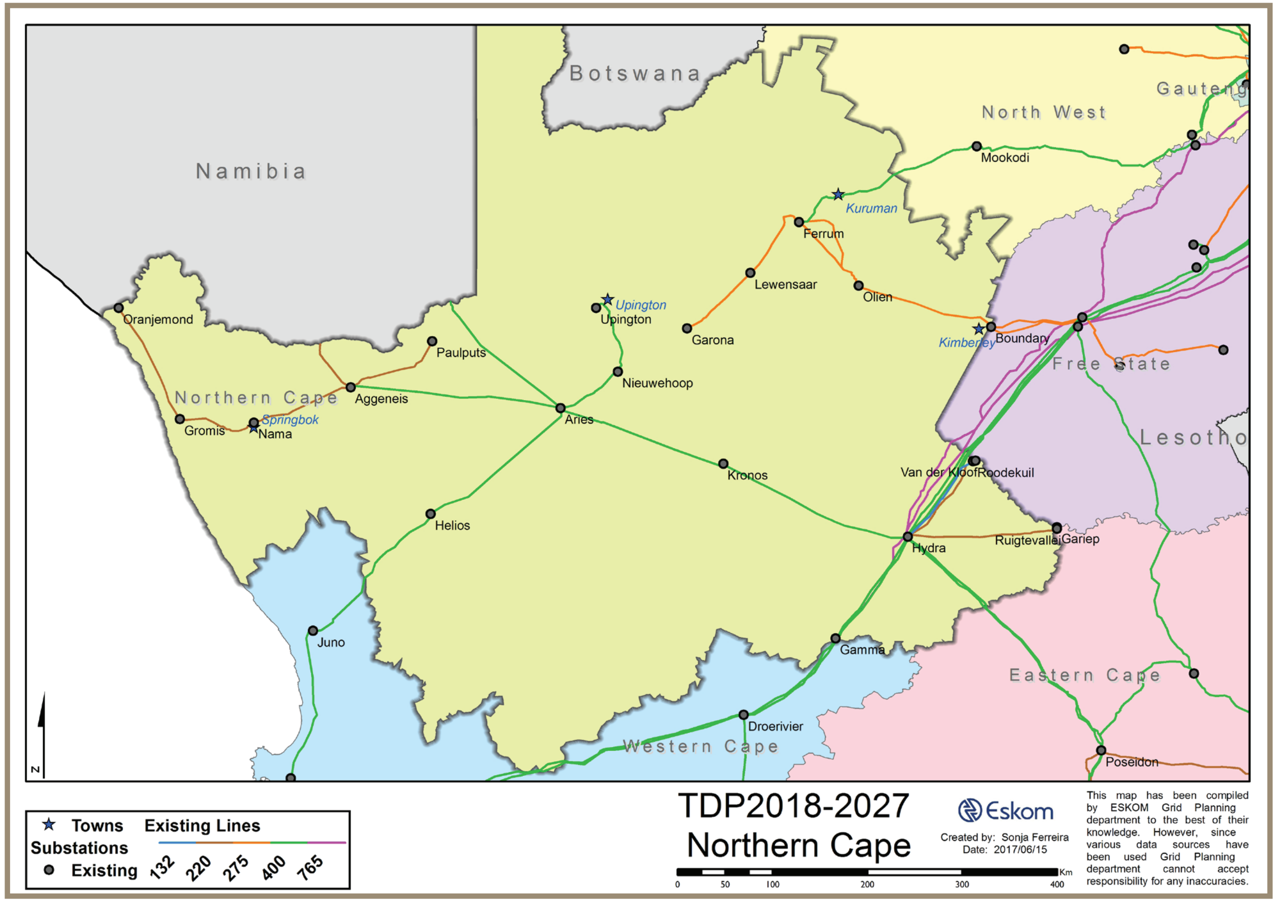



***Figure 6.19:*** Current Northern Cape province network diagram

## Generation

Van Der Kloof Power Station is a hydro scheme straddling the provincial boundaries of the Free State within the Karoo CLN. Van Der Kloof has a generating capacity of 240 MW, with two units rated at 120 MW each.

## Renewables

The Northern Cape has a high potential for renewable energy due to its climate and proximity to the coastal line. Table 6 14 shows all the approved projects under REIPPPP 1 to 4 in the Northern Cape.

**Table 6.14:** Approved projects in the Northern Cape under the REIPPPP

| REIPPP Round | Technology | Percentage (%) | MW |
|---|---|---|---|
| *1* | *CSP* | *22* | *150* |
| | *Wind* | *11* | *72.75* |
| | *PV* | *67* | *461.75* |
| | | **REIPPP 1 Capacity** | **400** |
| *2* | *CSP* | *15* | *50* |
| | *Wind* | *3* | *3* |
| | *PV* | *82* | *269.7* |
| | | **REIPPP 2 Capacity** | **329.7 MW** |
| *3* | *CSP* | *20* | *200* |
| | *Wind* | *58* | *590.5* |
| | *PV* | *22* | *225* |
| | | **REIPPP 3 Capacity** | **1015.5 MW** |
| *3.5* | *CSP* | *100* | *200* |
| | | **REIPPP 3.5 Capacity** | **200 MW** |
| *4* | *Wind* | *40* | *279.8* |
| | *PV* | *60* | *415* |
| | | **REIPPP 4 Capacity** | **694.8 MW** |
| *4B* | *Wind* | *80* | *514* |
| | *PV* | *20* | *130* |
| | | **REIPPP 4B Capacity** | **644 MW** |
| **NORTHERN CAPE TOTAL GENERATION CAPACITY = 3568.5 MW** | | | |

## Load forecast

The load forecast for the Northern Cape is shown in Figure 6.20. 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.

## Major schemes

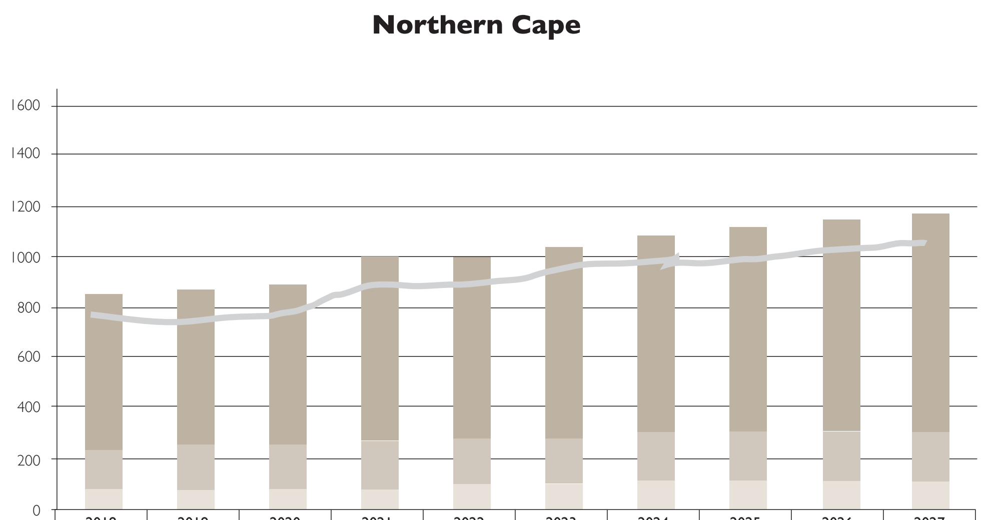
Several projects are required to support the medium to long-term REIPP integration and load growth requirements in the province. The main schemes in the Northern Cape province are as follows:

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

**Northern Cape Reinforcement: Aggeneis-Paulputs 2nd 220 kV and Paulputs Transformation Framework**
This project introduces the 2nd Aggeneis- Paulputs 220 kV line built at 400 kV to meet the N-1 security standard for Paulputs area.

**Upington substation Integration**
The integration includes the construction of two Upington-Aries 400 kV lines, the Upington-Niewehoop and Upington-Ferrum 400 kV lines. The introduction of Nieuwehoop substation will link the Aries and Ferrum 400 kV networks in order to strengthen the transmission system in the province.

***Figure 6.20:*** Northern Cape Province load forecast




| | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 |
|---|---|---|---|---|---|---|---|---|---|---|
| Kimberley CLN @ Grid Peak | 775 | 778 | 792 | 1750 | 891 | 937 | 999 | 1035 | 1065 | 1098 |
| Karoo CLN @ Grid Peak | 198 | 219 | 225 | 228 | 232 | 235 | 239 | 242 | 246 | 248 |
| Namaqualand CLN @ Grid Peak | 103 | 105 | 107 | 110 | 137 | 140 | 141 | 148 | 149 | 150 |
| Northern Cape @ Grid Peak | 14 | 14 | 14 | 14 | 14 | 14 | 14 | 14 | 14 | 14 |
| Mpumalanga @ TOSP | 975 | 985 | 1006 | 1150 | 1132 | 1180 | 1243 | 1285 | 1317 | 1351 |

**Kimberley Strengthening Phase 3**
This strengthening entails the construction of Mookodi-Hermes (later Selemo), Mookodi -Hotazel and Hotazel-Ferrum 400 kV lines.

The transmission development plans for Northern Cape Province Figure 6.21.

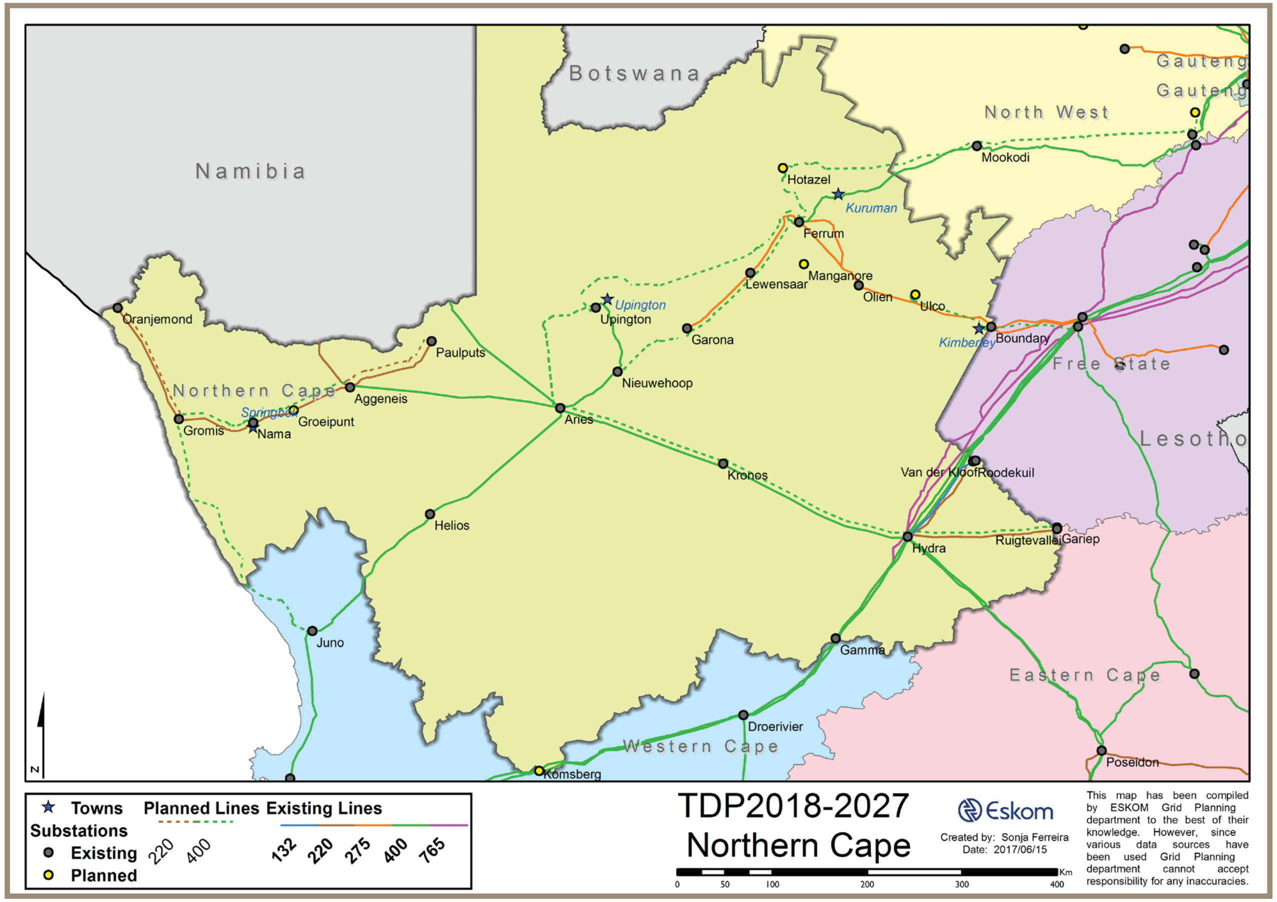



***Figure 6.21:*** Future Northern Cape province network diagram

## Major Schemes under NC Wind scenario

**Namaqualand Strengthening for Renewable Generation Integration: Gromis-Nama-Aggeneis 400kV line**

This project recommends the 1st Gromis – Nama – Aggeneis 400 kV line for the evacuation of the anticipated renewable generation in the Namaqualand CLN under the Northern Cape Wind Generation Scenario.

**Kimberley Strengthening Phase 4 – Part A**

This is a strategic project to enable the evacuation of potential renewable generation in the Kimberley.

## New substations

Major transmission substations to be established in Northern Cape Province over the TDP period are included in Section 6.7.4.

## Reactive power compensation

The following reactive power compensation devices will be installed in the Northern Cape Province.

- 1x 36 MVar capacitor bank at Hotazel 132 kV
- Aries 400MVAr Static VAR Compensator (SVC)

## Provincial summary

The increase in transmission assets by the end of 2022 and the end of 2027 and the cumulative total are shown in Table 6 15.

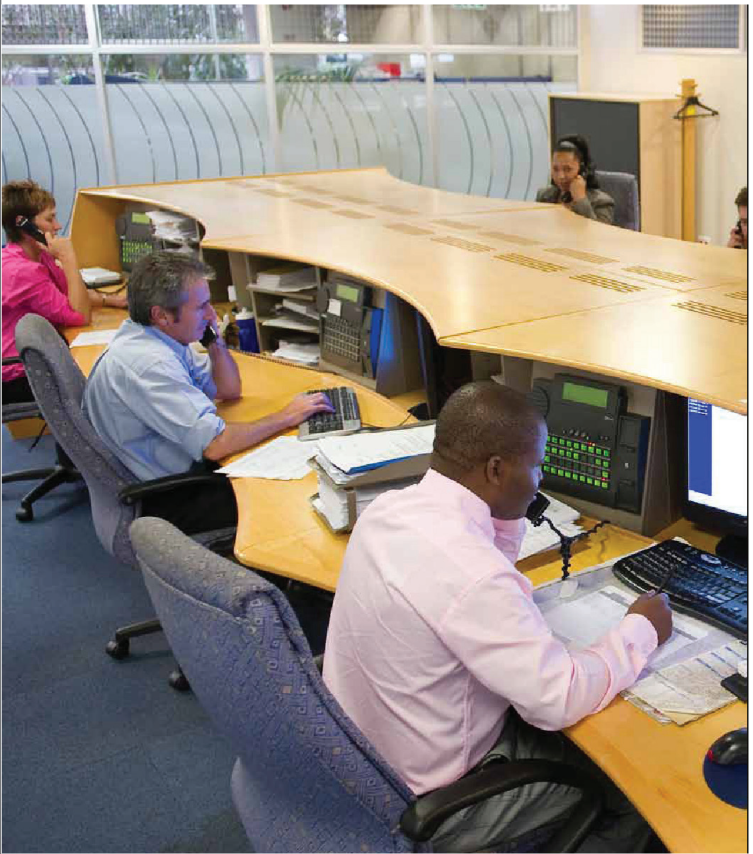


***Table 6.15:*** Cumulative TDP transmission assets for Northern Cape province

| Transmission Assets for Northern Cape Province | New assets expected in 2018 to 2022 | New assets expected in 2023 to 2027 | Total new assets |
|---|---|---|---|
| **Power lines (km)** | | | |
| *765 kV* | *0* | *0* | *0* |
| *400 kV* | *573* | *811* | *1 384* |
| *275 kV* | *0* | *0* | *0* |
| **Total length (km)** | **573** | **811** | **1 384** |
| **Transformers** | | | |
| *Number of units* | *13* | *6* | *19* |
| **Total capacity (MVA)** | **3 135** | **2 750** | **5 885** |
| **Capacitors** | | | |
| *Number of banks* | *0* | *1* | *1* |
| **Total capacity (MVar)** | **0** | **36** | **36** |
| **Reactors** | | | |
| *Number of banks* | *3* | *5* | *8* |
| **Total capacity (MVar)** | **200** | **250** | **450** |

**Table 6.16:** Northern Cape Province – summary of projects and timelines

| TDP Scheme | Project name | Expected CO year |
|---|---|---|
| ***Garona Strengthening*** | *Kronos 400/132 kV transformation* | *Commissioned* |
| | *Kronos-Cuprum 1st & 2nd 132 kV feeder bays* | *2017* |
| ***Upington Strengthening Phase 1a*** | *Niewehoop-Upington 1st 400 kV line* | *2018* |
| | *Upington 1st 500 MVA 400/132 kV transformation* | *2018* |
| | *Upington 2nd 500 MVA 400/132 kV transformation* | *2022* |
| ****Upington Strengthening Phase 1b*** | *Aries-Upington 1st 400 kV lines* | *2024* |
| | *Aries-Upington 2nd 400kV lines* | *2024* |
| | *Upington 3rd & 4th 500MVA 400/132kV transformation* | *2024* |
| ****Upington Strengthening Phase 1c*** | *Ferrum-Upington 1st 400 kV lines* | *2025* |
| | *Upington 5th 500 MVA 400/132 kV Transformation* | *2025* |
| ***Kimberley Strengthening Phase 3*** | *Hermes-Mookodi 1st 400 kV line* | *2026* |
| | *Mookodi-Umtu 1st 400 kV line* | *2026* |
| | *Umtu 400/132 kV substation (1st & 2nd 500 MVA 400/132 kV transformers)* | *2026* |
| | *Umtu-Ferrum 400kV 1st 400 kV line)* | *2026* |
| | *Hotazel Ext 132kV 1st 36 Mvar capacitor bank* | *2026* |
| ***Kimberley Strengthening Phase 4A*** | *Ulco Substation 1st and 2nd 500 MVA 400/132 kV* | *2027* |
| | *Beta-Ulco 1st 400 kV double circuit line* | *2027* |
| | *Manganore Substation 1st and 2nd 500 MVA 400/132 kV* | *2027* |
| | *Ulco-Manganore 1st 400 kV double circuit line* | *2027* |
| | *Manganore-Ferrum 1st 400 kV double circuit line* | *2027* |
| ***Kimberley Strengthening Phase 4B*** | *Boundary Strengthening: loop-in Beta-Ulco 400 kV line in Boundary Substation* | *2028* |
| ***Kimberley Strengthening Phase 4C*** | *Olien Strengthening: loop-in Ulco-Manganore 400 kV line in at Olien Substation* | *2028* |
| ***Garona Strengthening Phase 2*** | *Loop in and out of Nieuwehoop-Ferrum 400 kV line* | *2024* |
| | *Garona Substation 1st 500 MVA 400/132 KV* | *2024* |
| ***Hydra 400 & 132 kV equipment upgrade*** | *Hydra 400 kV & 132 kV equipment upgrade* | *2018* |
| ***Western & Northern Cape Series Caps decommissioning*** | *Decommission Hydra Series Capacitors* | *2023* |
| ***Hydra Wind Phase 2*** | *Hydra 3rd 400/132 kV transformer 500 MVA* | *2018* |
| ***Hydra B*** | *New Hydra B 400/132 kV substation* | *2025* |

**Table 6.16:** Northern Cape Province – summary of projects and timelines (continued)

| TDP Scheme | Project name | Expected CO year |
|---|---|---|
| ***Kronos Transformation (Customer)*** | *Ruigtevallei 3rd 20MVA 132/66 kV Transformer* | *2020* |
| ***Ruigtevallei MTS Transformation*** | *Loop in and out of Droerivier-Hydra 400 kV line* | *2022* |
| ***Gamma IPP Transformation*** | *Establish 400 kV and 132 kV yards* | *2028* |
| | *Install 1 x 400/132 kV 500 MVA transformer* | *2028* |
| | *Helios 1x20MVA 132/66kV transformer* | *2028* |
| ***Northern Cape Transformation*** | *Decommission Helios Series Capacitors* | *2022* |
| ***Western & Northern Cape Series Caps decommissioning*** | *Aries 400MVAr SVC* | *2019* |
| ***Northern Cape reinforcement*** | *Juno-Gromis 400kV line and 1 x 400/220 kV 500 MVA transformer at Gromis Substation* | *2020* |
| ***Namaqualand Strengthening*** | *2nd Gromis-Oranjemond 220 kV lines* | *2021* |
| | *Aries-Niewehoop 400 kV line* | *2018* |
| ***N Cape reinforcement: Ferrum -Niewehoop-Aries 400 kV*** | *Ferrum-Niewehoop 400 kV line* | *Commissioned* |
| | *Aggeneis-Paulputs 2nd 220 kV line & Aggeneis 66 kV equipment upgrade (fault level requirements)* | *2019* |
| ***N Cape reinforcement: Aggeneis-Paulputs 2nd 220 kV*** | *Nama MTS Transformers Upgrade* | *2021* |
| ***Nama MTS Transformers Upgrade*** | *Northern Cape Line Transposition* | *2019* |
| ***Northern Cape Voltage Unbalance*** | *2nd Namaqualand SVC* | *2021* |
| ***Namaqualand Reactive Power Optimisation*** | *Paulputs 3rd 220/132 kV 250 MVA transformer* | *2028* |
| ***Paulputs 3rd 220/132 kV 250 MVA transformer*** | *Install 2 x 400/132 kV 500 MVA transformers* | *2023* |
| ***Nama transformation*** | *Loop in and out of Nama-Aggeneis 220 kV line* | *2024* |
| ***New Groeipunt Substation*** | *Establish New Groeipunt 220/132kV* | *2018* |
| | *Establish 132 kV at Aggeneis Substation* | *2018* |
| ***Aggeneis IPP transformation*** | *Install 1 x 400/132 kV 500 MVA transformers* | *2025* |
| | *Establish 132 kV at Aries Substation* | *2025* |
| ***Aries IPP transformation*** | *Install 1 x 400/132 kV 500 MVA transformer* | *2025* |
| | *Install 2nd 500 MVA 400/132 kV transformer* | *2025* |
| ***Helios IPP transformation*** | *Construct Gromis-Nama-Aggeneis 1st 400 kV line* | *2024* |
| ***Namaqualand Renewable Generation Strengthening*** | *Decommission 15 MVar 66 kV Shunt Cap* | *2026* |
| ***Oranjemond Shunt Cap*** | *Decommission 15 MVar 66 kV Shunt Cap* | *2019* |

## 6.8 Eastern Cape province

### Background

The Eastern Cape is South Africa's 2nd largest province by landmass after the Northern Cape. The Eastern Cape is located on the south-eastern coast of South Africa. The capital city of the Eastern Cape is Bhisho, but the two largest cities in the province are Port Elizabeth (PE) and East London (EL). The provincial economy is mainly driven by the automotive sector, which is the biggest manufacturing sector in the urban areas of the Eastern Cape. The Nelson Mandela Bay Metro in Port Elizabeth as well as the Buffalo City Metro in East London are the two major motor manufacturing hubs in the province. Due to its excellent wind energy resources, the Eastern Cape Province has attracted a significant share of the renewable energy projects procured to date. It is also expected that the bulk of future generation from wind energy resources will be located in the Eastern Cape Province.

The provincial load for the Eastern Cape peaked at 1 472 MW in 2016 and it is expected to increase to about 1896 MW by 2027. There is high potential for development in the Nelson Mandela Bay Metro in terms of load in the Port of Ngqura, popularly known as Coega. As a result, the overall demand for electricity in the Port Elizabeth area is forecasted to increase from 879 MW to about 1 190 MW in the next 10 years, which amounts to an annual load growth of 2 %. The bulk of expected load increase in the PE CLN is attributable to the industrial development at Coega. The PE 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 projects are anticipated in the northern parts of East London CLN, in

The current transmission network is shown in Figure 6 22.

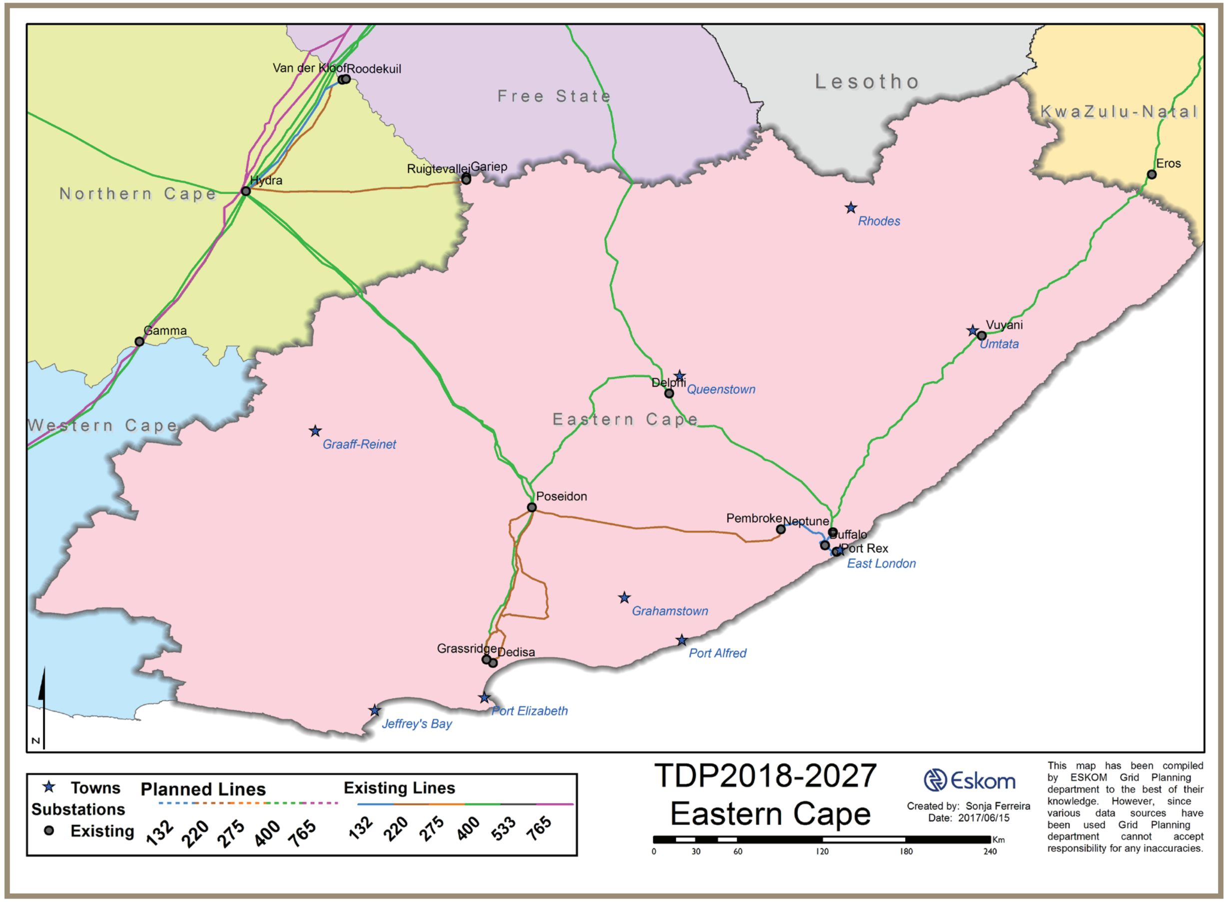



***Figure 6.22:*** Current Eastern Cape province network diagram

and around the Mthatha area. The anticipated rate of annual load growth in the East London area over the next ten years is 2 %. The Vuyani substation and associated 400 kV supply lines are expected to unlock future electrification in the Mthatha area. The installed capacity at Vuyani substation has the potential to unlock electrification of more than 125 000 homes. The number of in-feeds into East London consists of three 400 kV lines and a single 220 kV line to

Bhisho.

## Generation

Historically, the Eastern Cape did not have a huge amount of internal generation capacity. The only sizeable generation in the province was Port Rex with a capacity of 3 x 57 MW, which operates as a peaking plant. Gariep Hydro Power Station, located on the Northern and Eastern Cape provincial border evacuates most of its power via the Northern Cape networks. This power station has a generating capacity of 360 MW, with four units rated at 90 MW each evacuating power directly onto the Hydra 220 kV busbar via 220 kV and 132 kV lines. The power deficit in the Eastern and Northern Cape implies that the above mentioned generators operate as support for base load plant even outside the usual peak periods.

Furthermore, there is high interest in renewable energy projects in the Eastern Cape Province, as demonstrated by the number of renewable energy bids from the previous REIPPPP rounds. A total capacity of 1 504 MW was approved in the Eastern Cape comprising 151 MW in the East London CLN and 1 353 MW in the Port Elizabeth CLN. The interest in connecting renewable power projects in the subsequent rounds of the DoE REIPPPP programme is expected to remain strong due to excellent wind resources in the province.

There is also an interest in the integration of generation from natural gas close to the Port of Ngqura, amounting to about 2 000 MW. Further generation connections that are expected to materialise in the Eastern Cape include nuclear generation of about 1 600 MW. All the major generation projects mentioned will require extensive transmission infrastructure investment in the Eastern Cape Province.

If all these generation plans materialise, the Eastern Cape will be a net exporter of energy by a huge margin.

**Renewable energy generation integration**

The renewable energy plants that were approved for each REIPPPP round are shown in Table 6 17.

***Table 6.17:*** 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* |
| | *Solar* | *70* |
| | **REIPPPP 3 capacity** | **267** |
| 4 | *Wind* | *397* |
| | **REIPPPP 4 capacity** | **397** |
| *4B* | *Wind* | *33* |
| | **REIPPPP 4B capacity** | **33** |
| | **Eastern Cape total generation capacity** | **1 504** |

## Load forecast

The major economic drivers in the Eastern Cape are the manufacturing sector, construction, and in recent times, the renewable IPP sector and supporting industries. The rate of load growth has reduced significantly when compared to previous TDP cycles, with anticipated predictions of an annual growth rate of 6.6% or higher. The main reason for the decline in load forecast is the slow realisation of anticipated projects in the Coega Industrial Development Zone.

The load forecast for the Eastern Cape Province is shown in Figure 6.23.

## Major transmission development schemes

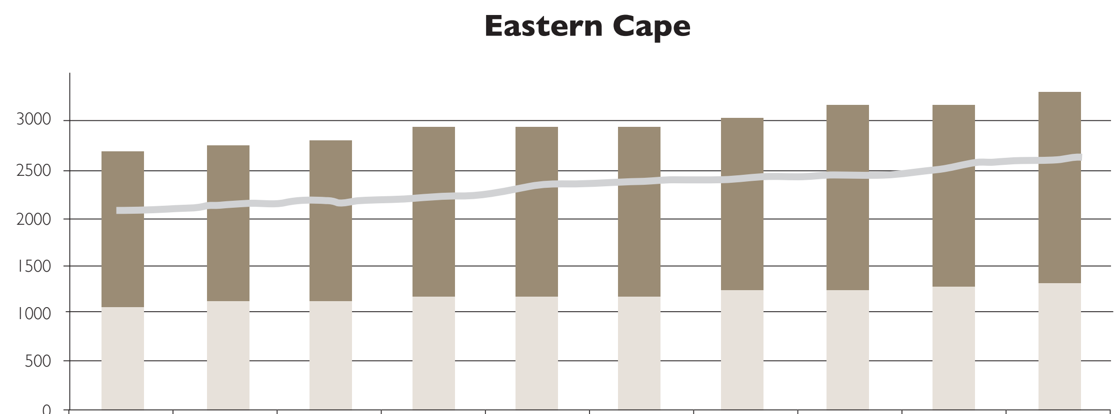
The major schemes within the Eastern Cape province are as follows:

**Greater East London Strengthening Phase 3 and 4**
The Greater East London Strengthening Phase 3 entails the integration of 400 kV at Pembroke substation as well as the Neptune-Pembroke 400 kV line. The Greater East London Strengthening Phase 4 is the construction on the second 400 kV corridor into Pembroke, Poseidon-Pembroke 400 kV line as well as the 2nd 400/132 kV transformer.

**Southern Grid Strengthening Phase 3 and 4**
Southern Grid Strengthening Phase 3 is an infrastructure investment project that entails the introduction of 765 kV into the Eastern Cape by means of the 1st Gamma Grassridge 765 kV line. The Southern Grid Strengthening Phase 4 refers to integration of the 2nd Gamma Grassridge 765 kV line.

**Port Elizabeth substation integration**
The project involves establishing a new 400/132kV substation near Port Elizabeth. This substation will serve as an additional source of supply for the city to cater for anticipated load growth and to enable the integration of Generation, south-west of the city.

**Thyspunt Nuclear Integration**
This infrastructure investment project is required to enable the integration of Thyspunt nuclear power station into the national Grid. The scope of the project is primarily made up of a 400 kV network overlay and associated transmission substations.




| | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 |
|---|---|---|---|---|---|---|---|---|---|---|
| Port Elizabeth @ Grid Peak | 985 | 1003 | 1029 | 1053 | 1069 | 1080 | 1120 | 1147 | 1167 | 1190 |
| East London @ Grid Peak | 718 | 731 | 750 | 768 | 779 | 787 | 817 | 836 | 851 | 867 |
| Eastern Cape @ TOSP | 1358 | 1385 | 1400 | 1428 | 1470 | 1499 | 1529 | 1550 | 1581 | 1630 |

***Figure 6.23:*** Eastern Cape Province load forecast

## New substations

The transmission substations to be established in the Eastern Cape province over the TDP period are included in Section 6.8.4.

## Reactive power compensation

The envisaged load growth in the Port Elizabeth CLN will result in under-voltages at Grassridge and Dedisa under contingencies. The following shunt compensation projects will be implemented for voltage support in the Eastern Cape province:

- Grassridge substation 132 kV reactive power compensation
- Dedisa substation 132 kV reactive power compensation
- Poseidon substation 132 kV reactive power compensation
- Delphi substation 132 kV reactive power compensation

The transmission development plans for the Eastern Cape province are shown in Figure 6.24.

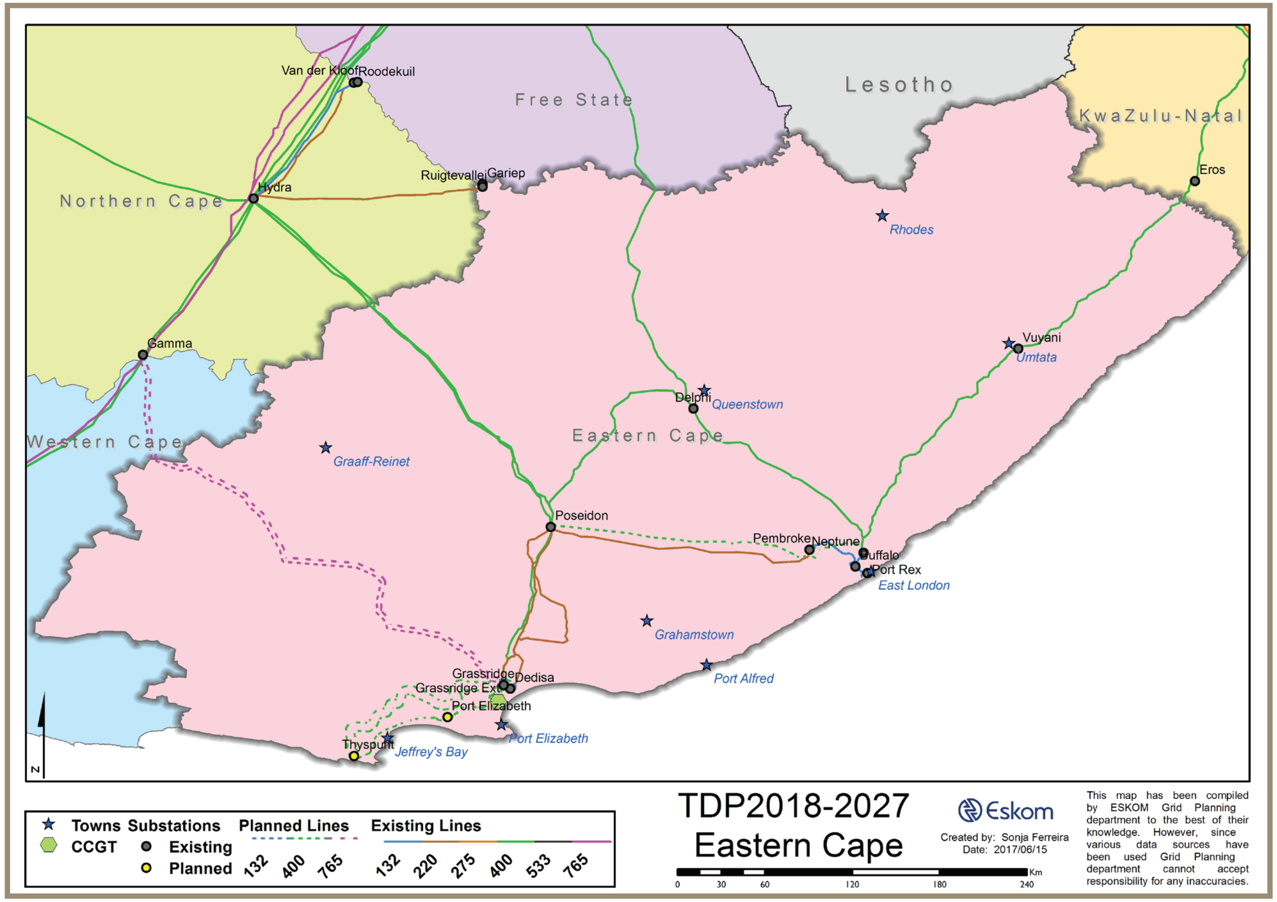



***Figure 6.24:*** Future Eastern Cape province network diagram

## Provincial summary

The increase in transmission assets by the end of 2022 and the end of 2027 and the cumulative total are shown in Table 6.17.

***Table 6.18:*** Cumulative TDP transmission assets for the Eastern Cape province

| Transmission Assets for Eastern Cape Province | New assets expected in 2018 to 2022 | New assets expected in 2023 to 2027 | Total new assets |
|---|---|---|---|
| **Power lines (km)** | | | |
| *765 kV* | *0* | *350* | *350* |
| *400 kV* | *150* | *306* | *456* |
| *275 kV* | *3* | *0* | *3* |
| **Total length (km)** | **153** | **656** | **809** |
| **Transformers** | | | |
| *Number of units* | *4* | *12* | *16* |
| **Total capacity (MVA)** | **60** | **5 320** | **5 380** |
| **Capacitors** | | | |
| *Number of banks* | *4* | *0* | *4* |
| **Total capacity (MVar)** | **400** | **0** | **400** |
| **Reactors** | | | |
| *Number of banks* | *0* | *2* | *2* |
| **Total capacity (MVar)** | **0** | **600** | **600** |

***Table 6.19:*** Summary of Eastern Cape province projects and timelines

| Scheme name | Project name | Expected year |
|---|---|---|
| ***Grassridge-Dedisa 1st 132 kV line*** | *Grassridge-Dedisa 1st 132 kV line* | *2018* |
| ***PE Strengthening Phase 3*** | *PE Strengthening Phase 3: 1st Shunt Cap Bank at Poseidon; Delphi; Grassridge; Dedisa* | *2018* |
| ***Buffalo & Pembroke Transformer*** | *Buffalo and Pembroke transformer LV supply normalisation* | *2019* |
| ***Gariep Strengthening*** | *Gariep Strengthening: Ruigtevallei Hydra de-rate line from 220 kV to 132 kV* | *2018* |
| ***Greater EL Phase 3*** | *Greater EL Phase 3: Neptune-Pembroke 400 kV line* | *2022* |
| ***Greater EL Phase 3*** | *Greater EL Phase 3: Pembroke 1st 400/132 kV 500 MVA transformer* | *2022* |
| ***Greater EL Phase 3*** | *Greater EL Phase 3: Pembroke 1st 132/66 kV 120 MVA transformer* | *2022* |
| ***Grassridge 3rd 500 MVA 400/132 kV transformer*** | *Grassridge 3rd 500 MVA 400/132 kV transformer* | *2023* |
| ***Dedisa 3rd 500MVA 400/132 kV transformer*** | *Dedisa 3rd 500 MVA 400/132 kV transformer* | *2023* |
| ***Delphi 500MVA 400/132 kV transformer*** | *Delphi 500MVA 400/132kV transformer* | *2024* |
| ***Southern Grid Phase 3*** | *Southern Grid Phase 3: 1st Gamma Grassridge 765 kV line* | *2026* |
| ***Greater EL Phase 4*** | *Greater EL Phase 4: Poseidon-Pembroke 400 kV line* | *2026* |
| ***Greater EL Phase 4*** | *Greater EL Phase 4: Pembroke 2nd 400/132 kV 500 MVA transformer* | *2026* |
| ***Greater EL Phase 4*** | *Greater EL Phase 4: Pembroke 2nd 132/66 kV 120 MVA transformer* | *2026* |
| ***Nuclear 1 Integration*** | *Nuclear 1 Integration: Thyspunt* | *2027* |
| ***Port Elizabeth SS Integration*** | *Port Elizabeth SS Integration* | *2027* |
| ***Southern Grid Phase 4*** | *Southern Grid Phase 4: 2nd Gamma Grassridge 765 kV line* | *2027* |

# 6.9 Western Cape province

## Background

The Western Cape Province is situated in the south-western part of South Africa with Cape Town as its capital. The provincial economy is mainly driven by tourism, financial services, business services, real estate, agriculture and manufacturing sectors. Cape Town is the economic hub of the province, with a robust clothing and textile industry that provides significant employment opportunities in the province.

The Western Cape region of South Africa is also noted for its abundance of wind resources, which makes it one of South Africa's ideal locations for wind energy projects, a number of which are already in operation. To date, 450 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 provincial load peaked at around 3 900 MW in 2016 and it is expected to increase to about 4 500 MW by 2027. The Western Cape province is comprised of three Customer Load Networks (CLNs), namely Peninsula, Outeniqua and West Coast. The Peninsula CLN is the main load centre in the province, consuming approximately 67% of the load. Outeniqua and West Coast CLNs make up the remaining 33% of the demand in the province.

The Western Cape Transmission network consists mostly of 400 kV lines. It stretches over a distance of about 550 km from Gamma Substation (near Victoria West) to Philippi Substation (near Cape Town).

Local strengthening is planned across the province, mainly comprising of new 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.

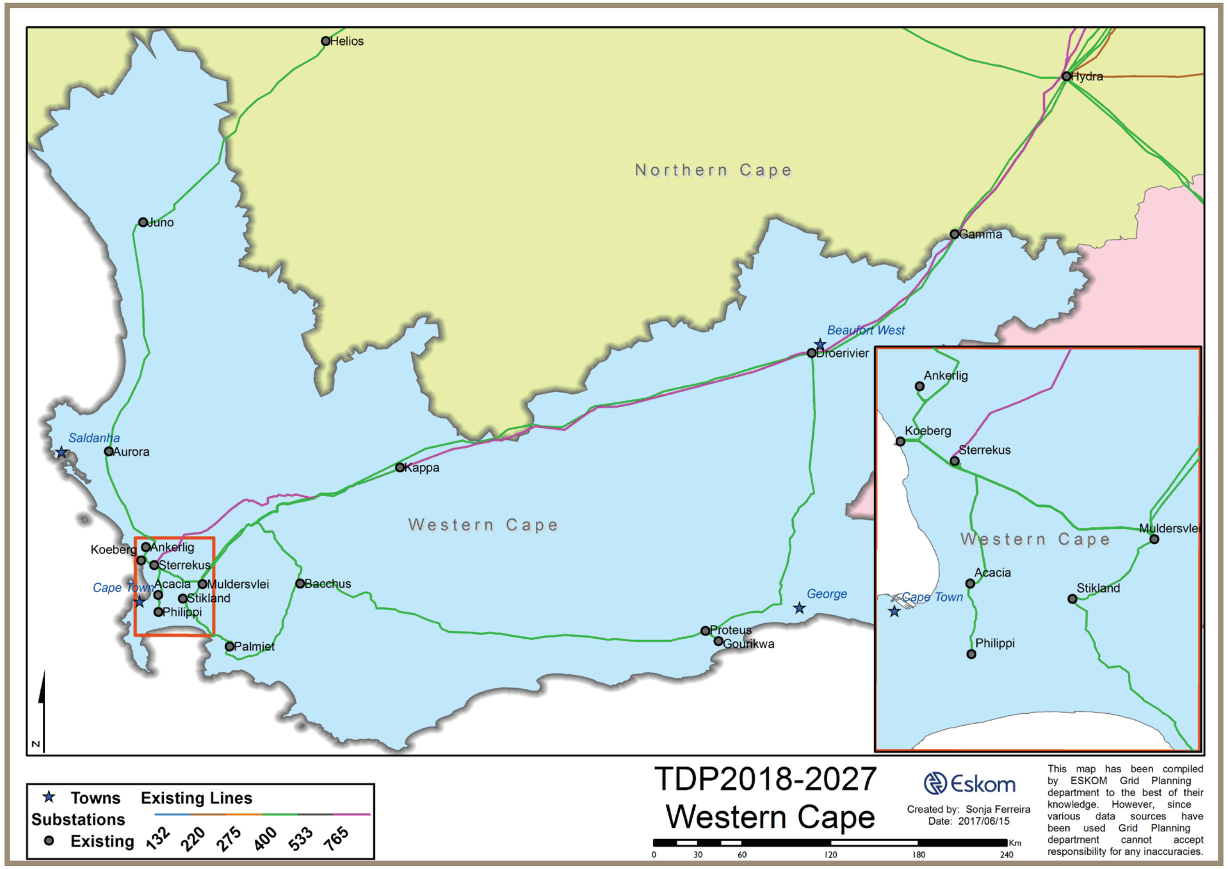



***Figure 6.25:*** Current Western Cape province network diagram

## Generation

Koeberg Power Station is the only base-load power station situated locally in the Western Cape. There are also four Eskom peaking plants in the Western Cape, consisting of pumped-storage and gas turbine generation which help to meet the demand in the Western Cape as well as in the national grid during generation shortages. These comprise of the Palmiet pumped-storage station, Ankerlig and Gourikwa open-cycle gas turbine (OCGT) stations and the Acacia gas turbine station. Three City of Cape Town-owned (CoCT-owned) peaking plants in Cape Town help to manage the CoCT demand. These are the Steenbras pumped-storage station and the Athlone and Roggebaai gas turbine stations. The Western Cape has also benefited from renewable energy generation due to its climate and proximity to the coastal line.

The deficit between local generation and the Greater Cape (Western Cape, Eastern Cape and Northern Cape) load is offset by the generation pool in the Highveld via the Cape Corridor.

**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 30 years and has a further active life of about 20 years. Koeberg Power Station has a generating capacity of 1 860 MW. The 2 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 mode of operation (SCO) to regulate the voltage. In addition, it provides an off-site electrical supply to Koeberg Power Station as per the National Nuclear Regulator licencing requirement.

**Ankerlig and Gourikwa Power Stations**
The open-cycle gas turbines (OCGT) 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). Some of the units have been fitted with dual fuel burners in anticipation of conversion to closed-cycle gas turbines (CCGT). In addition to their 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 inter-catchment 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.

### Steenbras Pumped Storage Scheme

Steenbras Dam is an earth-fill type dam located on the Steenbras River in the Hottentots-Holland Mountains, high above Gordons Bay, near Cape Town. In 1979, Steenbras Dam became part of the first pumped storage scheme in the country to supplement Cape Town's electricity supply during periods of peak demand.

Steenbras Pumped Storage Scheme is a CoCT generating facility. It consists of 4 x 45 MW units and is integrated into the City's network.

### Athlone and Roggebaai power stations

The Roggebaai and Athlone Gas power stations are two gas turbine stations which are owned and operated by CoCT. They are used to generate electricity over much shorter time periods as they make use of much more expensive fuel (Aviation Jet-A1).

Athlone Power Station is located at the site of the demolished Athlone coal-fired power station along the N2 highway near Pinelands and has an installed capacity of 36 MW. Roggebaai Power Station is situated at the V&A Waterfront and has an installed capacity of 42 MW.

Both power stations are used for reducing the CoCT's peak load but can also be used to supply local loads during emergencies.

### Klipheuwel Wind Energy Demonstration Facility

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

Since the commercial operation of the facility, the plant has reached the end of its useful life and Eskom is in the process of decommissioning this demonstration facility. One of the turbines will be used for practical training at the South African Renewable Technology Centre (SARETEC) situated in Bellville, Cape Town. The remainder of the wind farm (land and the two Vestas wind turbines) will be disposed of following Eskom's commercial processes.

### Darling Wind Power

The Darling Wind Power generating facility is a Department of Energy demonstrator site which 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 which was completed in January 2015 and has a capacity of 100 MW. It is located north-west of Vredendal in Skaapvlei, approximately 300 km north of Cape Town.

### Renewable Energy Independent Power Producers

The Renewable Energy Independent Power Producer Procurement Programme (REIPPPP) has resulted in over

***Table 6.20:*** Commissioned projects in the Western Cape under the REIPPPP

| Round | Name of Project | Type | Capacity | Capacity (MW) |
|---|---|---|---|---|
| *1* | *Dassiesklip Wind Energy Facility* | *Wind* | *26* | *Bacchus 132 kV* |
| | *Hopefield Wind Farm* | *Wind* | *65* | *Aurora 132 kV* |
| | *SlimSun Swartland Solar Park* | *PV* | *5* | *Aurora 132 kV* |
| | *Touwsrivier Project* | *PV* | *36* | *Bacchus 132 kV* |
| 2 | *Gouda Wind Facility* | *Wind* | *135* | *Muldersvlei 132 kV* |
| | *West Coast 1* | *Wind* | *90* | *Aurora 132 kV* |
| | *Aurora* | *PV* | *9* | *Aurora 132 kV* |
| | *Vredendal* | *PV* | *9* | *Juno 66 kV* |
| 3 | *Electra Capital (Pty) Ltd* | *PV* | *75* | *Aurora 132 kV* |

1 000 MW of wind and PV generation being procured in the Western Cape. As of 30 June 2017, there is 450MW in commercial operation as per Table 6 20.

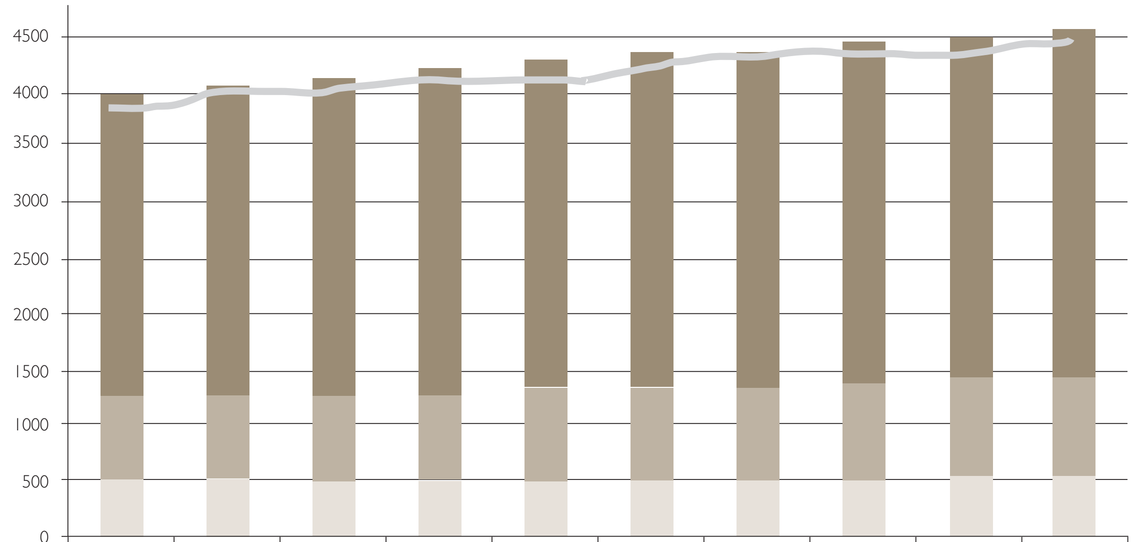
## Load forecast

The Western Cape GDP is the third-highest contribution to the country's total at around 15% and has one of the fastest growing economies in the country. Industries in the Western Cape comprise financial and business services, manufacturing, tourism, agriculture, fishing and wine. 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 electricity business in terms of new renewable energy and gas are also major drivers of the economy across the province.

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 area around Philippi and Mitchell's Plain where higher density residential properties are being developed on existing residential areas.

Substantial load growth in 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 within 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.

**Western Cape**




| | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 |
|---|---|---|---|---|---|---|---|---|---|---|
| Peninsula @ Grid Peak | 2715 | 2791 | 2830 | 2873 | 2918 | 2971 | 3015 | 3050 | 3084 | 3118 |
| Outeniqua @ Grid Peak | 752 | 763 | 775 | 788 | 800 | 812 | 824 | 836 | 851 | 864 |
| West Coast @ Grid Peak | 498 | 520 | 529 | 532 | 536 | 539 | 542 | 550 | 553 | 556 |
| Western Cape @ TOSP | 3876 | 3981 | 4038 | 4094 | 4147 | 4222 | 4279 | 4332 | 4382 | 4431 |

***Figure 6.26:*** Load forecast for the Western Cape Province

Historical data has shown that the Western Cape does not peak at the time of system peak (TOSP). The province peak tends to be about 2.5% higher than the province load at the time of system peak. The province peak is expected to grow by 15% from ~3 900 MW to ~4 500 MW by 2027.

The load forecast is shown in Figure 6 26.

## Major schemes

The Cape Corridor comprises of 400 kV and 765 kV lines originating from Zeus Substation (near Bethal) and Alpha Substation (near Standerton) in Mpumalanga to Hydra Substation (near De Aar) in the Northern Cape. It then extends into the Western Cape and terminates at Muldersvlei Substation (near Klapmuts) and Sterrekus Substation (near Melkbosstrand).

The immediate problems in the corridor between Beta, Perseus and Hydra substations have been alleviated by the strengthening north of De Aar. The Beta-Delphi 400 kV line has also brought additional relief to this 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 been strengthened with the first 765 kV line comprising of the following sections that were commissioned and energized over the last five 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
- Kappa-Sterrekus in December 2016

Additional improvements in the transfer limits will be brought about by the following strengthening projects in the Northern Cape province:

- Aries-Nieuwehoop-Ferrum 400 kV line
- Juno-Gromis 400 kV line
- Aries FACTS device

Some of the existing 400 kV series capacitor installations contain PCBs and an Eskom directive that requires these be removed from the system by 2023 in compliance with SANS 290, the "Regulation to phase-out the use of Polychlorinated Biphenyl (PCB) materials and Polychlorinated Biphenyl (PCB) contaminated materials". In accordance with this, the series capacitors at Juno, Helios, Victoria and Hydra will be decommissioned.

The Bacchus series capacitor will be bypassed with the integration of the planned Agulhas Substation (near Swellendam) and the Proteus series capacitor will be relocated to the planned Narina Substation (near George). Due to the addition of a 400/132 kV substation at Komsberg, the Komsberg 2 series capacitor will be downsized.

All of the above projects will result in Cape Corridor network adequacy until 2027. Beyond 2027, the preferred strengthening to provide additional transfers into the Cape is the construction of a second Zeus-Sterrekus 765 kV line.

The future Western Cape Province transmission network is shown in Figure 6 27.

## New substations

The following new substations will be established in the Western Cape in order to address load growth as well as IPP integration:

Load growth in the Peninsula in the residential, commercial and light industrial sectors will necessitate the introduction of the following 400/132 kV substations:

- Pinotage Substation in the Stellenbosch area
- Asteria Substation in the Houhoek area
- Erica Substation in the Mitchell's Plain area

Load growth in the Outeniqua CLN in the residential, tourism and agricultural sectors will necessitate the introduction of two new 400/132 kV substations, namely:

- Agulhas Substation in the Swellendam area
- Narina Substation in the George area

Furthermore, IPP integration in this CLN will necessitate the following developments:

- Construction of Komsberg 400 /132 kV Substation
- Introduction of 132 kV at Kappa Substation

There are plans to establish an Industrial Development Zone (IDZ) in Saldanha; in order to support this development, the new Bokkom 400/132 kV Substation will be integrated in the West Coast CLN.

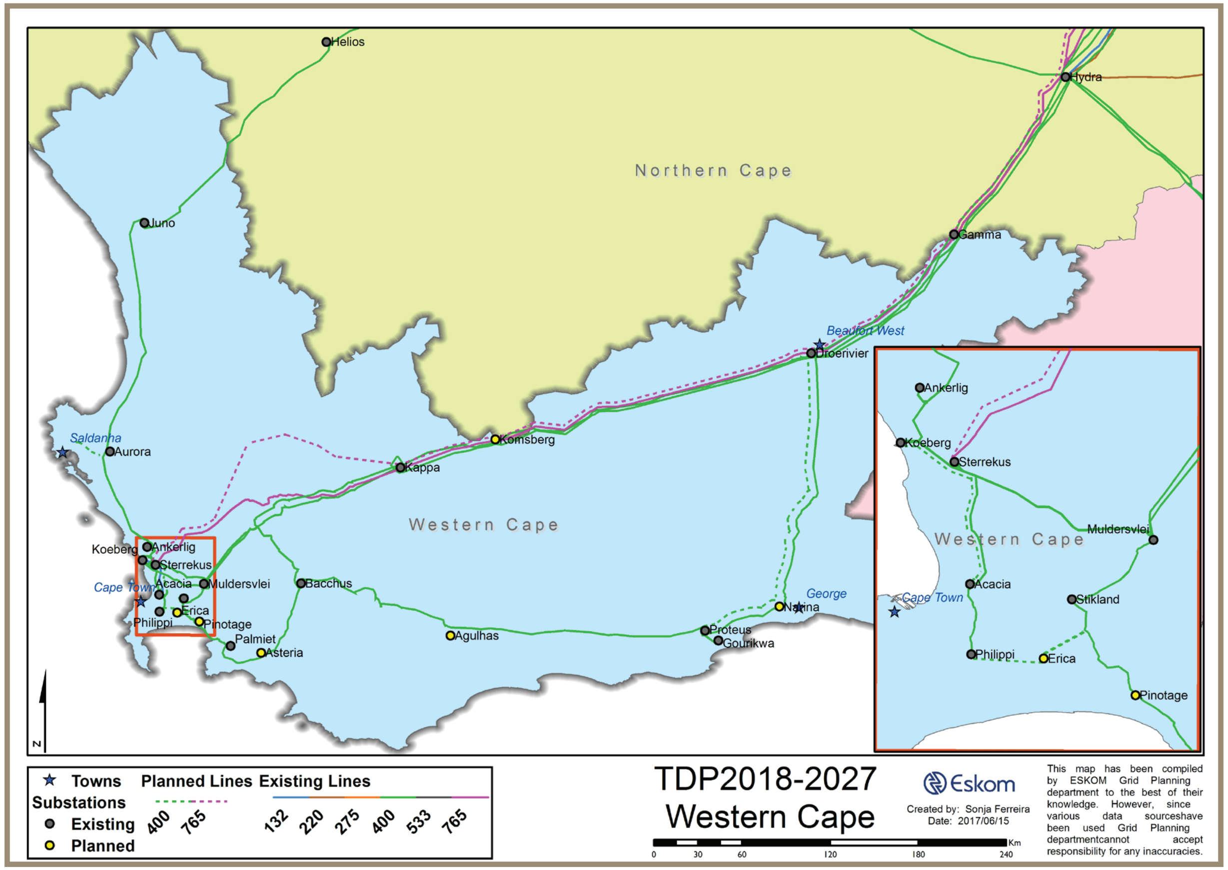



***Figure 6.27:*** Future Western Cape Province transmission network diagram

## Reactive power compensation

Additional 132 kV capacitor banks will be installed at Aurora and Bacchus substations as part of the Cape Corridor Shunt Capacitor Strengthening Project. Table 6 21 shows a list of the banks and respective sizes (total Mvar).

**Table 6.21:** Future shunt capacitor banks in the Western Cape

| Capacitor Designation | Nominal Output |
|---|---|
| *Aurora 1* | *72* |
| *Aurora 2* | *72* |
| *Bacchus 11* | *72* |

## Provincial summary

The increase in transmission assets by the end of 2022 and the end of 2027 and cumulative total are shown in Table 6 22.

**Table 6.22:** Cumulative TDP transmission assets for Western Cape Province

| Transmission Assets for Western Cape Province | New assets expected in 2018 to 2022 | New assets expected in 2023 to 2027 | Total new assets |
|---|---|---|---|
| **Power lines (km)** | | | |
| *765 kV* | *0* | *0* | *0* |
| *400 kV* | *46* | *75* | *121* |
| *275 kV* | *0* | *0* | *0* |
| **Total length (km)** | **46** | **75** | **121** |
| **Transformers** | | | |
| *Number of units* | *7* | *8* | *15* |
| **Total capacity (MVA)** | **3 060** | **4 000** | **7 060** |
| **Capacitors** | | | |
| *Number of banks* | *0* | *0* | *0* |
| **Total capacity (MVar)** | **0** | **0** | **0** |
| **Reactors** | | | |
| *Number of banks* | *0* | *0* | *0* |
| **Total capacity (MVar)** | **0** | **0** | **0** |

**Table 6.23:** Western Cape Province – summary of projects and timelines

| TDP Scheme | Project name | Expected CO year |
|---|---|---|
| ***Pinotage Substation (Firgrove Transmission Substation)*** | *Pinotage Substation (1st and 2nd 400/132 kV 500 MVA transformers)* | *2018* |
| | *Loop-in and out of Palmiet-Stikland 400 kV line* | *2018* |
| ***Muldersvlei 3rd 400/132 kV transformer & 132 kV series reactors*** | *Replace the 2 x 240 MVA units with a 3rd 500 MVA 400/132 kV transformer* | *2018* |
| | *Install 132 kV transformer FCLRs* | *2018* |
| ***Establish Koeberg off-site supply at Ankerlig Power Station*** | *Establish Koeberg off-site supply at Ankerlig Power Station* | *2019* |
| | *Loop-in and out of Koeberg-Dassenberg 132 kV line* | *2019* |
| ***Komsberg Substation*** | *Komsberg 400/132 kV Substation (1st 500 MVA transformer)* | *2020* |
| | *Loop-in and out Droerivier-Kappa 2 400 kV line* | *2020* |
| | *Resize Komsberg 2 series capacitor bank* | *2020* |
| ***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* |
| ***PCB phase-out plan*** | *Decommission Helios series capacitor* | *2019* |
| ***Koeberg 400 kV busbar reconfiguration and transformers upgrade*** | *Koeberg 400 kV GIS busbar* | *2022* |
| | *Replace 2 x 250 MVA transformers with new 250 MVA units* | *2022* |
| | *Koeberg 400 kV lines rerouting to the new busbar* | *2022* |
| ***Juno Substation transformation upgrade*** | *Replace the 2 x 120 MVA 400/132 kV units with 2 x 125 MVA units* | *2016* |
| | *Replace the 2 x 40 MVA 132/66 kV units with 2 x 80 MVA units* | *2021* |
| | *Install an additional 20 MVA 66/22 kV unit with the existing 10 MVA unit.* | *2021* |
| ***2nd Koeberg-Acacia 400 kV line*** | *2nd Koeberg-Acacia 400 kV line* | *2021* |
| ***Erica Substation (Mitchells Plain Transmission Substation)*** | *Erica Substation (1st and 2nd 400/132 kV 500 MVA transformers)* | *2023* |
| | *Loop-in and out Pinotage-Stikland 400 kV line* | *2023* |
| | *Philippi-Erica 400 kV line* | *2023* |

***Table 6.23:*** Western Cape Province – summary of projects and timelines (continued)

| TDP Scheme | Project name | Expected CO year |
|---|---|---|
| ***Philippi Substation extension (Phase 1)*** | *Establish 400 kV busbar* | *2022* |
| | *Install 3rd 400/132 kV 500 MVA transformer as a hot-standby* | *2022* |
| ***Philippi Substation extension (Phase 2)*** | *Extend 132 kV GIS busbar* | *Deferred* |
| | *Install 132 kV transformer FCLRs* | *Deferred* |
| ***Agulhas Substation (Vryheid Transmission Substation)*** | *Agulhas Substation (1st and 2nd 400/132 kV 500 MVA transformers)* | *2026* |
| | *Loop-in and out Bacchus-Proteus 400 kV line* | *2026* |
| | *Bypass Bacchus series capacitor bank* | *2026* |
| ***Saldanha Bay Network Strengthening (Phase 1)*** | *At Aurora Substation, replace two of the four existing 400/132kV 250 MVA units with 2 x 500MVA units as part of refurbishment* | *2025* |
| | *Strategically acquire a substation site in the Saldanha Bay area* | *2025* |
| | *Construct 2 x 400 kV lines (operated at 132 kV) from Aurora Substation to the new Distribution Blouwater Substation* | *2025* |
| ***Saldanha Bay Network Strengthening (Phase 2)*** | *Bokkom Substation (1st and 2nd 400/132 kV 500 MVA transformers)* | *Deferred* |
| | *Loop-in Ankerlig-Aurora 1 400 kV line* | *Deferred* |
| ***Asteria Substation Houhoek Transmission Substation)*** | *Asteria Substation (1st and 2nd 400/132 kV 500 MVA transformers)* | *2021* |
| | *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)* | *2025* |
| | *Loop-in and out Droërivier-Proteus 400 kV line* | *2025* |
| | *Relocate Proteus series capacitor bank to Narina* | *2025* |
| ***PCB Phase-Out Plan*** | *Decommission Juno, Victoria and Hydra series capacitors* | *2022* |

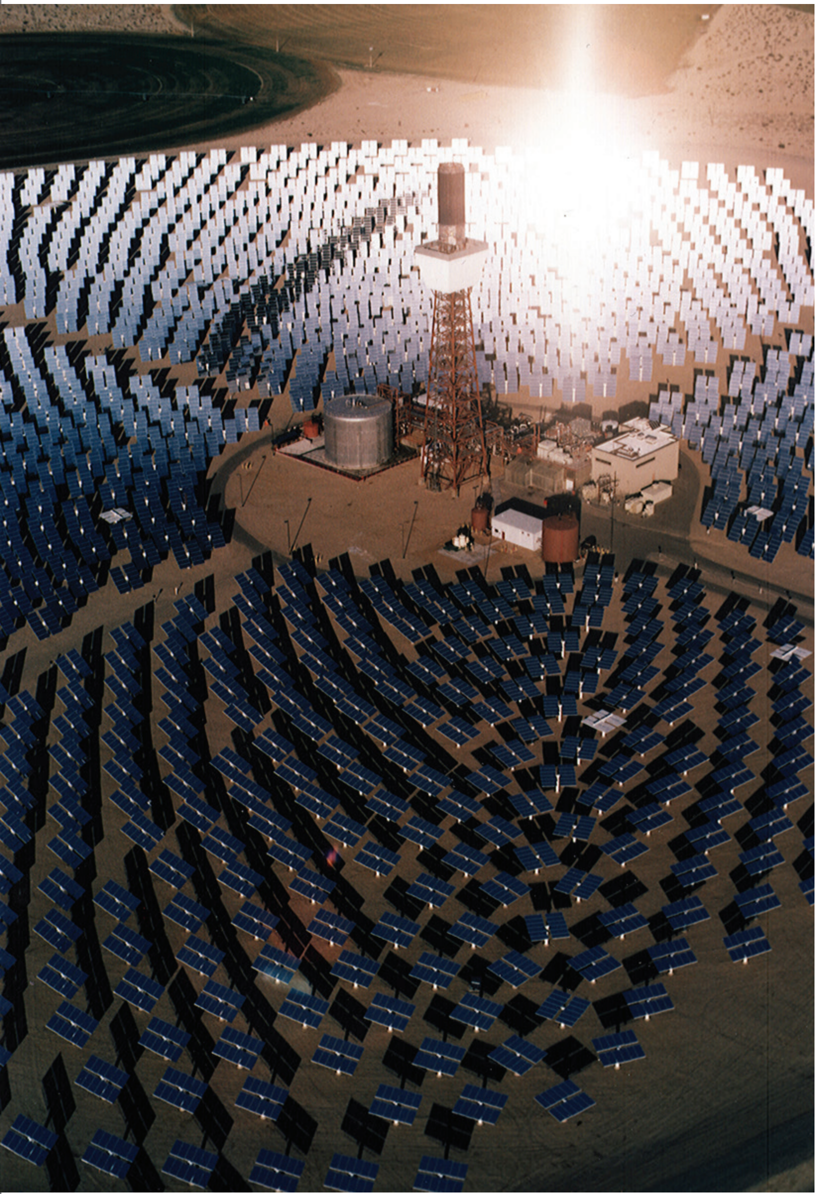
**Table 6.23:** Western Cape Province – summary of projects and timelines (continued)

| TDP Scheme | Project name | Expected CO year |
|---|---|---|
| ***Cape Corridor phase 4: 2nd Zeus-Sterrekus 765 kV line*** | *Zeus-Perseus 1st 765 kV line* | *Deferred* |
| | *Series compensation at Zeus and Perseus* | *Deferred* |
| | *Perseus-Gamma 2nd 765 kV line* | *Deferred* |
| | *Gamma-Kappa 2nd 765 kV line* | *2028* |
| | *Kappa-Sterrekus 2nd 765 kV line* | *Deferred* |
| | *Loop-in and out Koeberg-Stikland 400 kV line into Sterrekus* | *Deferred* |
| | *Sterrekus Substation 2nd 765/400 kV 2 000 MVA transformer* | *Deferred* |
| ***Droërivier-Narina-Gourikwa 400 kV line*** | *Droërivier-Narina-Gourikwa 400 kV line* | *Strategic EIA* |
| | *Bypass series capacitor at Narina* | *Strategic EIA* |
| ***Windmill Transmission Substation*** | *Windmill 400/132 kV Substation (1st and 2nd 500 MVA transformers)* | *Deferred* |
| | *Loop-in and out Bacchus-Muldersvlei 400 kV line* | *Deferred* |
| ***Stikland 132 kV transformer FCLRs*** | *Stikland 132 kV transformer FCLRs* | *Deferred* |

# 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. This capacity has been rapidly allocated, especially in the areas with better renewable resources. However, there are areas with very good renewable energy resources that have no transmission grid access at all. 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. The grid will have to be extended to create more access for the bid windows beyond Round 4B, specifically for the period 2023 to 2027. 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.

The transmission development plans to integrate these IPP programmes were based on the various generation assumptions scenarios, as the specific IPP project size, technology, location and timelines were not stated in the IRP. Scenario planning serves as a sensitivity test to mitigate transmission infrastructure over-investment as the projects required to integrate generation in all potential locations would lead to excess capacity in many areas, as well as enormous requirement of capital to execute.



As mentioned earlier, there is very little difference between the renewable energy generation resources in the 2017 - 2026 TDP (Previous TDP) and those proposed in the Draft IRP. As a result, the transmission plans required to integrate renewable energy generation projects during the 2018 - 2027 TDP period are not vastly different from the plans proposed in the previous TDP. In contrast, there has been a notable difference between Draft IRP and the 2017 - 2026 TDP (Previous TDP) in Nuclear, Coal and Gas generation resources, which has an impact on the generation integration plans in Eastern Cape, Western Cape, Kwazulu-Natal and Limpopo Provinces. While the nuclear programme is not expected to be commissioned within the current TDP period according to the Draft IRP, the onerous approach of incorporating a total of 1 600 MW in the last year of the TDP (2017) was adopted. This was to test the network's robustness for the evacuation of aggregated generation from renewables, gas and nuclear, in order to identify and advance grid enabling activities for total potential generation where required. A 1 600 MW was included in 2027 at Thyspunt for this purpose, which is significantly lower than the 4 800 MW allocated in the Previous TDP.

The 2016 Draft IRP has a total of 3 300 MW of OCGT capacity in the TDP period, which has been allocated at Dedisa Substation (1 000 MW in 2022) and Athene Substation (1 000 MW in 2024 and the balance in 2026). Furthermore, there is also a proposal for 700 MW CCGT generation during the current TDP period, which is assumed to be located at Dedisa substation.

Various alternative generation scenarios were considered for the 2018 - 2027 TDP, to assess the impact of some future generation location uncertainty on the TDP baseline for the period. The different scenarios, discussed individually later in this chapter, are listed below:

- Limpopo PV Scenario
- Northern Cape Wind Scenario
- Western Cape Wind, Gas and Nuclear Scenario

The above scenario testing helps us identify elements of transmission strengthening that are of high confidence, irrespective of scenarios considered. Resulting from this would be a collection of Transmission projects that are ready for release, from which only the final selected ones need approval and funding, thus enabling faster construction and commissioning than previously possible. The preparation work on all of the identified projects will be undertaken in order that they can be expedited should they be required for an IPP programme. 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 fulfilment of the requirements of the DoE IRP and the needs of the country.

The following types of transmission infrastructure were identified from the studied scenarios, yielding projects that have different requirements, but impact each other:

- Infrastructure to enable the collection of dispersed renewable energy generation, and
- Infrastructure to evacuate conventional generation such as nuclear, coal, or large gas

# 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 4B are known, as shown in Figure 7 1. From this, the locations of the renewable generation allocated for the period 2022 to 2027 have been assumed and the likely transmission infrastructure requirements were identified.

The required network expansions for the assumed REIPP integration requirement in the short to medium term are outlined below, provided that the location of such generation is within the areas with sufficient corridor capacity.

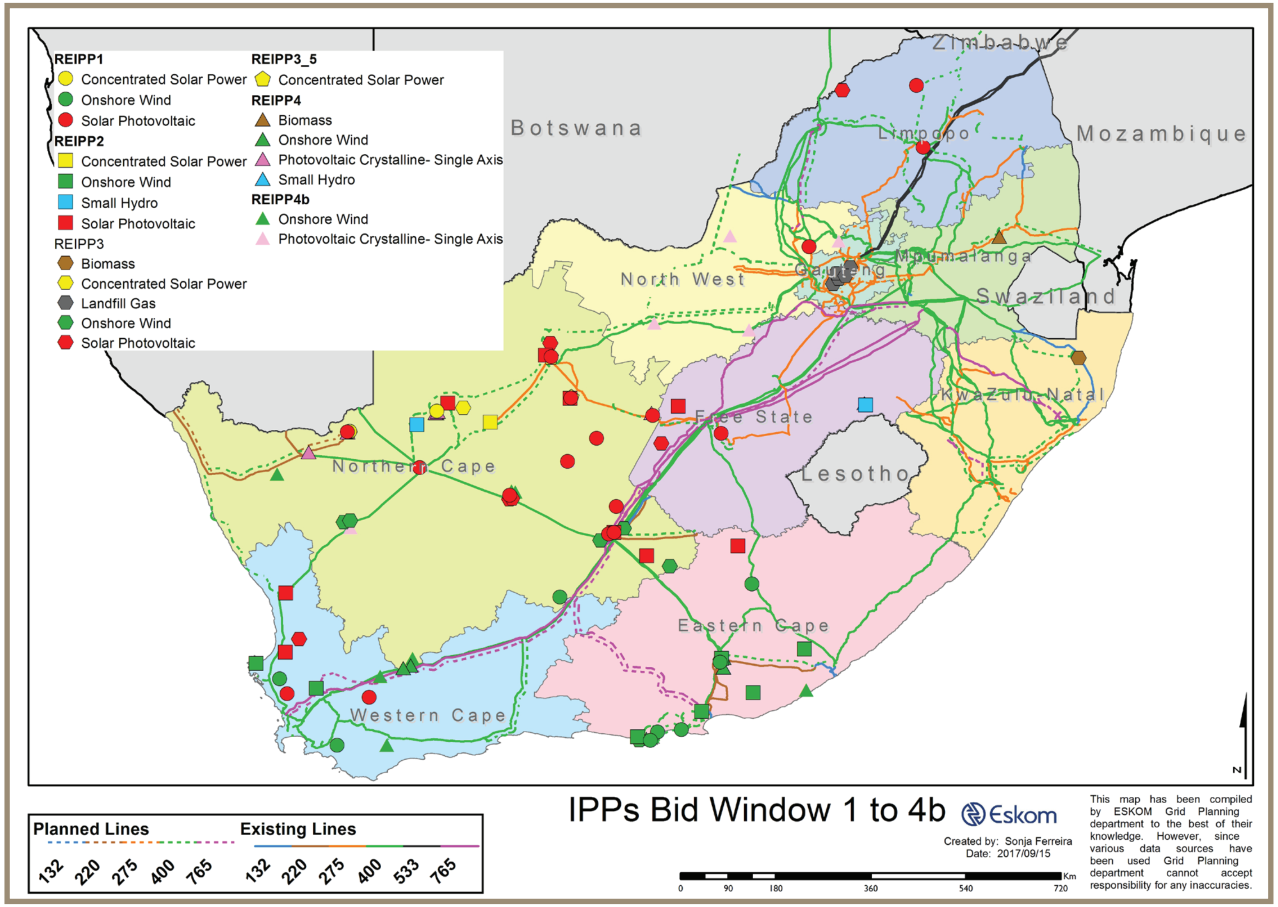



*Figure 7.1:* REIPP Bid Window 1 – 4B projects by technology

## The Eastern Cape

The majority of wind generation in the Eastern Cape Province beyond REIPPPP Bid Window 4B 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 400/132kV substations will be required in the vicinity of the Poseidon and Delphi substations, including additional 400kV lines, to enable the evacuation of the renewable energy out of the province.

## The Northern Cape

The majority of short to medium term wind and Solar PV generation within the provincial boundary of the Northern Cape has been assumed, mainly in the Namaqualand and De Aar areas beyond REIPPPP Bid Window 4B. These are expected to be located in the proposed REDZs for this province.

To accommodate this generation, at least the following will be required in addition to the infrastructure identified for TDP base line scenario:

- 400/132kV substation is required in the Hydra substation area, including the 400kV integration lines
- A new 400/132kV substation around the Nama area and a Gromis-Aggeneis 400kV line
- A 400/132 kV at Aggeneis and Aries substation
- Additional transformers at Kronos and Upington substations

## The Western Cape

The majority of short to medium term wind generation within the Western Cape Province 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 400/132kV substation is required in the Droërivier substation area and the establishment of 400/132kV transformation at the Komsberg series capacitor site and Kappa substation. This may result in additional 400kV lines being required to help evacuate the collected generation.

The investment in this transmission infrastructure is dependent upon the DoE REIPP procurement programme requirements within the TDP period. Furthermore, additional Distribution network strengthening in the form of sub-transmission lines and collector substations (not included in the above) will be required.

# 7.2 Conventional generation

There are two areas that could potentially require the evacuation of conventional 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 Lephalale area

The 2016 Draft IRP has no further provision for new coal fired power stations beyond the allocated 900MW. However, the "Waterberg Generation 400kV Stability Enhancement" project is expected to improve the potential IPP connection capacity in the province to 1 200MW. This infrastructure investment scheme was proposed to ensure compliance with the transient stability criteria in terms for the Grid Code, and comprises the following scope:

- Construct 1x400kV line from Medupi to Witkop (~200km)
- Construct 1x400kV line from Borutho to Silimela (~100km)

## The Port Elizabeth area

The 765kV infrastructure from Gamma substation to Grassridge substation in Port Elizabeth will be able to evacuate around 4 000MW of generation. This would be adequate for nuclear generation at the Thuyspunt site at 1 600MW and a large gas generation plant within the Coega area at 1 000MW.

## 7.3 Impact of the DoE generation scenarios

The TDP is based on the baseline generation assumptions. To adjust for spatial uncertainty and allow for prudent planning, generation scenarios were agreed upon with the Department of Energy's (DoE) Independent Power Producer (IPP) office. The scenarios have resulted in more robust plans and help in expediting the EIA and land acquisition processes. The period of consideration for these scenarios was 2027, as only the full impact was considered, not the phased roll-out of these scenarios.

These generation scenarios are listed below and the specific assumptions and likely impact of each scenario are discussed separately. The different scenarios, as introduced earlier in this chapter, are as follows:

- Limpopo PV Scenario
- Northern Cape Wind Scenario
- Western Cape Wind, Gas and Nuclear Scenario

### Limpopo PV Scenario

Limpopo Province has a huge potential of power generation from renewable sources, specifically Solar. There are currently three projects that have been allocated generation capacity from the approved REIPPPP Bid Windows. There have also been several enquiries from potential PV generators in the Province. The following scenario was considered for additional Solar PV generation in the Limpopo Province by 2027:

Solar PV generation amounting to a total of 1000 MW moved from the Northern Cape to Limpopo Province as an alternative to the baseline allocation. The capacity output allocation per local area was tested as follows:

- Medupi: 200MW
- Witkop: 100MW
- Ndzhelele: 200MW
- Tabor: 200MW
- Spencer: 200MW
- Foskor: 100MW

This scenario will not require additional infrastructure investment in Limpopo Province for power evacuation purposes. However, the evacuation of additional power is contingent upon completion of the following projects, which are currently in execution:

- Waterberg Generation 400kV Stability Enhancement consisting of Medupi-Witkop 400kV line and Borutho-Silimela 400kV line.

## Northern Cape Wind Scenario

The Northern Cape Province is an ideal location for generation from renewable sources in South Africa. The majority of approved projects under the REIPPPP to date are located in the Northern Cape Province. Moreover, the highest number of applications processed for the REIPPPP expedited programme was located in the Northern Cape, which confirms the province as the hub of generation from renewable sources. The following scenario was considered for additional wind generation in the Northern Cape Province by 2027:

Wind generation amounting to a total of 2 300MW moved to the Northern Cape as an alternative to the baseline allocation. The capacity output allocation per location was as follows:

- Aries: 400MW
- Kronos: 500MW
- Gamma: 400MW
- Nama: 200MW
- Gromis: 100MW
- Aggeneis: 300MW
- Oranjemund: 400MW

The study took into account the massive diversity between the Norther Cape and the Eastern Cape and Western Cape wind generation. The following strengthening projects were recommended to evacuate additional power from wind generation in the Northern Cape:

**Namaqualand Strengthening: Gromis-Nama-Aggeneis 400kV line**
This project entails the 1st Gromis-Nama-Aggeneis 400kV line for the evacuation of the anticipated renewable generation in the Namaqualand CLN under the Northern Cape Wind Generation Scenario.

**Kimberley Strengthening Phase 4 – Part A**
This is a strategic project to enable the evacuation of potential renewable generation in the Kimberley area. The scope of work includes:

- Beta-Ulco 1st 400kV line
- Ulco-Manganore 1st 400kV line
- Manganore-Ferrum 1st 400kV line

## Western Cape Wind, Gas and Nuclear Scenario

There are two designated renewable energy development zones in the Western Cape Province, namely Overberg and Komsberg. These have been identified as areas with high potential for RE generation and were gazetted as such in February 2016.

There has also been several enquiries for potential gas generation integration ranging from around 500MW to 1 000MW in the vicinity of Atlantis, near Ankerlig Power Station.

The Western Cape is therefore a prime location for wind generation as well as for nuclear and gas generation, with some potential for PV generation. As a result of this, the following scenario was conceived for additional generation in the Western Cape by 2027:

- 1 600MW of nuclear generation at Duynefontein
- 730MW of gas generation at Ankerlig
- 3 500MW of wind generation distributed between Aurora, Bacchus, Droërivier, Juno, Komsberg, Muldersvlei, Kappa, Asteria and Agulhas substations
- 300MW of PV generation at Kappa Substation

For renewable generation, this is in addition to what has already been commissioned or allocated to preferred bidder up to REIPPPP Bid Window 4B. This scenario results in the Western Cape becoming a net exporter of power, with as much as 6GW of excess generation. Additional infrastructure will be required to evacuate the power from the Western Cape; this will be in the form of 765kV and 400kV lines, especially in the northern ring.

Integration plans for the nuclear and gas generation have already been developed and are as follows:

The project scope for the integration of Nuclear 1 at Duynefontein is dependent on the completion of the 2nd Gamma-Kappa 765kV line and the 2nd Kappa-Sterrekus 765kV line as part of Cape Corridor Phase 4. The integration at Duynefontein entails the construction of five Transmission lines as follows:

- 3 x 400kV lines to Sterrekus (~10 km)
- 1 x 400kV line to Acacia (~32 km)
- 2 x 400kV lines to Stikland (~46 km)

The scope of work to enable the evacuation of expected power from the Koeberg and Ankerlig generation pool under this scenario is as follows:

- Energise the existing Koeberg-Acacia 2 400kV line at 400kV.
- Establish Ankerlig-Sterrekus 1st and 2nd 400kV lines

The wind and PV generation will require mostly additional transformers at existing substations. The Transmission infrastructure required to integrate renewables in the Overberg and Komsberg areas will be:

Additional 400/132kV transformers in existing substations i.e. Droërivier, Kappa and Komsberg.

Establishment of Koring Substation by turning in Droërivier-Komsberg 1 and Droërivier-Kappa 1 400kV lines and bypassing the series capacitor bank.

Additional infrastructure over and above this will be required to deliver the power to the load centres in the central and eastern parts of the country. This scope builds on strengthening provided by projects such as Kimberley Strengthening Phase 4 and the proposed Cape Corridor Phase 5. A 2nd 765kV line from Mercury to Sterrekus will be required, together with an additional 400kV evacuation path out of Kronos. The backbone strengthening can be summarised as follows:

- 2nd Mercury-Sterrekus 765kV line with series compensation.
- Additional 765 / 400kV transformation at Juno, Aries and Hotazel (Lereko), Sterrekus, Hydra and Zeus
- 1 x Kronos-Ferrum 400kV line
- 1 x Kronos-Boundary-Beta 400kV line

For the most part, the line routes lie within the recently gazetted electricity grid infrastructure (EGI) corridors; furthermore, some EAs are already in place for the lines required for the Nuclear 1 Integration at Duynefontein.

# Chapter 8
# Capital expenditure plan

The total capital expenditure for Transmission amounts to R 168.025 billion, and is summarized in Table 8 1. It is clear that the majority of the cost will be related to expansion, compared to other categories of expenditure, because this relates directly to the strengthening of the network to accommodate new customers as well as new generation.

***Table 8.1:*** Capital expenditure per category of projects for FY2018 to FY2027

| Categories | Rand (billions) |
|---|---|
| *Capital expansion* | *119.151* |
| *Capital expansion for IPPs* | *18.756* |
| *Refurbishment* | *23.442* |
| *Production equipment* | *1.537* |
| *Land and rights* | *5.157* |
| **Total** | **168.043** |

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 8 2 shows the provincial split for transmission expansion projects which amount to R137.9 billion over the next ten years.

***Table 8.2:*** FY2018 to FY2027 Capital expenditure per province for expansion projects

| Province | Rand (Billions) |
|---|---|
| *Eastern Cape* | *22.840* |
| *Free state* | *3.898* |
| *Gauteng* | *18.587* |
| *Kwa-Zulu Natal* | *33.163* |
| *Limpopo* | *13.700* |
| *Mpumalanga* | *7.845* |
| *North West* | *5.010* |
| *Northern Cape* | *17.528* |
| *Western Cape* | *15.336* |
| **Total** | **137.907** |

# Chapter 9
## Conclusion

The most visible difference between this TDP and the 2015 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 26 additional IPP successful bidders announced by the DoE in Rounds 4 and 4B. There is an assumed plan for future REIPP programmes 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, regrettably, increases the overall risk to the network. However, this risk can be managed, as the N-1 criterion 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 individual customers and South Africa at large.

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 is generally on the critical path of connecting and integrating large new loads and generation due to the long lead times for securing corridors. It is recommended 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; 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, albeit at a later date than previously envisaged mainly due to funding constraints.

# Chapter 10
## Appendices

***10.1 Appendix A:*** Generation assumptions

***Table A1***: The Conventional Generation Plan for the TDP 2018 to 2027

| Conventional Generation Allocation (MW) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Classification** | **Power Station** | **2016** | **2017** | **2018** | **2019** | **2020** | **2021** | **2022** | **2023** | **2024** | **2025** | **2026** | **2027** | **Total** |
| ***Coal*** | ***Medupi*** | *846* | *1692* | *0* | *1692* | *846* | *0* | *0* | *0* | *0* | *0* | *0* | *0* | *5076* |
| ***Coal*** | ***Kusile*** | *0* | *0* | *846* | *846* | *846* | *1692* | *846* | *0* | *0* | *0* | *0* | *0* | *5076* |
| ***Hydro*** | ***Ingula*** | *666* | *666* | *0* | *0* | *0* | *0* | *0* | *0* | *0* | *0* | *0* | *0* | *1332* |
| ***OCGT Peaker*** | ***Dedisa*** | *335* | *0* | *0* | *0* | *0* | *0* | *0* | *0* | *0* | *0* | *0* | *0* | *335* |
| ***OCGT Peaker*** | ***Avon*** | *670* | *0* | *0* | *0* | *0* | *0* | *0* | *0* | *0* | *0* | *0* | *0* | *670* |
| ***Nuclear*** | ***Thyspunt*** | *0* | *0* | *0* | *0* | *0* | *0* | *0* | *0* | *0* | *0* | *0* | *1600* | *1600* |
| ***New Coal*** | ***Khanyisa*** | *0* | *0* | *0* | *0* | *0* | *225* | *0* | *0* | *0* | *0* | *0* | *0* | *225* |
| ***New Coal*** | ***Massa*** | *0* | *0* | *0* | *0* | *0* | *450* | *0* | *0* | *0* | *0* | *0* | *0* | *450* |
| ***New Coal*** | ***Kriel*** | *0* | *0* | *0* | *0* | *0* | *225* | *0* | *0* | *0* | *0* | *0* | *0* | *225* |
| ***New OCGT*** | ***Dedisa*** | *0* | *0* | *0* | *0* | *0* | *0* | *1000* | *0* | *0* | *0* | *0* | *0* | *1000* |
| ***New OCGT*** | ***Athene*** | *0* | *0* | *0* | *0* | *0* | *0* | *0* | *1000* | *0* | *1000* | *0* | *0* | *2000* |
| ***New CCGT*** | ***Dedisa*** | *0* | *0* | *0* | *0* | *0* | *0* | *0* | *0* | *0* | *732* | *0* | *0* | *732* |
| **Total** | | **2517** | **2358** | **846** | **2538** | **1692** | **2592** | **1846** | **1000** | **0** | **1732** | **0** | **1600** | **18721** |

***Table A2:*** The annual PV allocation per Substation for the TDP 2018 to 2027

| PV Allocation per Substation per year (MW) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **2015** | **2016** | **2017** | **2018** | **2019** | **2020** | **2021** | **2022** | **2023** | **2024** | **2025** | **2026** | **2027** | **Total** |
| **Aggeneis** | 0 | 0 | 0 | 40 | 0 | 100 | 0 | 0 | 0 | 0 | 100 | 0 | 0 | 240 |
| **Aries** | 10 | 0 | 0 | 0 | 0 | 200 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 210 |
| **Aurora** | 5 | 75 | 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 89 |
| **Bacchus** | 36 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 36 |
| **Bighorn** | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100 | 107 |
| **Boundary** | 78 | 0 | 75 | 75 | 0 | 0 | 0 | 0 | 100 | 0 | 0 | 0 | 0 | 328 |
| **Ferrum** | 75 | 0 | 149 | 0 | 0 | 100 | 0 | 0 | 0 | 0 | 100 | 100 | 0 | 524 |
| **Foskor** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100 | 100 |
| **Garona** | 0 | 0 | 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 9 |
| **Harvard** | 64 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 64 |
| **Helios** | 0 | 0 | 0 | 0 | 75 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 75 |
| **Hydra** | 205 | 0 | 112 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 317 |
| **Hydra B** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100 | 0 | 100 | 0 | 100 | 0 | 300 |
| **Juno** | 0 | 0 | 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 9 |
| **Koruson** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100 | 0 | 0 | 100 | 100 | 0 | 300 |
| **Kronos** | 20 | 150 | 0 | 0 | 55 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 225 |
| **Lomond** | 0 | 0 | 0 | 0 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 50 |
| **Matimba** | 0 | 60 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 60 |
| **Mercury** | 0 | 0 | 0 | 0 | 68 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 68 |
| **Mookodi** | 0 | 0 | 0 | 0 | 75 | 0 | 0 | 0 | 100 | 100 | 200 | 0 | 0 | 475 |

***Table A2:*** The annual PV allocation per Substation for the TDP 2018 to 2027 (continued)

| PV Allocation per Substation per year (MW) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **2015** | **2016** | **2017** | **2018** | **2019** | **2020** | **2021** | **2022** | **2023** | **2024** | **2025** | **2026** | **2027** | **Total** |
| ***Nama*** | *0* | *0* | *0* | *0* | *0* | *0* | *0* | *0* | *0* | *100* | *100* | *100* | *0* | *300* |
| ***Olien*** | *64* | *0* | *75* | *0* | *0* | *0* | *0* | *0* | *0* | *0* | *0* | *0* | *0* | *139* |
| ***Paulputs*** | *10* | *0* | *0* | *75* | *0* | *0* | *0* | *0* | *0* | *0* | *0* | *0* | *0* | *85* |
| ***Perseus*** | *0* | *0* | *60* | *0* | *0* | *0* | *0* | *0* | *0* | *0* | *0* | *0* | *0* | *60* |
| ***Ruigtevallei*** | *0* | *0* | *70* | *0* | *0* | *0* | *0* | *0* | *0* | *0* | *0* | *0* | *0* | *70* |
| ***Spencer*** | *0* | *0* | *0* | *0* | *0* | *0* | *0* | *0* | *0* | *0* | *0* | *0* | *100* | *100* |
| ***Tabor*** | *28* | *0* | *0* | *0* | *0* | *0* | *100* | *0* | *0* | *0* | *200* | *0* | *100* | *428* |
| ***Theseus*** | *0* | *0* | *0* | *0* | *0* | *100* | *0* | *0* | *0* | *0* | *0* | *100* | *0* | *200* |
| ***Upington*** | *0* | *0* | *0* | *0* | *225* | *100* | *0* | *0* | *100* | *0* | *100* | *0* | *0* | *525* |
| ***Watershed*** | *0* | *0* | *0* | *0* | *75* | *0* | *0* | *0* | *0* | *0* | *0* | *0* | *0* | *75* |
| ***Witkop*** | *30* | *0* | *0* | *0* | *0* | *0* | *0* | *100* | *0* | *0* | *0* | *0* | *100* | *230* |
| **Total** | **632** | **285** | **567** | **190** | **623** | **600** | **100** | **300** | **300** | **300** | **900** | **500** | **500** | **5797** |

***Table A3:*** The annual Wind allocation per Substation for the TDP 2018 to 2027

| Wind Allocation per Substation per year (MW) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **2015** | **2016** | **2017** | **2018** | **2019** | **2020** | **2021** | **2022** | **2023** | **2024** | **2025** | **2026** | **2027** | **Total** |
| **Aggeneis** | 0 | 0 | 0 | 0 | 137 | 100 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 237 |
| **Aries** | 0 | 0 | 0 | 0 | 0 | 0 | 100 | 0 | 0 | 0 | 0 | 0 | 0 | 100 |
| **Aurora** | 65 | 0 | 91 | 0 | 0 | 100 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 256 |
| **Bacchus** | 26 | 0 | 0 | 0 | 32 | 0 | 0 | 0 | 0 | 0 | 0 | 100 | 0 | 158 |
| **Delphi** | 97 | 0 | 0 | 0 | 0 | 100 | 100 | 0 | 0 | 100 | 200 | 0 | 0 | 597 |
| **Droerivier** | 0 | 0 | 0 | 0 | 0 | 100 | 0 | 0 | 0 | 100 | 0 | 0 | 0 | 200 |
| **Grassridge** | 238 | 0 | 265 | 140 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 642 |
| **Gromis** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 200 | 100 | 0 | 300 |
| **Helios** | 0 | 0 | 276 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 276 |
| **Hydra** | 73 | 236 | 79 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 387 |
| **Hydra B** | 0 | 0 | 0 | 0 | 0 | 100 | 0 | 200 | 100 | 100 | 300 | 100 | 0 | 900 |
| **Juno** | 100 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100 |
| **Komsberg** | 0 | 0 | 0 | 140 | 279 | 200 | 0 | 0 | 0 | 0 | 200 | 0 | 0 | 819 |
| **Koruson** | 0 | 0 | 0 | 0 | 108 | 0 | 100 | 0 | 100 | 200 | 200 | 0 | 0 | 708 |
| **Kronos** | 0 | 0 | 0 | 0 | 238 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 238 |
| **Muldersvlei** | 0 | 0 | 135 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 135 |
| **Nama** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100 | 0 | 100 | 0 | 0 | 0 | 200 |
| **Pembroke** | 0 | 0 | 21 | 0 | 33 | 0 | 0 | 0 | 100 | 100 | 100 | 0 | 0 | 353 |
| **Poseidon** | 135 | 87 | 161 | 118 | 139 | 100 | 100 | 0 | 0 | 100 | 0 | 100 | 0 | 1040 |
| **Thyspunt** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 200 | 0 | 0 | 200 |
| **Total** | **734** | **322** | **1027** | **398** | **965** | **800** | **400** | **300** | **300** | **800** | **1400** | **400** | **0** | **7846** |

***Table A4:*** The annual CSP allocation per Substation for the TDP 2018 to 2027

| Wind Allocation per Substation per year (MW) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | Total |
| Ferrum | 0 | 0 | 0 | 100 | 0 | 150 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 250 |
| Garona | 50 | 0 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100 |
| Olien | 0 | 0 | 0 | 0 | 100 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100 |
| Paulputs | 100 | 0 | 100 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 200 |
| Upington | 0 | 0 | 100 | 0 | 0 | 300 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 400 |
| | 150 | 0 | 250 | 100 | 100 | 450 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1050 |

***Table A5:*** Other generation allocation per Substation for the TDP 2018 to 2027

| Wind Allocation per Substation per year (MW) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | Total |
| Etna | 18 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 18 |
| Impala | 0 | 17 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 17 |
| Marathon | 0 | 0 | 0 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 |
| Paulputs | 0 | 0 | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 10 |
| Tugela | 0 | 0 | 4 | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 9 |
| | 18 | 17 | 14 | 25 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 79 |

***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.

| Team Members | Title | Role |
|---|---|---|
| *Leslie Naidoo* | *Snr Manager Grid Planning* | *Reliability Plans* |
| *Makoanyane Theku* | *Middle Manager Grid Planning* | *Project Management* |
| *Ronald Marais* | *Snr Manager Grid Planning* | *Strategic Plans* |
| *Roy Estment* | *Corporate Specialist* | *Grid Planning* |
| *Caswell Ndlhovu* | *Chief Engineer Grid Planning* | *Strategic Plans* |
| *Dalton Matshidza* | *Chief Engineer Grid Planning* | *Reliability Plans* |
| *Thamsanqa Ngcobo* | *Chief Engineer Grid Planning* | *Reliability Plans* |
| *Lulama Maqabuka* | *Senior Engineer Grid Planning* | *Reliability Plans* |
| *Tonderayi Gumunyu* | *Senior Engineer Grid Planning* | *Reliability Plans* |
| *Thokozani Bengani* | *Chief Engineer Grid Planning* | *Reliability Plans* |
| *Caroleen Naidoo* | *Senior Engineer Grid Planning* | *Reliability Plans* |
| *Queen Melato* | *Chief Engineer Grid Planning* | *Reliability Plans* |

| Team Members | Title | Role |
|---|---|---|
| *Kabir Singh* | *Chief Engineer Grid Planning* | *Reliability Plans* |
| *Ahmed Hansa* | *Chief Engineer Grid Planning* | *Reliability Plans* |
| *Jafta Chweu* | *Engineer Grid Planning* | *Project Management* |
| *Lynn David* | *Engineer Grid Planning* | *Project Management* |
| *Sonja Ferreira* | *Snr Technologist Grid Planning* | *GIS Support* |
| *Camille Shah* | *Middle Manager Stakeholders* | *Printing and Communications* |
| *Tinkie Ndzamela* | *Snr Advisor Communication* | *Printing and Communications* |
| *Jurie Groenewald* | *Middle Manager Projects* | *Capital Budget* |
| *Alwyn Marais* | *Chief Engineer Electrical* | *Capital Budget* |
| *Sandy Dalgleish* | *Middle Manager Capital Plan* | *Capital Budget* |
| *Annerie Van Velden* | *Middle Manager Projects* | *Capital Budget* |
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***Appendix C:*** Contact details

This document will be available for download via the Eskom website (www.eskom.co.za), but should you have any queries, please contact the following people:

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