3 PROJECT DESCRIPTION

3.1 Introduction

Electricity supply throughout the world is undergoing a revolution. At a global level this is being caused mainly, but not solely, by electricity utilities having to meet new pressures resulting from global markets, where national governments are open to foreign investors to help fund power sector expansion and development. As a result, utilities have to act as businesses. South Africa is not immune to these forces, and will have to move broadly in line with developments taking place in the rest of the world, while also ensuring that the supply industry evolution meets South Africa's special requirements. At a local level, the main drivers for change in South Africa are potential economic efficiency gains and technological change - for example, different economies of scale in power plant construction, and new information and control technologies (White Paper on the Energy Policy of the Republic of South Africa, December 1998).

The South African Government is currently targeting a six percent economic growth rate, which is equivalent to an average increase of four percent in electricity demand. Eskom is currently experiencing increased demand in excess of four percent. Based on Eskom's projections, there is a requirement for more than 40 000 Megawatts (MW) of new electricity generating capacity over the next 20 years in South Africa. A number of new coal fired power stations are currently being considered, with two new base load power stations approved to come on-line between 2012 and 2016. However, these are not sufficient to meet the demand for electricity and additional power stations will be required.

The Eskom Conversion Act, 2001 (Act No. 13 of 2001) establishes Eskom Holdings SOC Limited (Eskom) as a State Owned Enterprise (SOE), with the Government of South Africa as the only shareholder, represented by the Minister of Public Enterprises. The main objective of Eskom is to provide energy and related services including the generation, transmission, distribution and supply of electricity, and to hold interests in other entities.

3.2 Need and Justification for the project

The Polokwane Customer Load Network (CLN), including the Tabor and Spencer power corridor, remains susceptible to voltage instability and is the weakest part of the Northern Grid network due to being operated beyond its reliability power transfer limit. In addition to this, the Polokwane CLN, i.e., Tabor and Spencer 275 kV and 132 kV network is susceptible to low voltages regardless the approved and commissioned network strengthening in year 2010 below:

- Tabor-Spencer 275 kV line, and
- 2nd 250MVA 275/132 kV transformer

Listed below is the approved 400 kV network re-enforcement in the Polokwane CLN which is expected for commissioning by the end of year 2012:

- Witkop-Tabor 400 kV line, and
- Tabor 500MVA 400/132 kV transformer.

The combined transformation capacity at Tabor and Spencer MTS end state of 846MW exceeds the installed and the approved transformation capacity of 712 MW. In addition to this, the low voltages and thermal constraints in the 132 kV Distribution network for both existing and planned network remains.

The Tabor and Spencer 275/132 kV transformation recorded peak in year 2010 was 280 MW and 210 MW, respectively. The exceeded Tabor 275/132 kV transformation firm will be restored once the Witkop-Tabor 400kV line and the 1st 500 MVA 400/132 kV transformer have been commissioned.

The Spencer 275/132 kV transformation firm capacity of 234 MW will be exceeded by 40 MW in year 2015. Therefore, compromising the network reliability by violating the set Grid Code N-1 transformation criteria.

The lengthy Tabor and Spencer 132 kV Distribution networks stretching 200 km from Polokwane to 50 km away form the Mussina border-post result in low voltages and thermal constraints during N-1 transformation and line contingencies in year 2011 and beyond.

The expected Tabor and Spencer 132 kV load growth is located 100km north of Tabor and 70 km from Spencer, therefore, the Transmission outreach constraint will cap the load growth.

Following the findings after an assessment of the Tabor and Spencer 400 kV, 275 kV and 132kV network constraints for the 20 year horizon, Grid Planning proposes the following:

- Establish 4 x 250 MVA 400/132 kV Nzhelele Main Transmission Station (MTS) (**this project**)
- Construct Tabor–Nzhelele 130 km 400 kV line (**this project**),
- Construct Borutho–Nzhelele 250 km 400 kV line (**being undertaken concurrently by Nzumbululo Heritage Solutions**), and
- Commission all the associated infrastructure by year 2017.

The proposed servitudes for the Tabor-Nzhelele and Borutho 400 kV lines are likely to be more challenging to acquire due to the Mapumgubwe mountain range which the lines will have to be built through to feed into the Nzhelele MTS. However, the planned commissioning date, i.e., 2017 take into account the EIA approval processes and challenges.

The above proposed network solution meets the 10 year Distribution load requirements in the Tabor and Spencer network area and it is also informed by the 20 year Transmission and Distribution load forecast in meeting the Transmission 20 year plan.

The advantages of the newly proposed transmission lines include:

- Creation of a more flexible electrical network;
- Improvement in the overall reliability of the electrical systems, which will be of benefit to both Eskom and to all electricity users in the region;
- The availability of a reliable electricity supply of good quality is fundamental to investment and economic growth within Limpopo Province. The medium to long-term socio-economic benefits of this project are accordingly significant; and
- The proposed power lines will reduce the inherent risk profile of the northern grid by augmenting the existing supply, resulting in less frequent power outages and an improved quality of electricity supply at a regional level.

3.3 Electricity Transmission

3.3.1 Electrical power transmission and distribution

Electricity is generated as it is used. Unlike other commodities, there is very little ability to store electricity. Because of the instantaneous nature of the electric system, constant modifications must be made to assure that the generation of power matches the consumption of power. The South African electric system is very complex and dynamic, and needs to be adjusted to meet changing needs.

Electric power transmission, is and a process in the delivery of electricity to consumers, can be defined as the bulk transfer of electrical power. Typically, power transmission is between a Power Station and Substations that connect the national grid and end users.

Electricity is transmitted over long distances at high voltage along transmission powerlines from the Power Stations to the areas where it is needed. Electricity must be carried at high voltages (kilovolts, or kV) along transmission powerlines in order to make up for losses that occur over long distances, and to limit the number of power lines required. In order for the electricity to be transmitted safely and efficiently over long distances, it must be at a high voltage (pressure) and a low current (flow).

The voltages at which power is generated at the Power Stations are too low for transmission over long distances. To overcome this problem, transformers are installed at the power stations and substations to increase the voltage. Transformers step-up the voltage from, for example, 22kV to 220kV, 275kV, 400kV or 765 kV, and feed the electricity into Eskom's national grid.

When the electricity arrives at a distribution Substation, bulk supplies of electricity are taken for primary distribution to towns and industrial areas, groups of villages, farms and similar concentrations of consumers. The lines are fed into intermediate Substations where transformers reduce (step-down) the voltage. This could be 11kV in large factories and 380/220 volts in shops and homes. Power is distributed to end-users via reticulation power lines (See **Figure 3.1**).

In South Africa, Eskom has a total of 32 342 km (as of January 2012) of high voltage transmission lines. All the high voltage lines, plus the transformers and related equipment, form the transmission system also known as the national grid.

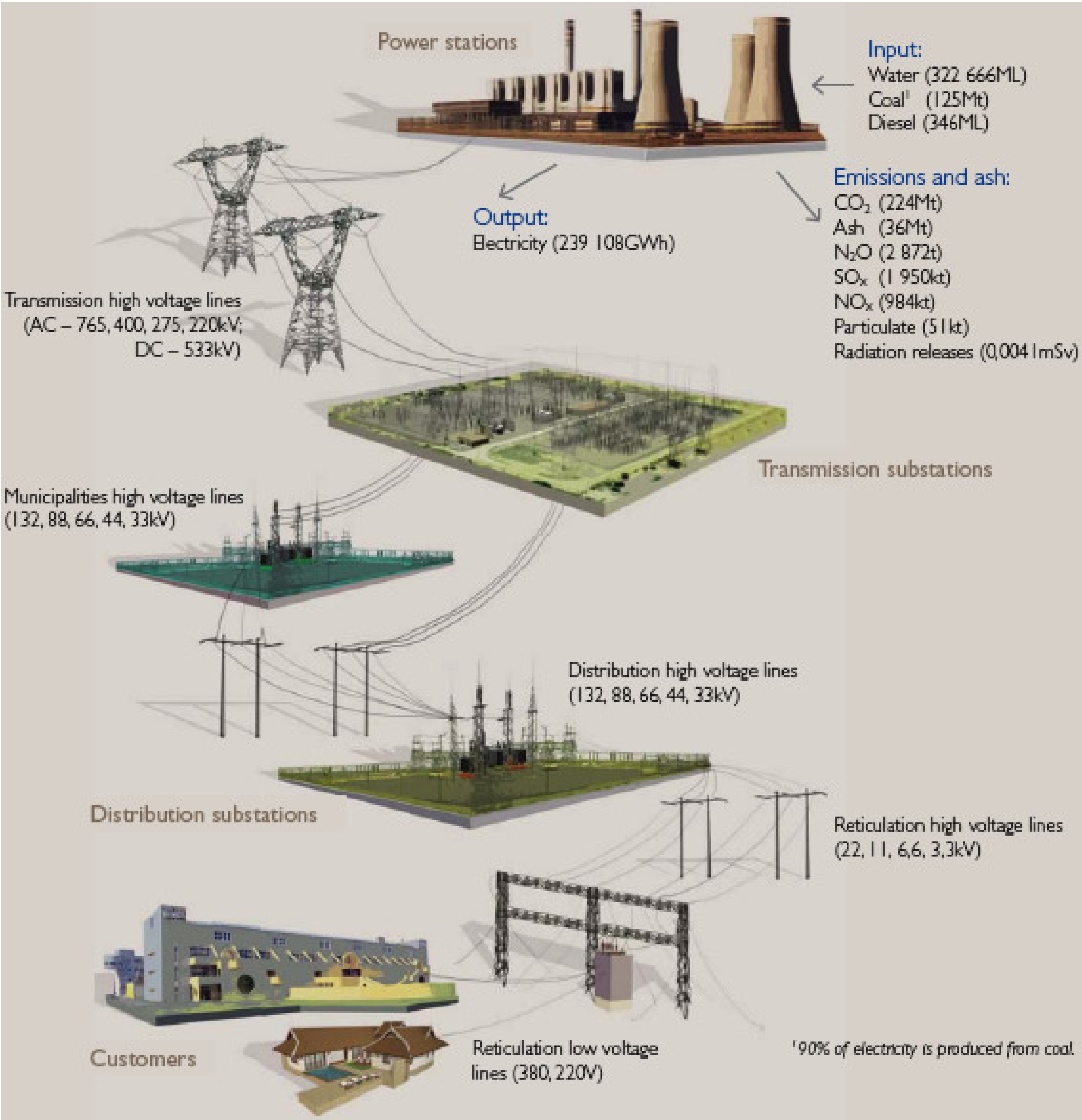

Figure 3.1: Simplified electrical transmission and distribution system
(source: www.eskom.co.za)

3.3.2 Components of a typical transmission line system

The main components of a typical electrical transmission system include the following:

- *Transmission towers*

  Transmission towers are the most visible component of the power transmission system. Their function is to *inter alia*, keep the high-voltage conductors (powerlines) separated from their surroundings and from each other. A variety of tower designs exist. Some tower designs reflect the specific function of the tower, while others have come about as a result of technological progress. Tower designs are discussed in Chapter 4 of this report; **Figure 3.2** below highlights two different tower designs.

Figure 3.2: Photograph of Self-supporting Strain tower (in foreground) and Cross Rope Suspension tower (in centre) designs**.**

- *Conductors*

  Conductors are the powerlines that carry the electricity to and through the grid. Generally, several conductors per phase are strung from tower to tower. The number of conductors per phase depends on the design for the line, typically 3 to 4 conductors per phase. Conductors are constructed primarily of metal or other types of materials as appropriate. An example is illustrated in **Figure 3.3**.

Figure 3.3: Photograph of conductors strung between transmission towers.

- *Substations*

The very high voltages used for electric transmission are converted at **Substations** to lower voltages for consumer use. Substations vary in size and configuration but may cover several hectares; they are cleared of vegetation and typically surfaced with gravel. They are normally fenced, and are reached by a permanent access road. In general, substations include a variety of structures such as conductors, fencing, lighting, and other components (**Figure 3.4**).

Figure 3.4: Photograph of a Substation, which transforms electricity from high to low voltage for consumer use.

For the substation to perform it needs sophisticated protection equipment to detect faults and abnormal conditions. Action may consist for example, of automatically switching the power off and on again to cater for abnormal conditions such as lightning strikes or trees falling on lines. This action is necessary for safety reasons in the event of an accident or to keep the electricity supply constant.

- *Transformers*

A **transformer** is basically a very simple device (**Figure 3.5**). The alternating current is led through a primary coil of wire, which produces an alternating magnetic field in the ring-shaped core of soft iron. This in turn creates a voltage in a secondary coil, from which the output current can be drawn. If the secondary coil has more turns than the primary coil, the output voltage is higher than the input voltage. This is a step-up transformer. A step-down transformer has more turns in the primary coil than in the secondary coil to reduce the voltage.

Figure 3.5: Transformers at a Substation.

3.4 Location of the Proposed Development

The study area falls within the Limpopo Province between the Tabor Substation located just south of the Capricorn Toll Plaza approximately 67km north of Polokwane to the proposed new Bokmakirie (Nzhelele) substation approximately 45km south of Musina.

The regional location of the proposed project is indicated in **Figure 3.6**.

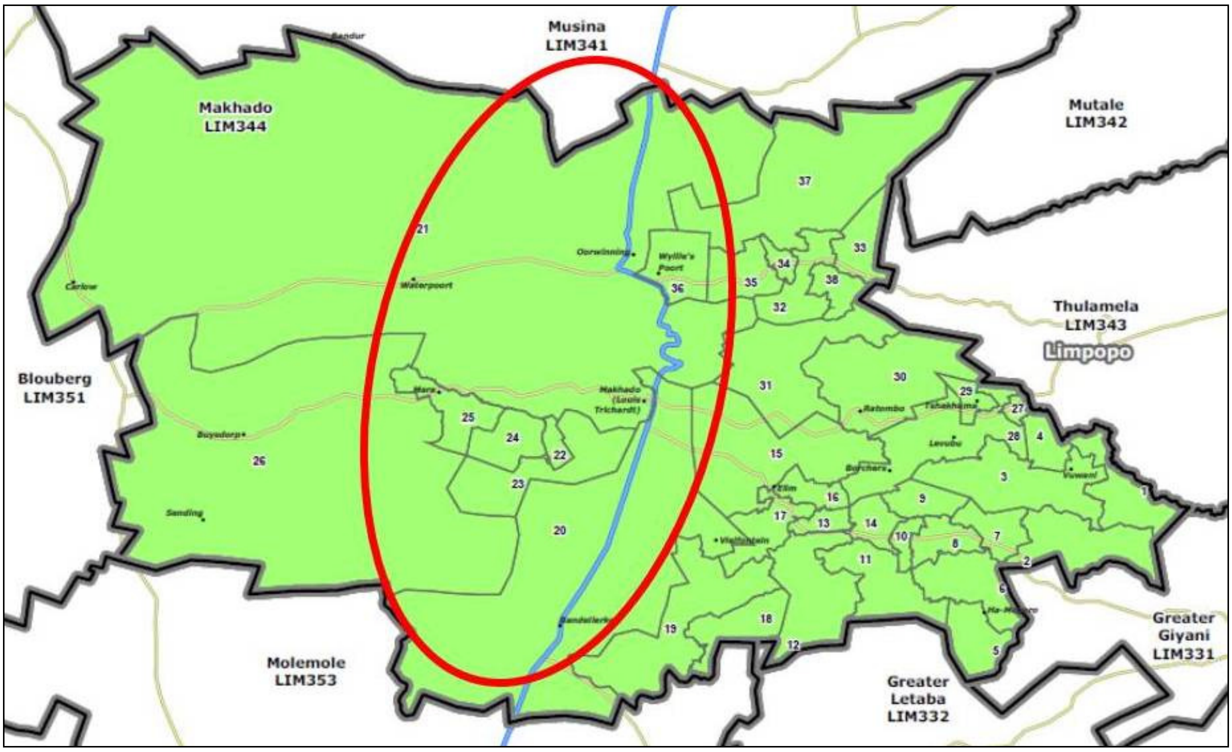

Figure 3.6: Locality of the Study Area within the Makhado Local Municipal area of Limpopo.

3.5 Detailed Description of the Project

The proposed project entails the construction of 1x 400 kV Transmission Powerline from the Tabor Substation located just south of the Capricorn Toll Plaza approximately 67km north of Polokwane to the proposed new Bokmakirie (Nzhelele) substation approximately 45km south of Musina. **Table 3.1** provides information on the points of origin and destination of the proposed Tabor - Nzhelele power line.

Table 3.1: Summary of points of origin and destination of the proposed power line

Name of power line	Origin of power line	Closest town / city (origin)	Destination of power line	Closest town / city (destination)
Tabor - Nzhelele	Tabor Substation	Louis Trichardt	Bokmakirie (Nzhelele) Substation	Musina

Although the Bokmakirie Substation is not yet built, it has received an Environmental Authorisation for the building of a Distribution size substation for the new 132 kV powerline that was recently established. This project will include the investigations and application for approval for the upgrading of the Bokmakirie substation to allow for the proposed new 400kV powerline.

The full scope of work includes:

- Establishment of 1 x 100km 400kV power line between Tabor and Bokmakirie (Nzhelele)
- Expansion of Bokmakirie (Nzhelele) Substation (by approximately 25 ha) with 4 X 250MVA 400KV/132KV transformers and associated infrastructure, including:
    - Terrace the Nzhelele 400kV yard for and end-state of 4x 400kV feeder bays,
    - Terrace the Nzhelele 132kV yard for and end-state of 8x 132kV feeder bays,
    - Establish the control building, telecommunication infrastructure, oil dam,
    - Establish all the access road infrastructure to and within Nzhelele
- Construction of a formal section of access road through the Farms Clydesdale and Vlakfontein

3.5.1 Components of the transmission power lines

The proposed powerline is a 400 kV transmission line. A brief overview of the physical/technical requirements of the project is as follows:

- One (1) x 400 kV transmission powerline between Tabor and Bokmakirie (Nzhelele).
- Straight line distance between Tabor and Bokmakirie (Nzhelele) is approximately 83 km.
- Servitude width for 1 x 400 kV power line = 55 m.
- Height of 1 x 400 kV power line = average of 48 m.
- Minimum conductor clearance = between 8.5 – 10.4 m.
- Span length between towers = approximately 450 m.
- Corridor investigated during EIA = 1 km (500m on either side of the centre line)

The design of the 400 kV towers and lines is unknown at present, as the choice is dependent on the conditions at the exact position of the transmission line on this chosen route. A description of the various tower alternatives has been included in **Chapter 4**. The actual number of towers required will vary according to the final route alignment determined.

A working area of approximately 100 m x 100 m is needed for each of the proposed towers to be constructed.

3.5.2 Clearance requirements for transmission power lines

For safety reasons, the transmission power lines require certain minimum clearance distances. These are as follows:

- The minimum vertical clearance distance between the ground and the power lines is 5.5 m.
- The minimum vertical clearance to any fixed structure that does not form part of the power line is 10.4 m - 11 m.

- The minimum distance between a 400 kV power line and an existing road is 60 m – 120 m (depending on the type of road).

Any farming activity can be practiced under the conductors provided that safe working clearances and building restrictions are adhered to.

3.5.3 Proposed associated infrastructure to be constructed / erected

The proposed development will require the following with respect to the permanent infrastructure:

- Where the transmission line crosses a fence between neighbouring landowners and there is no suitable gate in place, Eskom will erect a suitable gate in consultation with the landowner. These gates are necessary in order to ensure access to the line for maintenance and repair purposes. The installation and use of access gates is regulated through Eskom's Gates Guideline TRMAGABE1 (**Appendix C**).
- Existing road infrastructure will be used as far as possible to provide access for construction vehicles during the construction of the line. Thereafter, the roads are used for inspection and maintenance purposes. Where appropriate roads may be upgraded to access transmission lines and substations.
- Substation extension
- Fuel
- Fibre Optic cable could be strung on the earth cable if required for telecommunication

3.5.4 Use of services and resources during construction

- *Water*

Water will be required for potable use and in the construction of the foundations for the towers. The water will be sourced from approved water use points at locations closest to the area of construction.

- *Sewage*

A negligible sewage flow is anticipated for the duration of the construction period. On site treatment will be undertaken through the use of chemical toilets. The toilets will be serviced periodically by the supplier.

- *Roads*

Existing roads will be utilised as far as possible during the construction and operational periods. The use of roads on landowner property is subject to the Environmental Management Plan (EMP) and will be determined based on discussions with landowners during the negotiation process. In the event that areas are not accessible by road, access will be obtained for construction and maintenance activities via the utilisation of helicopters.

A formal access road will be developed through the farms Clydesdale and Vlakfontein as shown in **Figure 3.7**. Two sections of this road are proposed to be paved with a suitable surface (such as bitumen or concrete) in order to reduce erosion due to the steepness of the slopes. This road is proposed not only as an access road for the proposed 400kV line alternative but also required for the existing 132kV line.

A further 5km of access road will be built between the N1 and the new Nzhelele Substation (**Figure 3.8**)

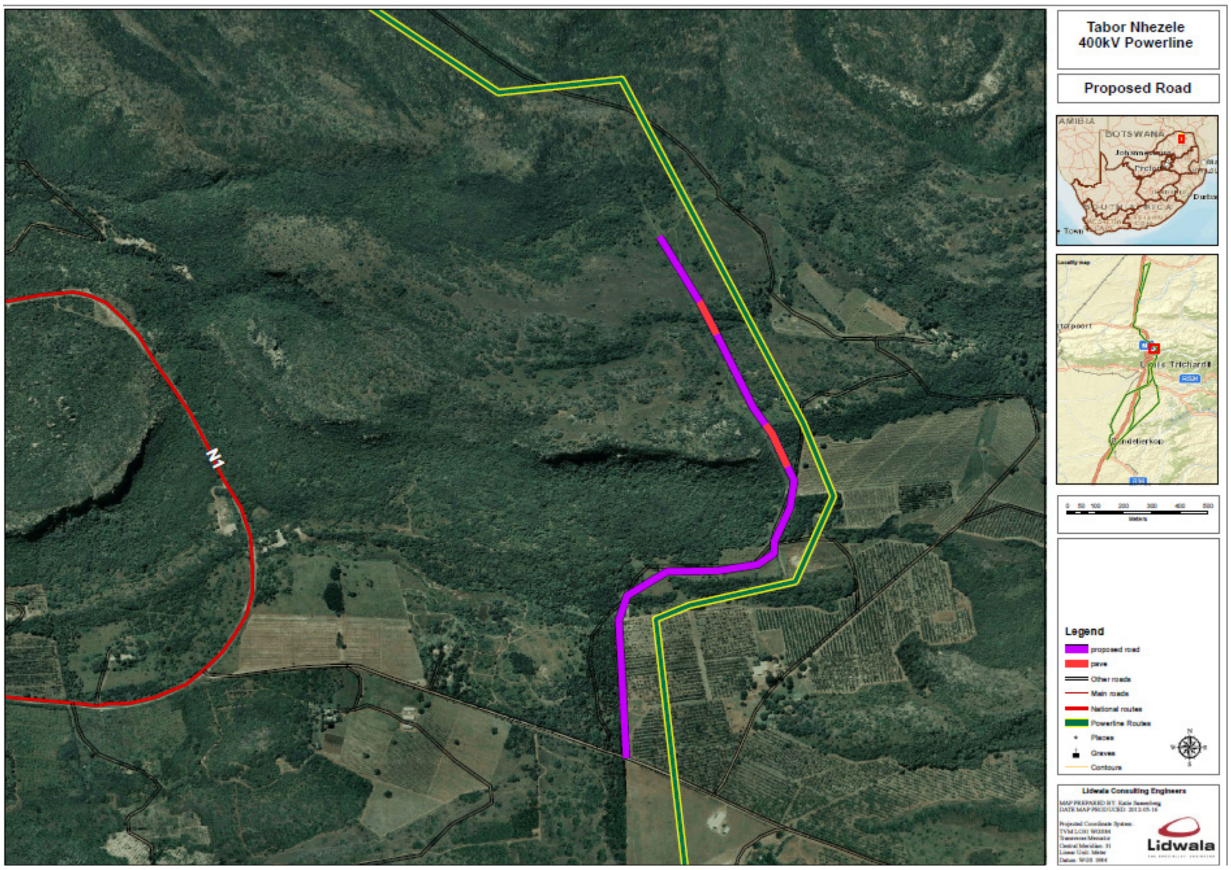

Figure 3.7: Access road proposed through the Farms Clydesdale and Vlakfontein

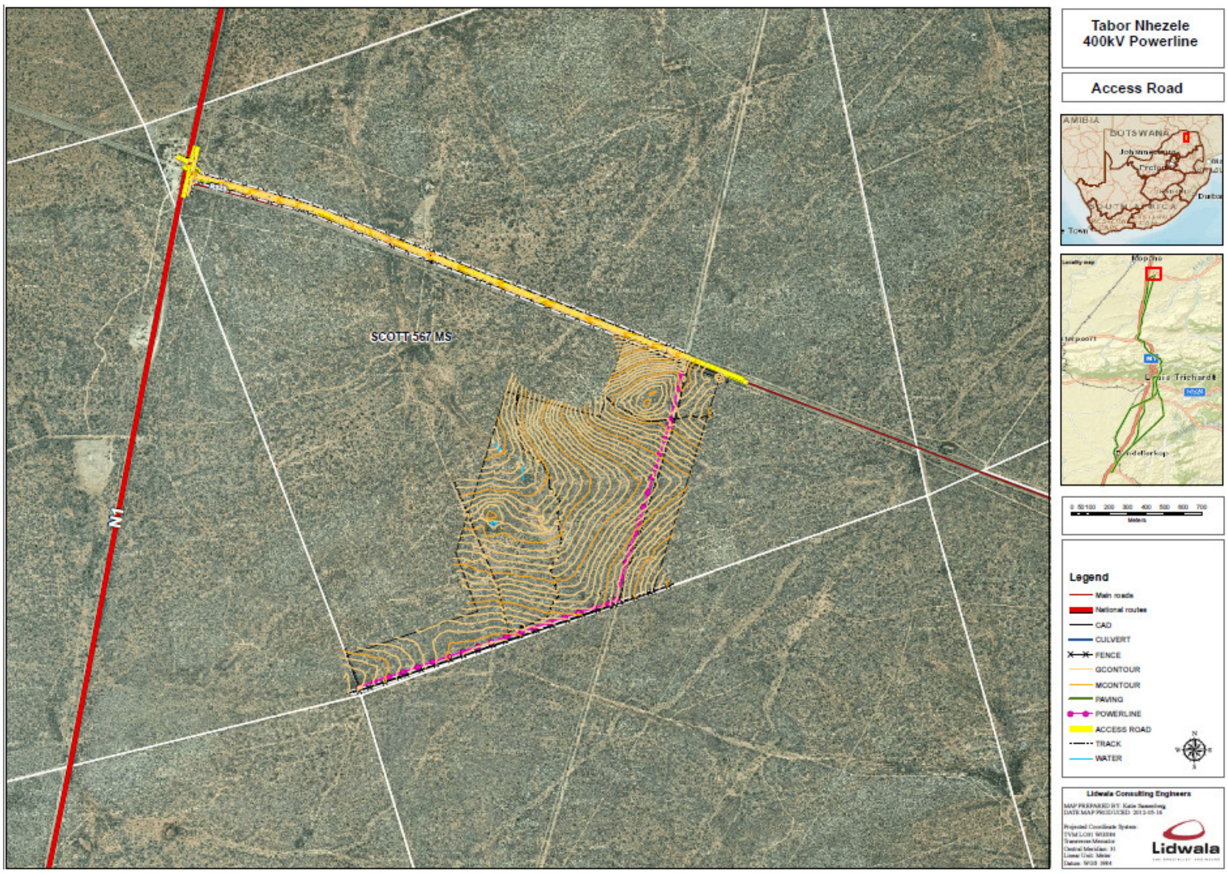

Figure 3.8: Access road proposed between the N1 and the Nzhelele substation

- *Stormwater*

Stormwater will be managed according to the Eskom Guidelines for Erosion Control and Vegetation Management, (see **Appendix D**), as well as the Environmental Management Programme (EMPR) (**Appendix E**) that will be compiled for the construction phase.

- *Solid waste disposal*

All solid waste will be collected at a central location at each construction site and will be stored temporarily until removal to an appropriately permitted landfill site in the vicinity of the construction site.

- *Electricity*

If required, substation sites have electrical connections via the distribution grid. Diesel generators may also be utilised for the provision of electricity during construction.

3.6 The steps in constructing and operating a transmission powerline

The typical steps involved in the construction and operation of a transmission powerline is summarised in **Table 3.2**.

Table 3.2: Typical steps in construction and operation of a transmission power line

Step	Activity
1	Determination of technically feasible alternative corridors
2	EIA of alternative corridors and recommendation on most preferred corridor
3	Authority authorisation of corridor
4	Negotiation of final route alignment within corridor with landowners
5	Aerial survey of the route
6	Selection of best-suited structures and foundations
7	Final design of line and placement of towers
8	Vegetation clearance and gate erection
9	Construction tender advertised and awarded
10	Establishment of construction camp and construction of access roads (if necessary)
11	Construction of foundations
12	Assembly and erection of towers
13	Stringing of conductors
14	Rehabilitation of working areas and protection of erosion susceptible area
15	Testing and commissioning of power line
16	Ongoing maintenance

3.6.1 Planning (Step 1)

The System Planning Department, as the system network planners, formulate a five-year, ten-year or twenty-year Transmission Development Plan (TDP), which is a strategic document aimed at identifying all infrastructure required throughout South Africa for the transmission of electricity. All projects initiated by these planners will have to be in line with the requirements stipulated in the TDP. All initiated projects are thoroughly investigated to ensure that they are both viable and feasible before being approved for implementation. Once approved, the Land and Rights Department initiates the process of the environmental impact assessment (EIA).

3.6.2 Environmental impact assessment and authority authorisation of corridor (Step 2 and 3)

The EIA process forms part of the scope definition stage of a project. The aim of this process is to identify the possible routes where the project can be implemented with the minimal impact on the environment.

The actual location of the towers across which the conductors (powerlines) are spanned is determined by a number of factors, including Eskom negotiation with landowners, environmental features and technical requirements. As a result of these factors, it is impossible to predict the exact position of towers within the EIA process. The inherent variation that is likely in the final placement of the towers is factored into the EIA through the assessment of power line corridors which are approximately five times the width of the final servitude actually required.

A final EIR is produced and provided to the DEA with all the alternative routes assessed during the EIA process. Recommendations for the least impacting route are provided for consideration during authorisation. The DEA will issue an environmental authorisation based on the information provided.

A project-specific Environmental Management Plan (EMP) is drafted for the project and this document details the specific controls which must be in place for the duration of the construction phase. An Environmental Control Officer (ECO) who acts as an intermediary between individual landowners, Eskom and the contractors, implements the EMP.

3.6.3 Negotiation and registration of a servitude (Step 4)

The Tabor-Bokmakirie (Nzhelele) line will require the registration of a 55 m wide servitude (27.5 m either side of the centre-line) for each of the four transmission lines, across all land traversed by the proposed project.

The servitudes do not imply that the holder of the servitude (Eskom) is the owner of the land but merely that the holder has a right to convey electricity over that land, subject to certain provisions. Registration of servitude can be a lengthy process, as it requires contractual negotiation with each affected landowners. Once this is complete, an application for registration of the servitude is lodged with the Registrar of Deeds to register the rights. Once Eskom exercises the option granted by the landowner, construction can commence. Sometimes construction starts before servitudes are registered at the Deeds office. For this reason Eskom pays the landowner a simple interest as determined by the Minister of Finance from the date of option to the date of registration.

3.6.4 Survey and line design (Steps 5 – 7)

Topographical surveys are conducted subsequent to identifying and securing the servitude. This is normally done by means of air-borne laser equipment to develop aerial photos. The topographical profile and plans are then used by the design engineers to design the tower foundations, structures, buildings, etc. All the above information would be required by the contractor before commencing construction.

3.6.5 Construction (Steps 8 – 13)

The final EMP will only be completed when all the profiles and site plans are available. This EMP will outline all activities that have to be undertaken, where they will take place, the responsible person/s, all possible environmental or social impacts, the mitigating measures, the rehabilitation plans, the monitoring methods, the frequency of monitoring and the performance indicators. This is a legally binding document which is used to ensure that Eskom adheres to all conditions of the Environmental Authorisation and EIR. Once this document has been approved by an authorised statutory body, the appointed contractor can commence construction.

Figure 3.9: Vegetation Clearance (Step 8)

Figure 3.10: Gate Erection (access for maintenance phase) (Step 8)

Figure 3.11: Access Roads (Step 10)

Figure 3.12: Construction Camp (Step 10)

Figure 3.13: Construction of tower foundations (Step 11)

Figure 3.14: Assembly and Erection of towers (Step 12)

Figure 3.15: Stringing of conductors (power lines) (Step 13)

3.6.6 Rehabilitation (Step 14)

After the project has been completed, all affected properties are rehabilitated to as close to their original status as possible. Landowners sign off release forms to confirm the rehabilitated status.

3.6.7 Commissioning of the line and on-going maintenance (Steps 15 – 16)

Eskom technicians will test and commission the transmission lines once all the above steps have been completed. Maintenance of the lines and the surrounding servitude will take place on an on-going basis (**Figure 3.16 – 3.17**), as per the finalised operational EMP. Regular monitoring will also take place to ensure that this EMP is complied with effectively, and penalties will be enforced for non-compliance.

Figure 3.16: Maintenance – Erosion Control

Figure 3.17: Maintenance – Fire breaks

3.7 Construction schedule

The Construction of the proposed transmission lines is expected to commence in June 2016 and will take place over 21 months.

The Construction of the proposed substation is expected to commence in November 2016 and will take place over 22 months.

3.8 Conclusion

This chapter provides a description of the proposed development and describes the various components of an electrical transmission system, namely; transmission towers, conductors, substations and transformers. This chapter further discusses the various associated infrastructure and the need for certain services and resources during construction. Finally, the various steps in constructing and operating a transmission power line are discussed and illustrated.