ELECTRICITY MASTER PLAN 2016/17

PRINCE ALBERT MUNICIPALITY

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EXECUTIVE SUMMARY

Makukhane Consulting Engineers CC t/a CVW Electrical was appointed by Prince Albert Municipality to develop a master plan to facilitate the future growth and upgrading needs of the Municipality's 22 kV electricity distribution network.

The main objective of the study was to produce an electrical network master plan for the distribution networks for the Prince Albert Municipality.

Study Tasks and Objectives

The study consisted of a number of tasks of which the following formed the basis of the study:

1. Information Review

During this task as much existing information as possible was gathered and includes mostly network and load related information. The task further entailed the review of all the information.

2. Field Inspection

During this task a field team performed data collection and visual inspections at all substations and electrical reticulation equipment within the study area. Information included all primary and secondary equipment such as power transformers, MV switchgear, auto-reclosers, MV overhead lines, distribution transformers, buried MV cables and pole mounted transformers.

3. Refurbishment Planning

During this task site specific assessments were conducted to provide a systematic across the board estimate of the life expectancy of all distribution equipment. Manufacturing dates obtained during field inspections and dates found in existing asset registers were used to develop a refurbishment plan.

4. Load Forecast

Load forecasting is a crucial input to the network expansion study and during this task a geographical load forecast was developed that was based on regional demographic and historical load growth patterns. The anticipated long-term load forecast was directly used as input to the expansion plan.

5. Strengthening Options and Technical Evaluation

The objective of this task was to identify network strengthening and expansion options and to perform technical evaluations to ensure that load and performance criteria were met.

Network analysis aimed to test compliance with the following minimum requirements:
1. Thermal loading,
2. Voltage standards, and
3. Contingency requirements.

Network studies were performed for distinct system loads, developed from the geographical load forecast.

The time frames and load representation were for:
1. Base year (2016-17),
2. Short-term (2017-2022), and
3. Long-term (2017-2037).

6. Cost estimates and Financial Evaluation

The objective of this task was to provide a cost estimate of the technically viable expansion and strengthening options.

The cost estimates were based on the requirements for:

- Expansion,
- Strengthening, and
- Performance improvement projects.

7. Recommendations for Expansion and Strengthening Requirements

The study has identified and documented expansion and strengthening projects to ensure the adequate performance of the network within the short-term and longer-term periods. These projects are documented in Section 5, as well as in Volume B. It is recommended that these projects be implemented in the phased manner as indicated.

8. Capital Program

The capital program was developed by using standard equipment cost, contained in an equipment library. The output from the various evaluation systems was used to set up three capital program scenarios, namely

- Distribution network development and optimization
- Refurbishment requirements.

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List of Abbreviations / Acronyms

a.c.	Alternating current
ACSR	Aluminium Conductor Steel Reinforced – Eskom standard conductor type used for overhead medium voltage lines. Code names are assigned to establish cross-sectional area of the conductor. Among most common used code names are: a. Hare cross-sectional area - 122.48mm² b. Mink cross-sectional area - 73.65mm² c. Fox cross-sectional area - 42.80mm²
d.c.	Direct current
IEC	International Electro-technical Commission
NMD	Notified Maximum Demand – demand limit set by Eskom for a customer – measured in kVA
MEC	Maximum Export Capacity
kV	kilo-Volt – standard unit in which large quantities of electromotive force or potential difference is expressed. ($1x10^3$)
kVA	kilo-Volt-Ampere – Unit in which apparent power is measured. ($1x10^3$)
kW	kilo-Watt - Unit in which real power is measured. ($1x10^3$)
kW/h	kilo-Watt per hour – Unit in which electricity is sold. ($1x10^3$)
LV	Low Voltage – Circuits up to and including 1000V a.c. or 1500V d.c. (SANS 10142-1)
MV	Medium Voltage – Circuits from 1000V but not exceeding 33000V (IEC 60038)
MVA	Mega-Volt-Ampere – Unit in which large quantity of apparent power is measured. ($1x10^6$)
NRS	National Rationalised Specifications
OHS Act	Occupational Health and Safety Act
POD	Point of delivery – point to which electrical energy is delivered
POS	Point of supply – point from which electrical energy is supplied to an installation
SABS	South African Bureau of Standards
SANS	South African National Standards
SLA	Service Level Agreement
SDP	Spatial Development Plan
SS	Sub Station
SSEG	Small Scale Embedded Generation/Generators

1 PROJECT BACKGROUND

This report covers the short (5 yrs.) and long Term (20 yrs.), Master Plan for Prince Albert CBD and its township areas. The report provides insight with regards to what needs to be implemented to complete refurbishment within the first 5 years of the Master Plan and gives excerpts of detailed schedules prepared, covering the works to be undertaken.

The report does not cover details or give cost estimates of the long term upgrading required. With the facts at hand, not much will need to be done for the long term planning and accordingly, expenditure will be minimal compared to the refurbishment proposals.

A detailed load flow and fault level report designed in **Dig-SILENT** is attached to the back of this report. This load flow report will in future allow the Municipality to make informed decisions about future developments such as adding or up-grading to the existing MV network.

Central Karoo – Municipalities:

Prince Albert Municipality is situated within the Central Karoo District Municipality.

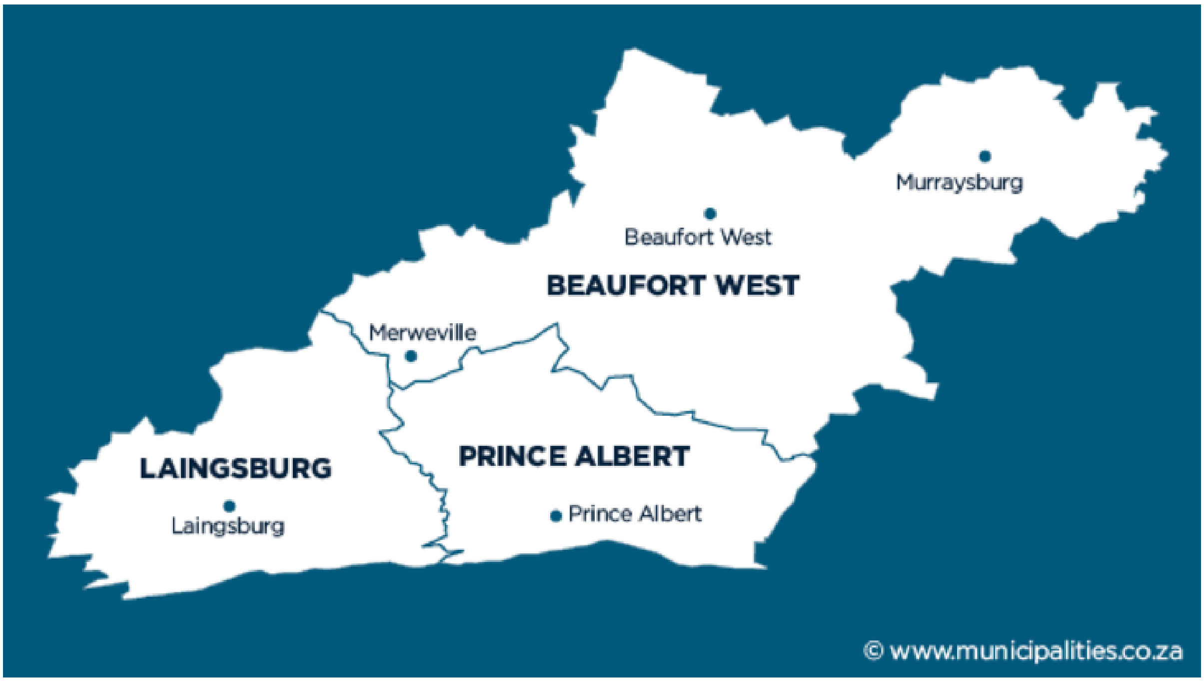


Figure 1-1: Central Karoo

Prince Albert Municipality:

Prince Albert is situated 400 km north of Cape Town and 170 km South West of Beaufort West. The land borders Beaufort West Local Municipality to the north and North West. Laingsburg is to the South West and the Eden District to the south. Prince Albert Municipal area covers a total area of 8,800km², a vast part of this being in the rural areas where vast hectares are under agricultural production, mainly fruit and sheep farming. District roads radiate out of Prince Albert connecting it to its satellite towns of Prince Albert Road on the N1 (45 km to the North West), Klaarstroom on the R329 (55 km to the east) and Leeu – Gamka on the N1 (85 km to the North). In recent years Prince Albert has seen the biggest economic growth in the region due to the demand in high-income property being bought by especially foreign investors. It is known as a little town with Victorian and Karoo style architecture, art & décor shops, side walk coffee shops, the breathtakingly beautiful Swartberg valley, Meiringspoort and the annual olive festival which attracts hundreds of tourists each year.

Prince Albert Municipality area map:

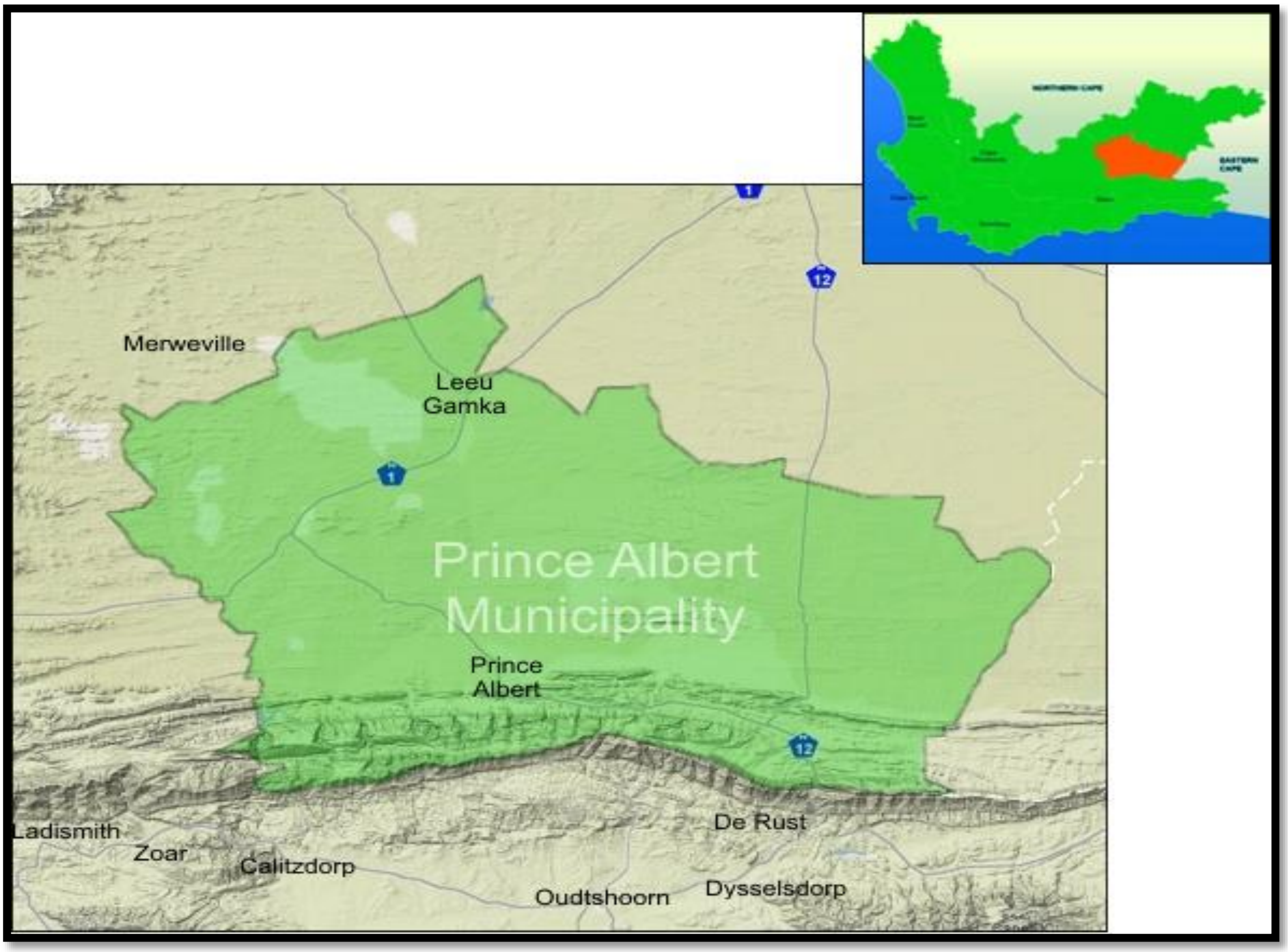


Figure1-2: Study Area

1.1 Document Structure

This report consists of two Volumes (A & B).

1.1.1 Volume A consists of the technical report providing fundamental methodology, data, analysis aspects, results and recommendations as shown hereunder.

Section 2 – Provides background with regard to the Methodology and Data that was used during the study,

Section 3 – Provides the Load Forecast, Methodology and Results,

Section 4 – Discusses the approach that was followed to develop the Distribution Network Model,

Section 5 – Provides the analysis framework for the Distribution Network Assessment. Aspects such as network performance under various loading scenarios and results and recommendations to proposed network strengthening strategies are dealt with,

Section 6 – Provides the Capital Program and Financial Evaluation for the preferred projects, and

Section 7 – Provides Conclusions and Recommendations to the study.

1.1.2 Volume B provides a set of Single diagrams, ArcGIS maps and Dig-Silent Load Flow studies that systematically show the progressive Network Development Plan for the Prince Albert Municipal Area.

2 METHODOLOGY AND DATA

2.1 Methodology

The long-term expansion and strengthening plan followed the basic process as outlined in Figure 2-1. The Sections below provide a high-level description of the objective for each task displayed in the process.

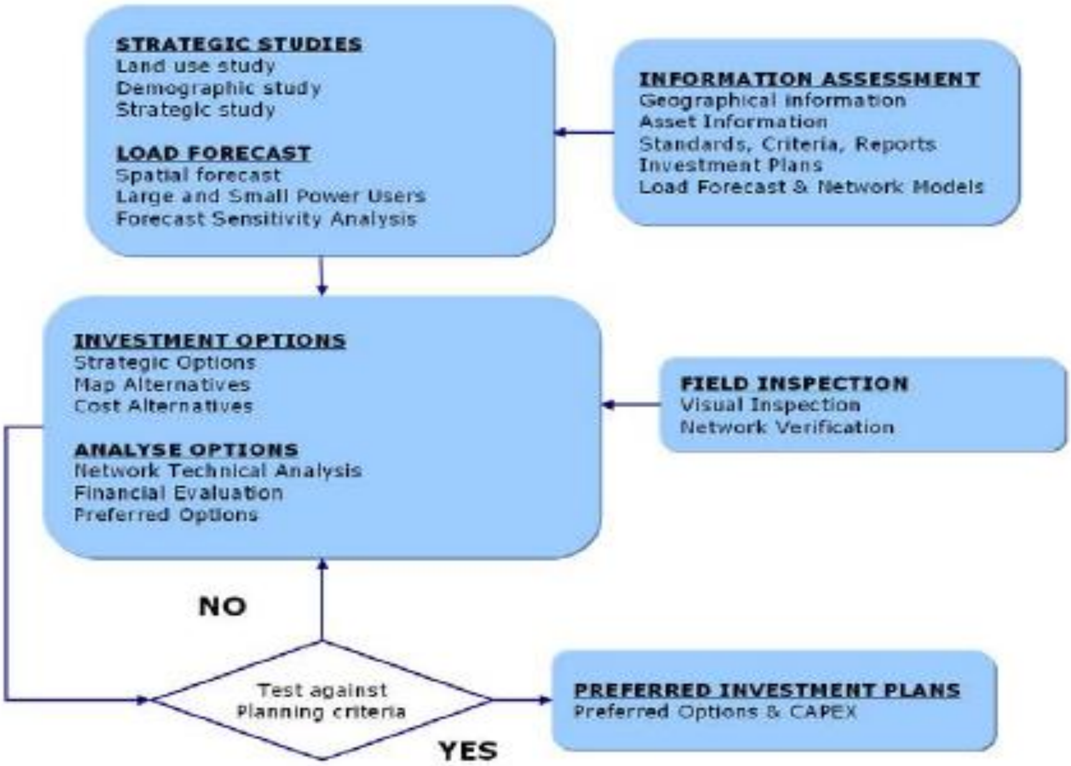


Figure 2-1: Network Expansion and Strengthening Planning Process

2.1.1 Information Review

During this task as much existing information as possible is obtained. Information includes mostly network and load related information. This task further entails the review of all obtained information.

2.1.2 Load Forecast

The load forecast is a crucial input to the network strengthening study. During this task a load forecast is developed that is based on regional demographic and historical load growth patterns. The anticipated long-term load forecast is directly used as input to the long-term expansion plan.

2.1.3 Strengthening Options and Technical Evaluation

The objective of this task was to identify network strengthening and expansion options and to perform technical evaluations to ensure that load and performance criteria were met.

Network analysis aimed to test compliance with the following minimum requirements:
1. Thermal loading,
2. Voltage standards, and
3. Contingency requirements.

2.1.4 Cost Estimates

The objective of this task is to provide a cost estimate of the technically viable options. The cost estimates are based on the requirements for:

- Expansion,
- Strengthening, and
- Performance improvement projects.

2.2 Data

2.2.1 Documentation

The following information was received for review purposes:

- Previous planning reports
- Historical billing for key customers
- Historical Eskom supply information
- Development initiatives as discussed with municipal personnel
- Spatial development Framework Spatial Development Plan (SDP)
- Land-use information obtained from GIS Global Image and discussions with regard to new developments and industrial projects were conducted with the MM.
- Existing network single line diagrams: MV / LV networks.

2.2.2 Other Information

The following is a list of information that was sourced by CVW Electrical or obtained from other organizations that was used to develop portions of the geographical load forecast:

- Ortho photos (Obtained from the Department of Land Affairs),
- Cadastral information, and
- Basic topological information.

2.3 Software

2.3.1 Mapping

All mapping and geographical presentation of information and data was done by using ArcMap-ArcGis and Auto-cad Ver10.0 software.

2.3.2 Network Modeling

The Dig-Silent Power Factory Ver 15.1 system modeling program and Retic Master Ver 11.4 was used to develop the Base Case network model.

2.3.3 Network Analysis

Model No. 1 – All transformers and mini-sub stations were set to 50 % loading on the 11000/400-volt bus bar.
Model No. 2– All transformers and mini-sub stations were set to 80 % loading on the 11000/400-volt bus bar.

3 LOAD FORECAST

3.1 Special Development Plan (SDP)

3.1.1 Background

A comprehensive Demand and Energy forecast was required to establish:

- The basis for the distribution system expansion plan, and
- A basis for the future forecast purchases, and sales of energy, and Maximum Demand

Low-income housing provision is a core mandate of all levels of South African government. High land prices, a shortage of available land and the reluctance of wealthier communities to accept low-income housing developments in their neighbourhoods have resulted in the development of low-cost housing on cheap land far from areas of existing economic activity. The prioritisation of building houses rather than functioning towns has resulted in the creation of many neighbourhoods with poor access to community services.

The overriding aim of the spatial development plan (SDP) is to create urban and rural settlements that generate meaningful shelter and livelihood opportunities for all residents. Their purpose is to create opportunities for quality housing and varying housing options, in appropriate locations adequately provided with the full range of community facilities and services. It should aim to increase the value of property as an asset, in particular those owned by poor communities. It places particular emphasis on locating poor communities close to economic activity, employment opportunities, education opportunities, and other public services and facilities. Areas prone to flooding, landslides and contamination should be avoided and pleasant settlement environments should be created with adequate landscaping, and recreational opportunities. Housing delivery should occur within a framework of meaningful participation and through a prioritised and accelerated planning and delivery process.

The future population will impact on the available Notified Maximum Demand (NMD) from Eskom for Prince Albert. Suitable land will have to be identified for future residential housing developments. The household growth up until 2030 indicates an increase of 2.2% per annum, an average of 3.6 people per household and that all future residential developments will be provided at a density of 25 dwelling units per hectare. This SDP shows an increase ± 2 652 houses over the next 14 years within the Prince Albert Municipal area of supply. The amount of new houses can be converted to NMD. The additional supply demand that will be required from Eskom equates to 6630 kVA at an ADMD of 2.5kVA. The additional demand can then be divided between the major towns within the Municipality. See below the different towns with their future housing developments as planned by the SDP.

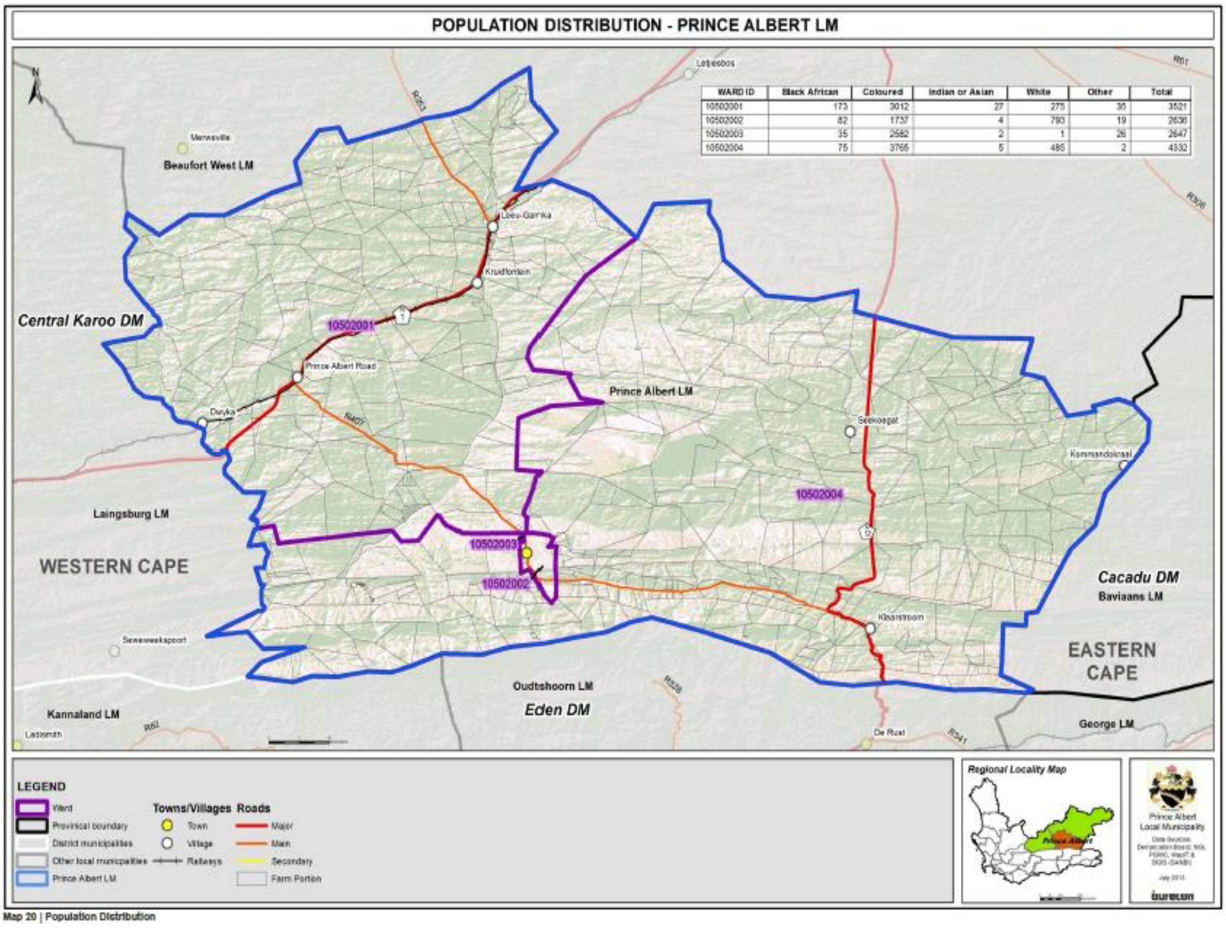


Figure 3-1: Population Map

Population Projections:

Settlement	Population (2001)	Population (2011)	Projected Population 2015	Projected Population 2020	Projected Population 2025	Projected Population 2030
Prince Albert	5646	7055	7713	8622	9638	10774
Bitterwater	1698	2122	2320	2594	2900	3242
Leeu Gamka	483	604	660	738	825	922
Klaarstroom	467	584	638	713	797	891
Prince Albert Non-Urban (NU)	2218	2772	3030	3387	3786	4232
Total	**10512**	**13137**	**14361**	**16054**	**17946**	**20061**

Table 3-1: Population projections

3.2 Methodology

The load forecast is derived from the percentage annual household growth increase derived from the SDF

The load forecast will be based on:

- Futuristic economic information,
- Demographic data,
- Available land use, and
- Future Development.

3.2.1 Strategic Inputs

A development perspective was obtained from the Spatial Development Framework Plan.

3.2.2 Geographical future Load Zoning

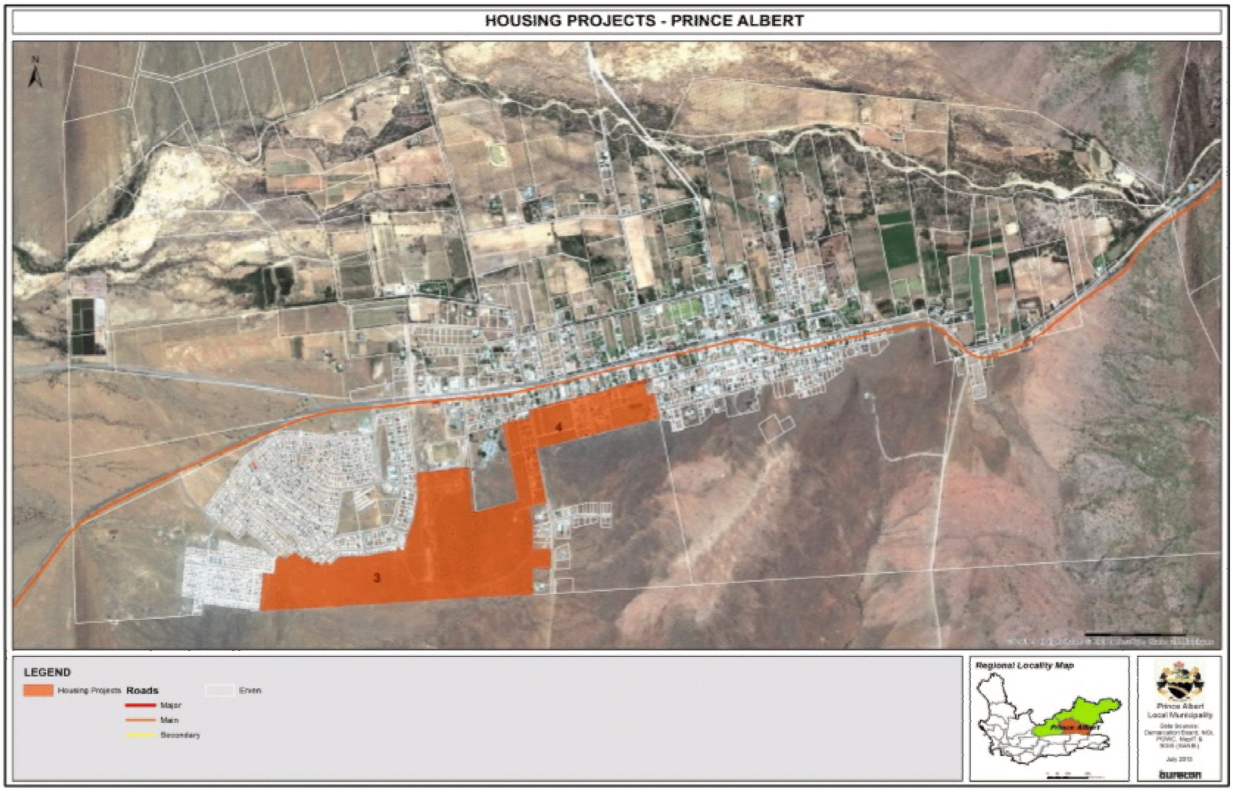


Figure 3-2: Prince Albert – Future housing area’s

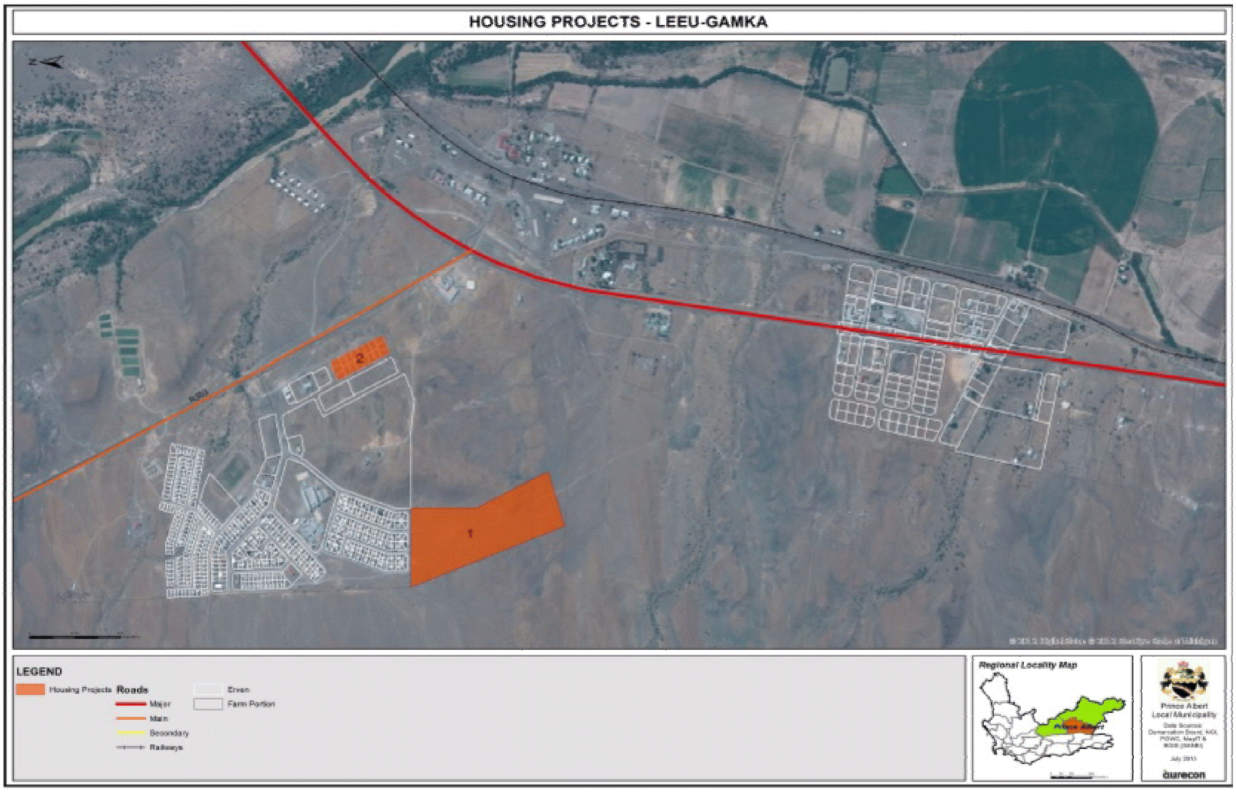


Figure 3-3: Leeu-Gamka – Future housing area's

Map 47 | Locality of Future Housing Projects – Prince Albert Raod

Figure 3-4: Prince Albert Road – Future housing area's

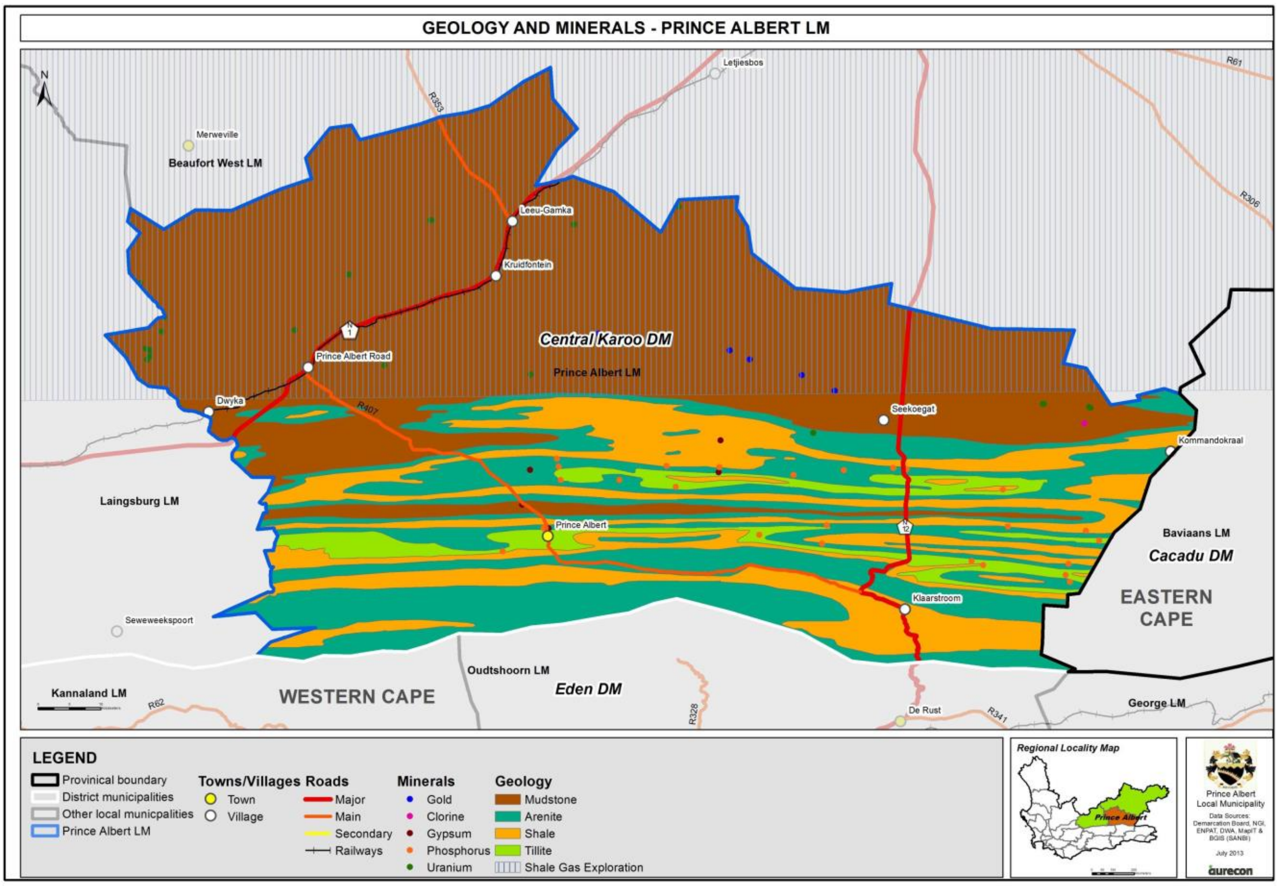


Figure 3-5: Prince Albert LM – Geology and Minerals

3.3 Geographical Load Forecasting

The future population will impact on the available Notified Maximum Demand (NMD) from Eskom for Prince Albert.

3.3.1 Set-up Load Forecast Database

All load zones were entered into Dig-Silent and linked to ArcGIS. This enables reporting on maps, providing a visual perception of growth areas. The measured load profiles were derived from Eskom billing information.

3.3.2 Short- and Long-term Forecasting

Prince Albert: Actual kVA Demand 2009-2016

The Eskom Notified Maximum demand indicated by the green line below shows that the municipality has exceeded the value of 2.5 MVA, which suggests that the municipality should immediately apply for an increase of ± 1 MVA.

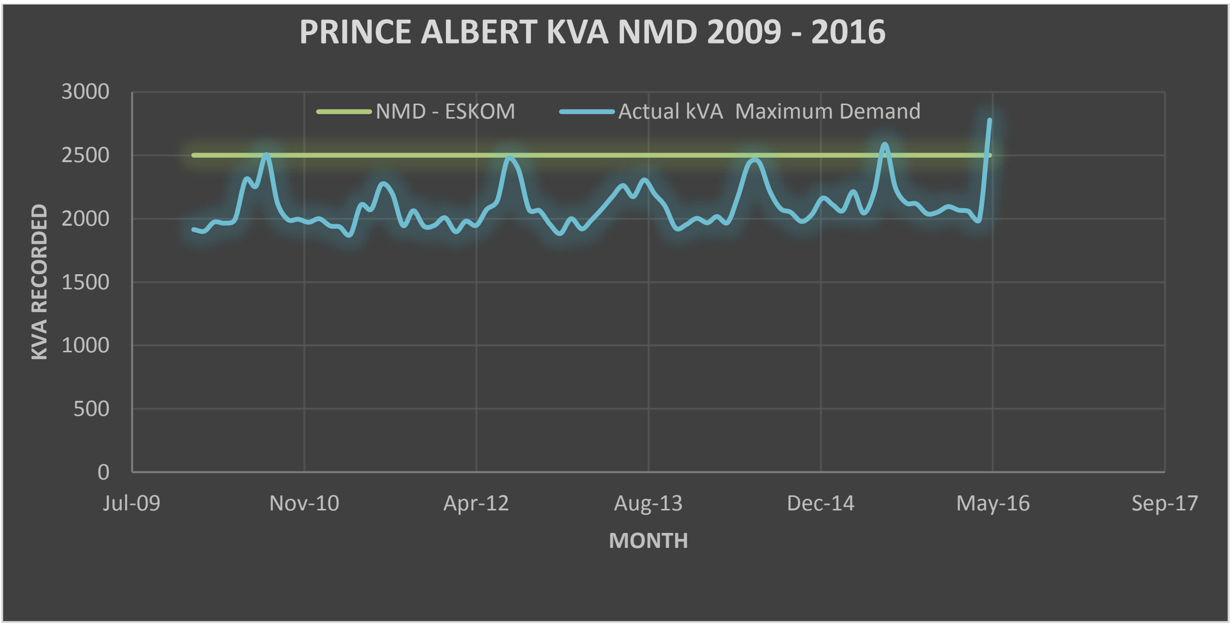


Figure 3-6: Prince Albert LM – Eskom NMD 2009-2016

Prince Albert: Actual kVA Demand 2009-2030

The Eskom Notified Maximum demand indicated by the purple line below shows the NMD should be increased to 3.5 MVA to accommodate the growth over the next 20 years.

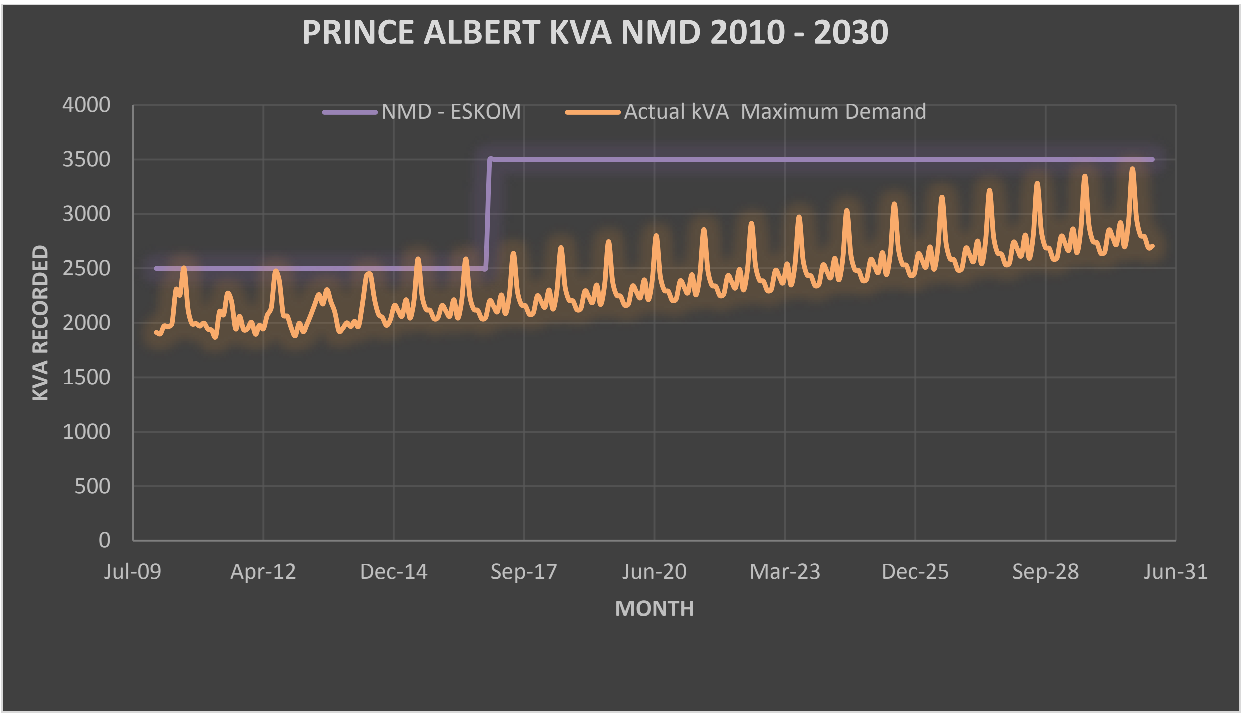


Figure 3-7: Prince Albert LM – Eskom NMD 2009-2030

3.4 Base Load Verification

INTRODUCTION AND BACKGROUND

Note: The integrating period is normally 30 minutes and the designated billing period refers to all time periods. Monthly utilised capacity is the higher of the customer's **notified maximum demand** (NMD) or **maximum demand**, measured in kVA or kW, registered during the billing month.

• Exceeding the NMD by more than the 5% dead band is charged for in the month of exceedance and for 11 other months.

• In the event that Eskom customers exceed the NMD by more than the 5% dead band for more than 2 consecutive months in the subsequent months it is charged for every exceedance within the rolling 12 months. The charge is calculated as follows: the capacity exceeded (kVA) multiplied by the rate (R/kVA) multiplied by the number of events. The excess charge is therefore as though the customers accumulates excess capacity whereas in fact the customer may be guilty for exceeding the same capacity (kVA) every month. NMD excess charges (penalties) therefore hugely increase the municipalities debt owed to Eskom.

• While customers that exceed their NMD are allowed to increase the NMD they can only do so as it is subjected to renegotiation of the power supply agreement. The renegotiation of the agreement is however subjected to a connection charge for additional dedicated cost and sharing in additional upstream cost.

• Application of the NMD rules is rigid and municipalities are finding it difficult to change their NMD. For example; a municipality may be aware it is underutilising or exceeding the NMD and requests to convert to appropriate NMD are onerous but the account of the municipality must be up to date etc. Publication of Eskom's NMD and MEC rules application Page 2 of 3 refers

• In terms of the existing NMD rules customers will not be charged for exceedance of NMD that is within the 5% dead band, however according to clause 2.2.2 (b) they (customers) will be charged a penalty for three or more events within the dead band.

• In terms of the existing NMD rules customers are not charged for the first two incidences of exceedance of NMD by more than 5% (dead band), however according to clause 2.2.2 (c) they (customers) will be charged a penalty for the first and all subsequent incidents outside the dead band.

3.4.1 Eskom 2015/16 Account: Prince Albert Substation

Prince Albert Municipality currently operates on a NMD of 2.5 MVA. This notified demand needs to be increased by ± 1 MVA.

Point of Delivery ID	Point of Delivery Description	Notified Maximum Demand
6772979804	MUNICIPALITY FILE 1/3234 INTERVAL	2500

2015 Eskom account summary

Year		Month	Total Monthly Rental	Consumption	Charged Demand	Actual kVA Maximum Demand	Actual kW Maximum Demand	Revenue	Cents Per Unit
2015	01	JANUARY	7192.57	964233		2161.19	2019.94	583946.95	60.56077214
	02	FEBRUARY	7192.57	931641		2107.35	1975.8	580280.49	62.28584723
	03	MARCH	7192.57	843213		2062.41	1937.96	538653.93	63.88112256
	04	APRIL	7192.57	881285		2213.6	2126.14	553342.54	62.78814912
	05	MAY	7192.57	846725		2044.1	1964.5	540360.64	63.81772594
	06	JUNE	7192.57	928157		2215.16	2158.76	785640.19	84.64518287
	07	JULY	7192.57	965914		2588.00	2532.64	1061872.96	109.9345242
	08	AUGUST	7297.84	1008236		2246.34	2197.8	1163800.43	115.4293667
	09	SEPTEMBER	7297.84	871517		2124.42	2044.6	835336.9	95.84860651
	10	OCTOBER	7297.84	815799		2116.71	2040.56	601058.65	73.67729674
	11	NOVEMBER	7297.84	865414		2038.52	1947.6	626334.89	72.37401868
	12	DECEMBER	7402.41	880537		2050.39	1910.6	643459.3	73.07578216
2015				**10 802 671**				**8514087.87**	

Figure 3-8: Prince Albert LM – Eskom 2015 Account summary

2016 Eskom account summary

Year		Month	Total Monthly Rental	Consumption	Charged Demand	Actual kVA Maximum Demand	Actual kW Maximum Demand	Revenue	Cents Per Unit
2016	01	JANUARY	7402.41	969208		2094.65	1906.3	676825.86	69.83288004
	02	FEBRUARY	7611.57	952516		2066.98	1930	674180.66	70.77893285
	03	MARCH	7611.57	862386		2057.24	1918.46	628840.22	72.91864896
	04	APRIL	7716.14	858091		1994.1	1921.56	615832.75	71.76776706
	05	MAY	7716.14	816332		2778.97	2698.5	600433.45	73.55260482
	06	JUNE	7716.14	866017		2096.2	2051.9	850814.65	98.24456679
	07	JULY	7716.14	951500		2351.55	2305.94	1154679.98	121.35365
	08	AUGUST	7716.14	943228		2184.01	2132.9	1149775.95	121.8979875
	09	SEPTEMBER	7716.14	848012		1956.65	1898.8	914828.04	107.8791385
	10	OCTOBER	7716.14	822608		2029.84	1960.1	659611.9	80.18544677
2016				**8 889 898**				**7925823.46**	

Figure 3-9: Prince Albert LM – Eskom 2016 Account summary

3.4.2 Confirm Growth

After the first calculation has been done the growth of each load zone is monitored to ensure that no irregular growth takes place. In the event of a load zone that has no land use change, the growth pattern is expected to be normal load growth of say an annual rate of 2.2%. Land use changes that do occur will also be limited to similar land use density in that same supply area (although some exceptions can occur). These are all checked and densities modified until all growth rates are within expectations.

***Abnormal growth scenario: Fracking*.**

Fracking in the Karoo has been the subject of heated debate but few people know that Prince Albert is also a potential site for fracking. While providing access to much-needed energy and economic resources, fracking will also change the pristine natural environment and have an impact that will be felt generations down the line.

The economic benefits of fracking are claimed to be potentially immense. In a controversial study commissioned and paid for by Shell, one of the applicants to explore for shale gas in South Africa, developing one tenth of the estimated Karoo for fracking could generate 200 billion rand per year and create 700,000 jobs. Prince Albert LM could benefit from Fracking should it become a reality and this will influence the long term load forecast.

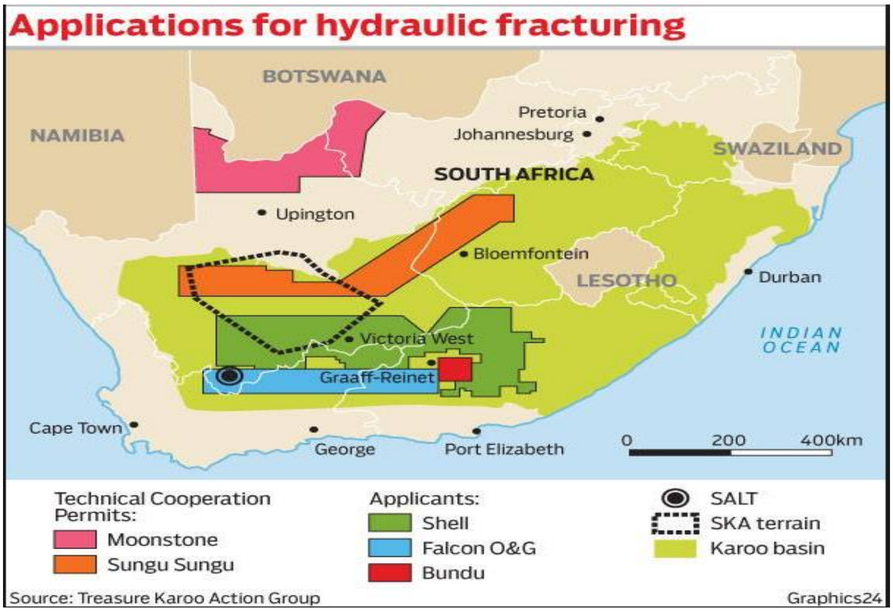


Figure 3-10: Prince Albert LM – Hydraulic Fracturing map

3.4.3 Verify Total Load

The diversified summated forecast to the top level, namely infeed supply areas must also be acceptable. Historically measured loads are always a good reference to determine whether the forecast is valid.

3.5 Results

Data from the Eskom billing spreadsheet were used to calculate the historical growth. The 2024 load values are the calculated forecast value due to the land use change forecast. The calculated value corresponds to an average yearly growth of 2.2% from year 2003 to 2023 for Prince Albert Municipal supply. Graphs showing the yearly demand growth are shown above, note that demand values are given in kW and MW.

4 DISTRIBUTION NETWORK MODEL

4.1 Overview

Prince Albert Municipality Distribution network was modelled using Dig-Silent 15.1 application. Dig-Silent is a windows based application designed and developed to store and manipulate electrical network information. The primary objective of Dig-Silent is to store electrical network data in its simplest form (equipment nameplate data) and use this data to generate power system analysis files for various analysis software applications. The focus is on system load flow and fault studies.

Figure 4-1 illustrates how the AutoCAD: Single line network fits together.
Figure 4-2 illustrates how the AutoCAD: Single line network fits together on cadastral.

Figure 4-3 illustrates how the Dig-Silent system fits together.

Network loads for up to 20 years can be read into the database from the Geographical Load Forecast application.

ELECTRICAL SYMBOL LEGEND

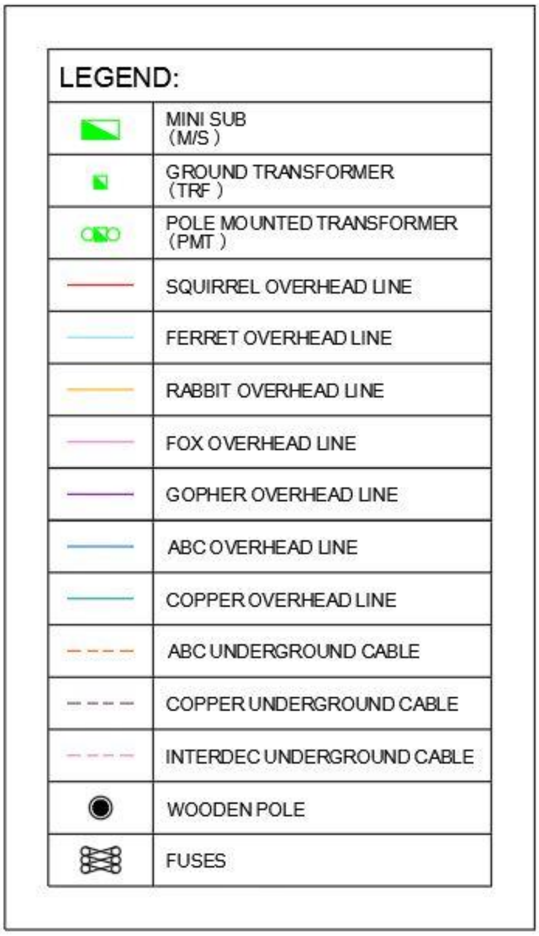


Figure 4-1: AutoCAD: Single line diagram - Exsiting electrical network.

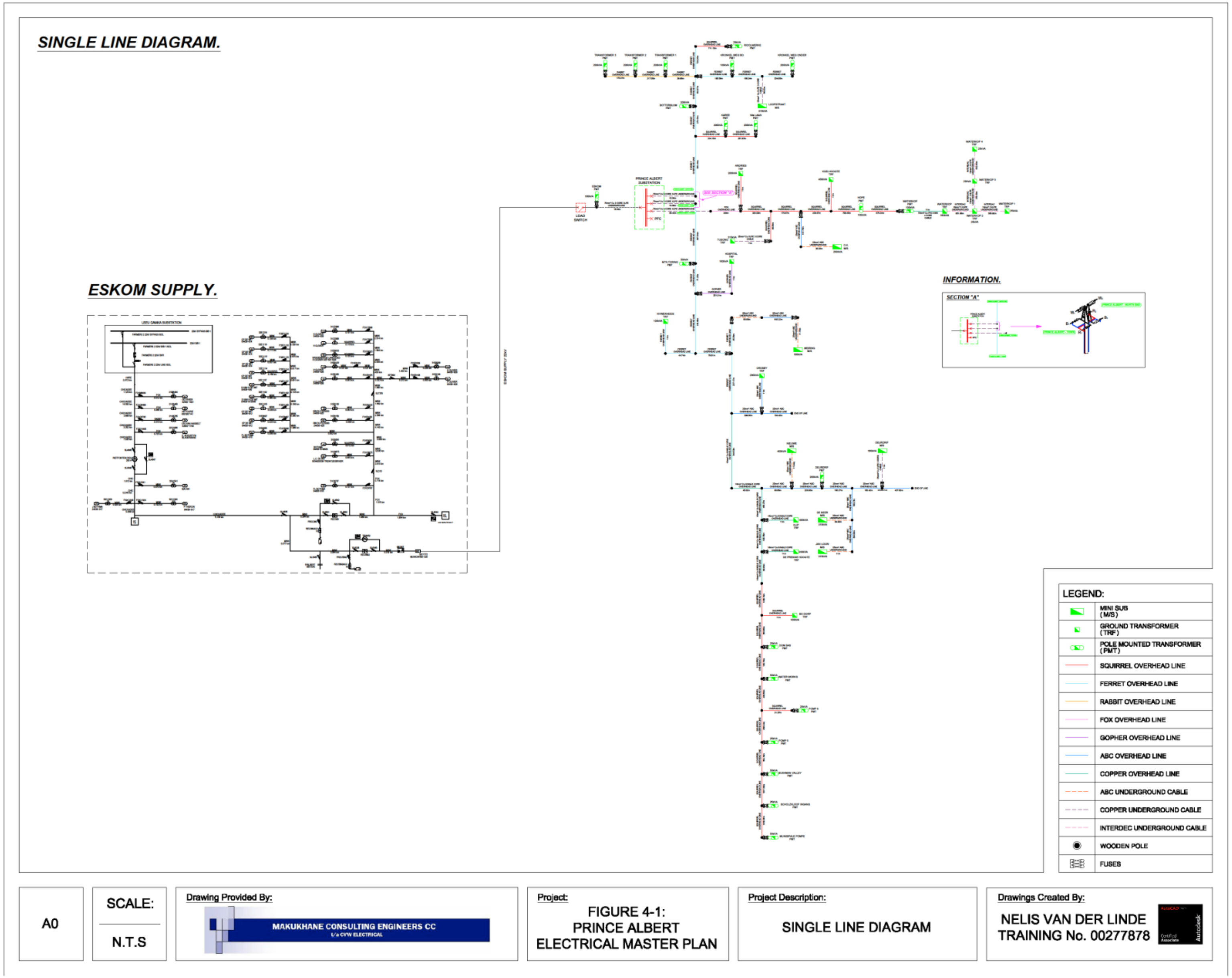


Figure 4-2: AutoCAD: Single line network - Cadastral.

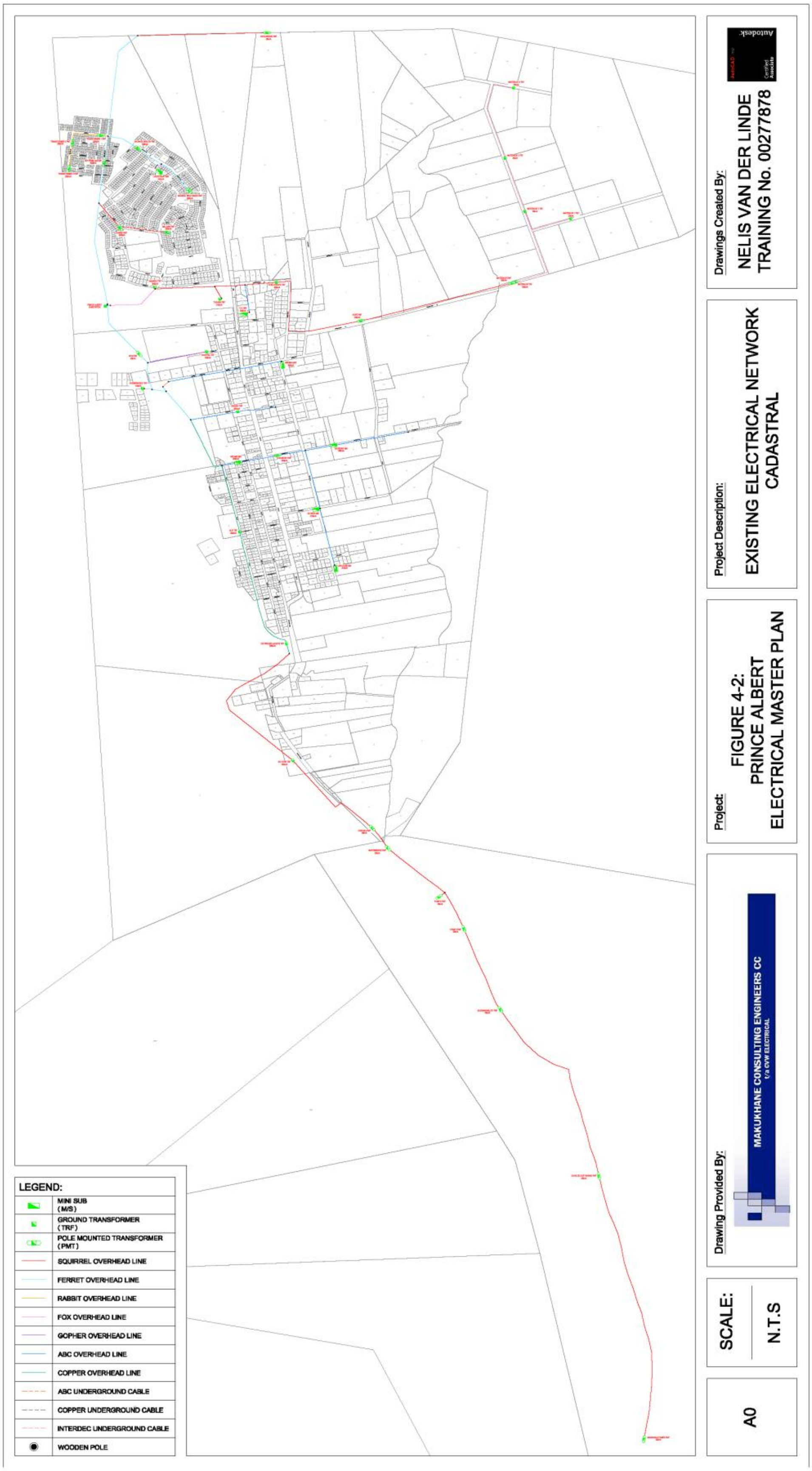
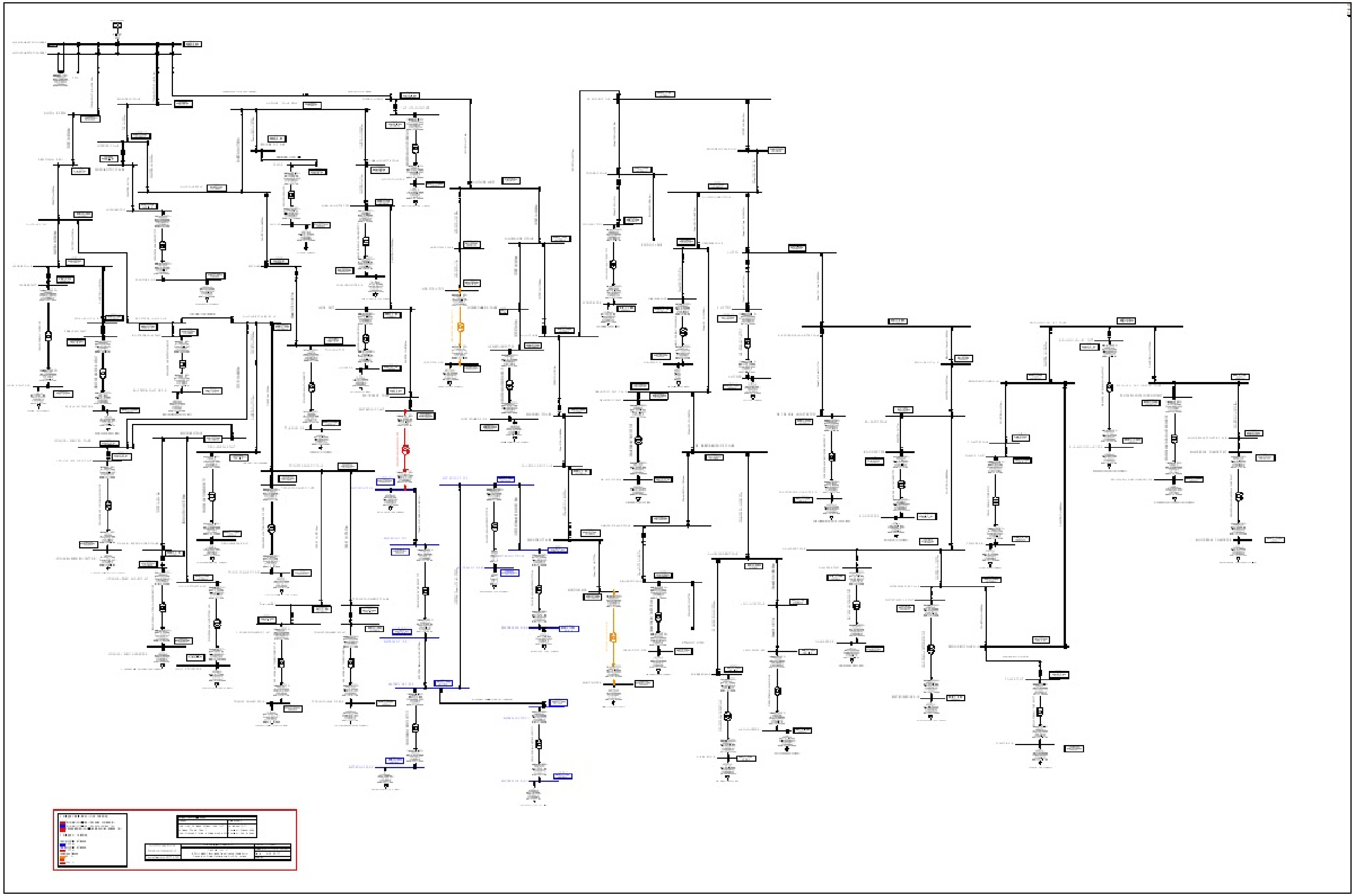


Figure 4-3: Dig-Silent Application Model



4.2 Distribution Model

The Prince Albert Municipality's network is defined as 11kV Overhead and Underground Distribution network. The Dig-silent model for the Distribution network included display the construction of models for:

- Distribution stations,
- Distribution lines, and
- Associated loads.

The following sections present aspects of the technical evaluation which include network analysis as well as operational considerations and results for Prince Albert Municipality.

Two network scenarios were developed, in line with the load growth scenarios, to review the expected performance of the Prince Albert Municipality network. These scenarios accounted for:

1. Most Likely growth (50 % loading), and
2. High growth (80% loading).

Network simulations were conducted on the existing and future 22kV networks for the above scenarios. Network simulations included:

1. System Intact analysis. Analyses were conducted on future network load level and configurations to identify thermal and voltage violations.

Figure 4-4: illustrates most likely growth (50 % loading).

Figure 4-5: illustrates High growth (80% loading).

Also a 3-phase short circuit analysis was done on the network to determine fault levels.

Figure 4-6: illustrates a 3-phase short circuit analysis at 50 % loading.

Figure 4-7: illustrates a 3-phase short circuit analysis at 80 % loading.

Figure 4-4: Dig-Silent Most Likely growth (50 % loading)

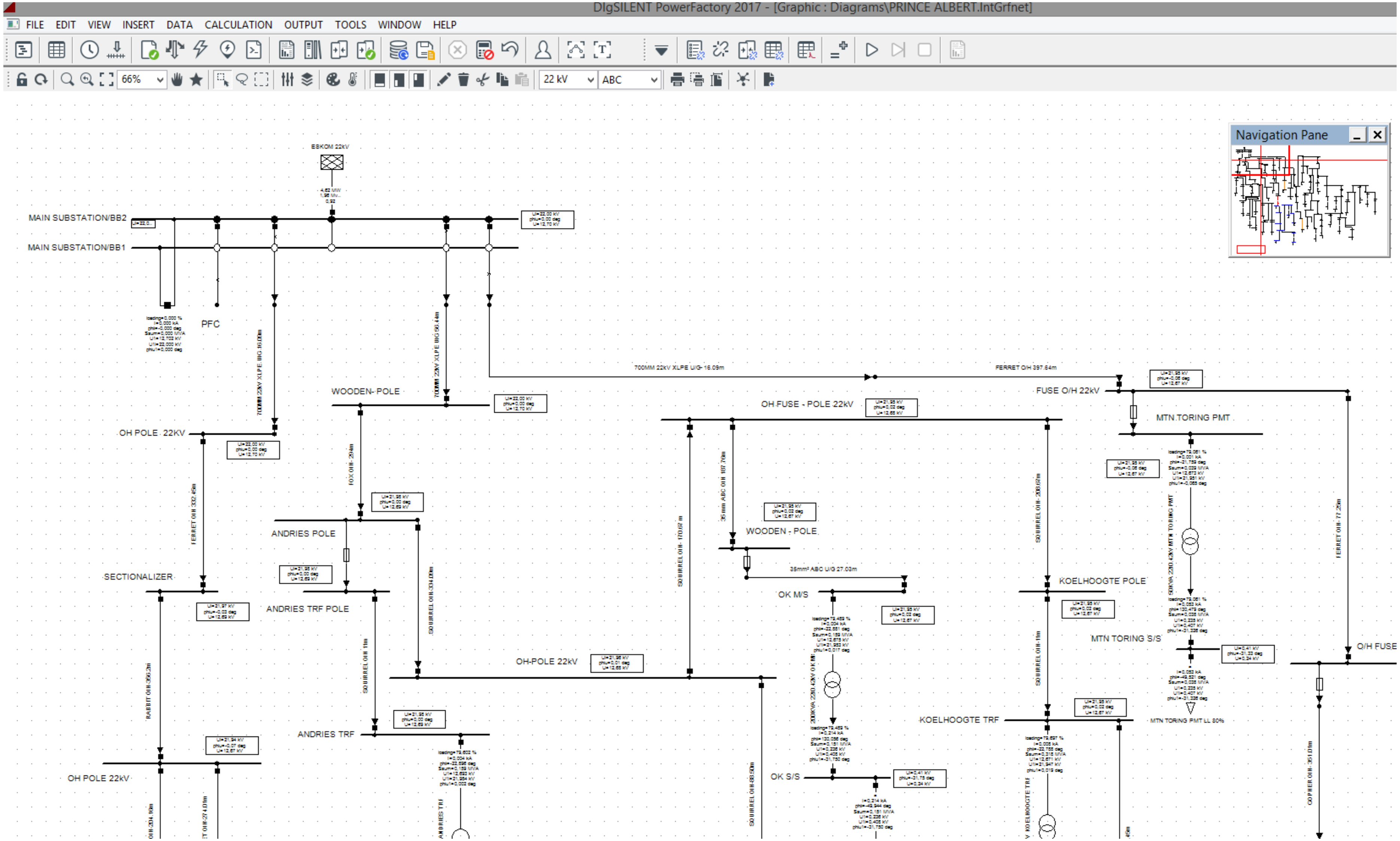


Figure 4-5: Dig-Silent High growth (80 % loading)

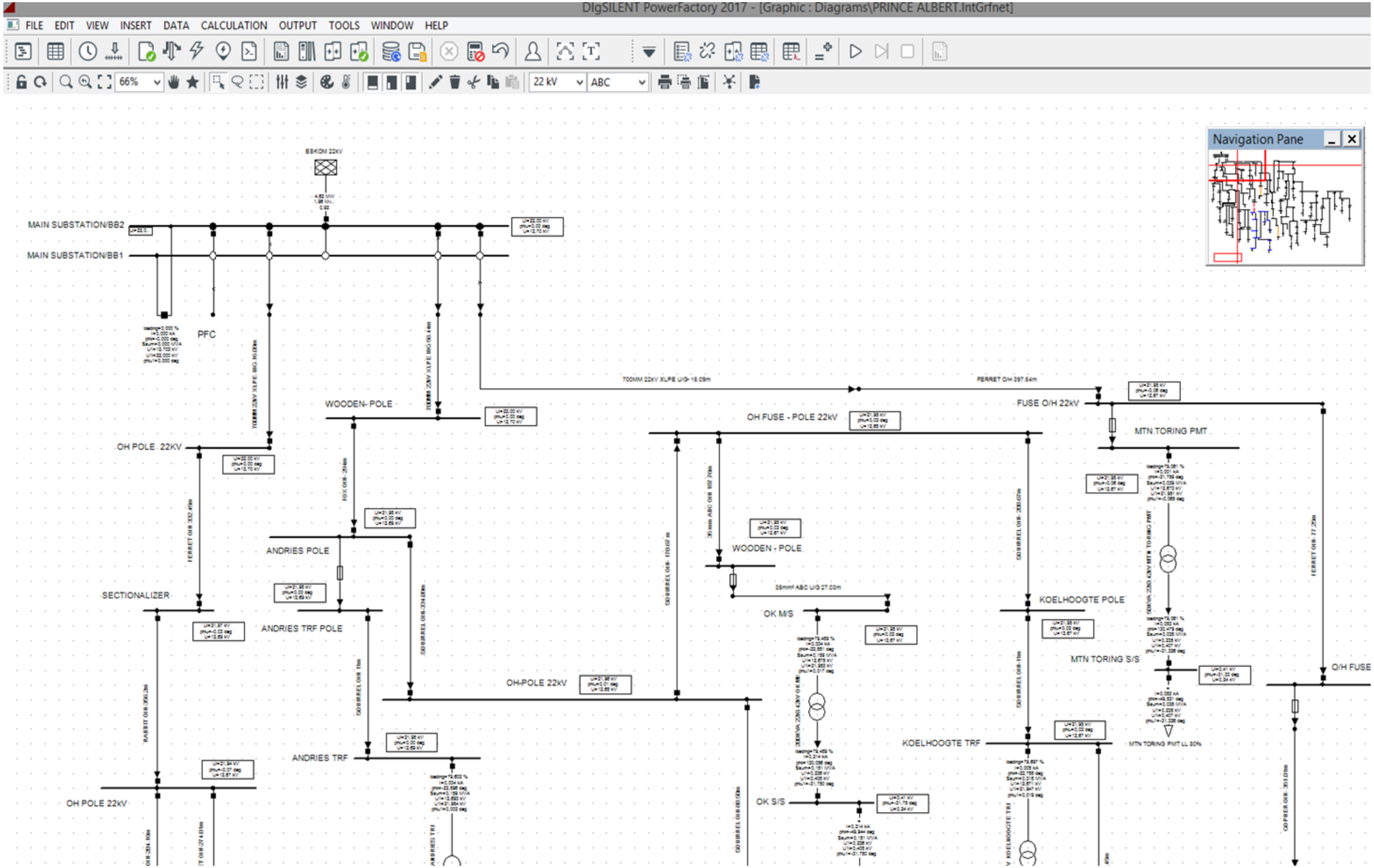


Figure 4-6: Dig-Silent 3-Phase Short Circuit (50% Loading)

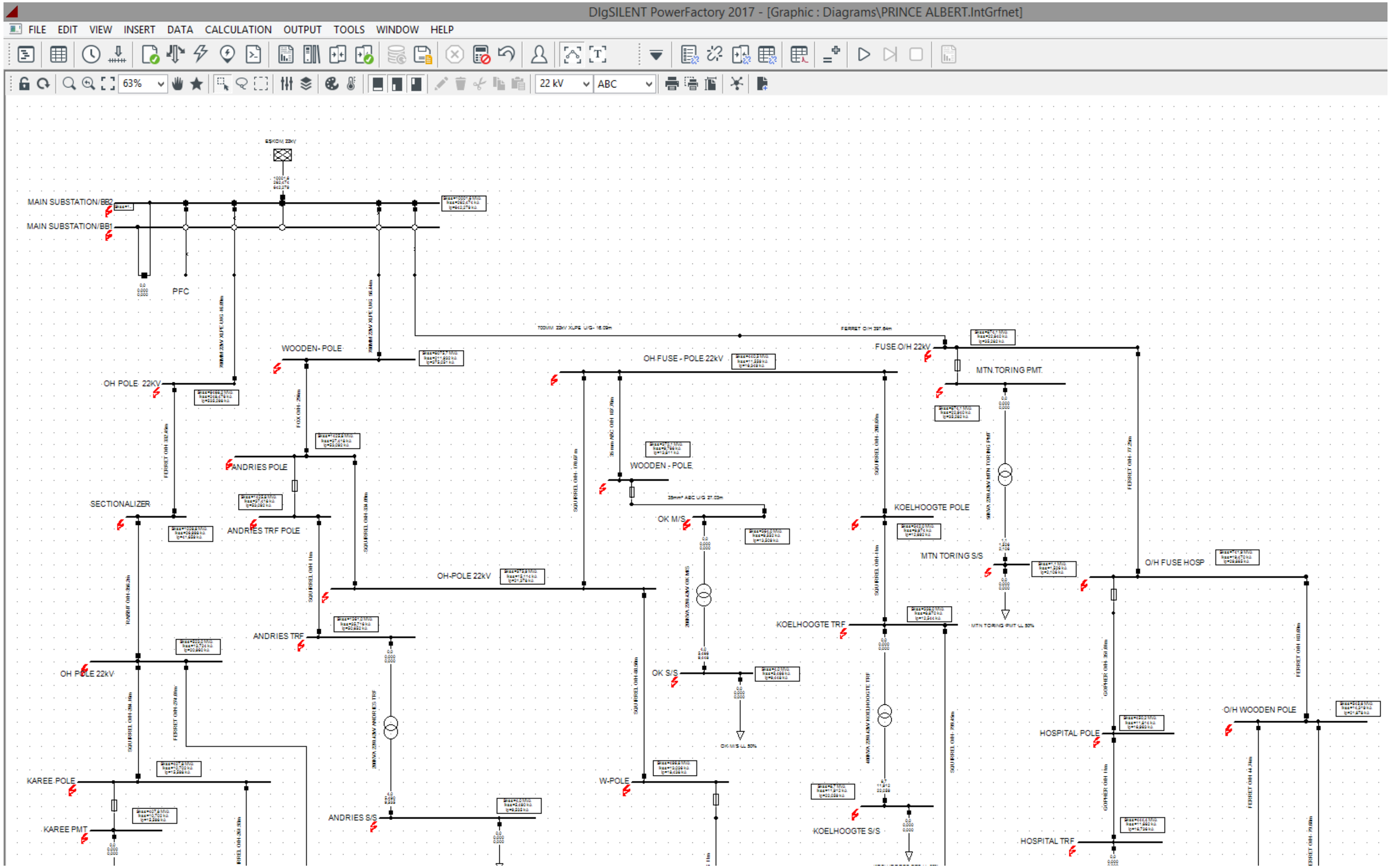
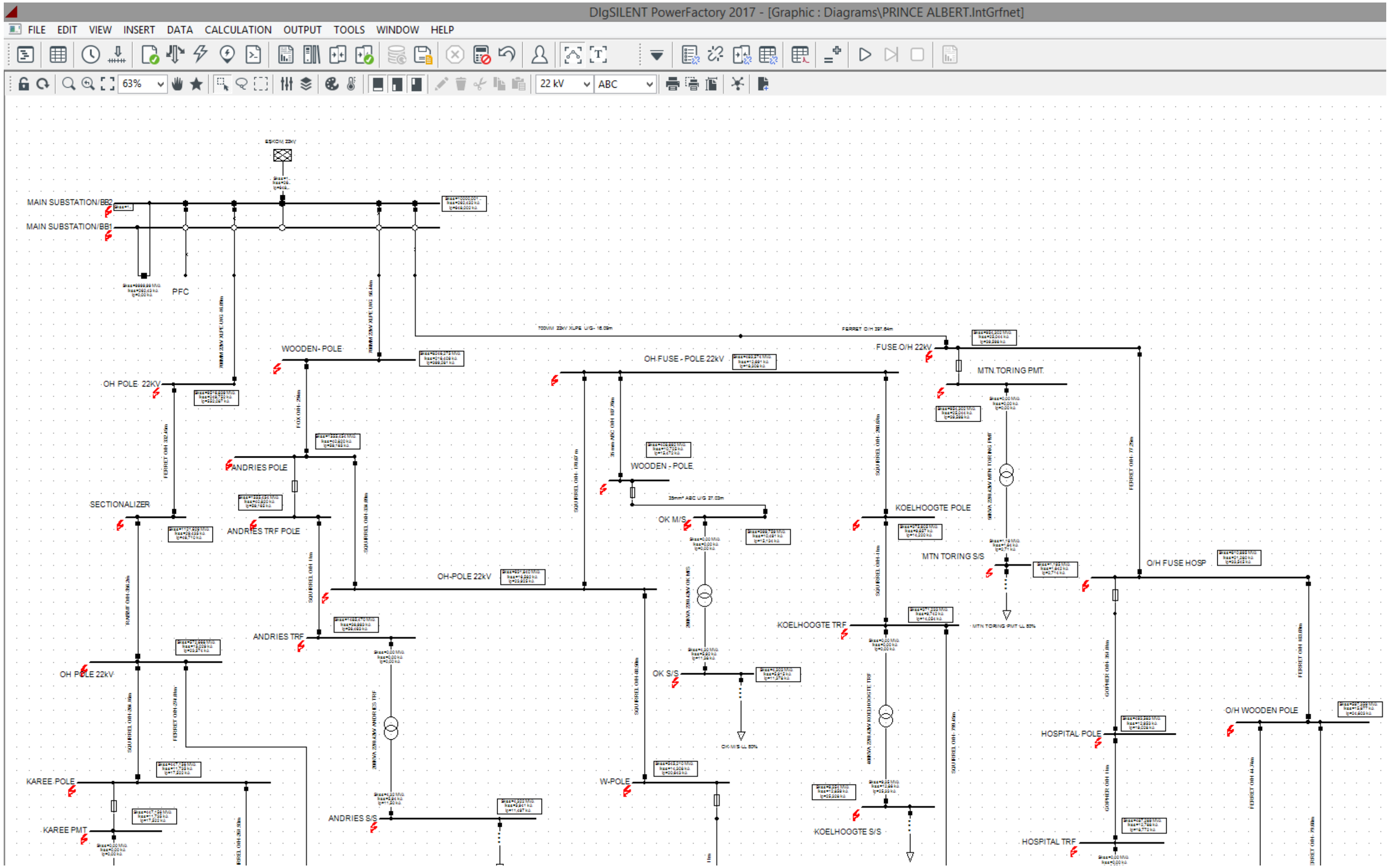


Figure 4-7: Dig-Silent 3-Phase Short Circuit (80% Loading)



5 DISTRIBUTION NETWORK ASSESSMENT

The following sections present aspects of the technical evaluation which include network analysis as well as operational considerations and results for Prince Albert, Prince Albert Weg, Leeu Gamka and Klaarstroom.

Two network scenarios were developed, in line with the load growth scenarios, to review the expected performance of the Prince Albert Municipality network. These scenarios accounted for:

- Most Likely growth, and
- High growth.

Network simulations were conducted on the existing and future 22kV networks for the above scenarios. Network simulations included:

- System Intact analysis. Analyses were conducted on future network load level and configurations to identify thermal and voltage violations.

The following sections provides some background and project descriptions for each of the studied regions.

5.1 Prince Albert Distribution Region

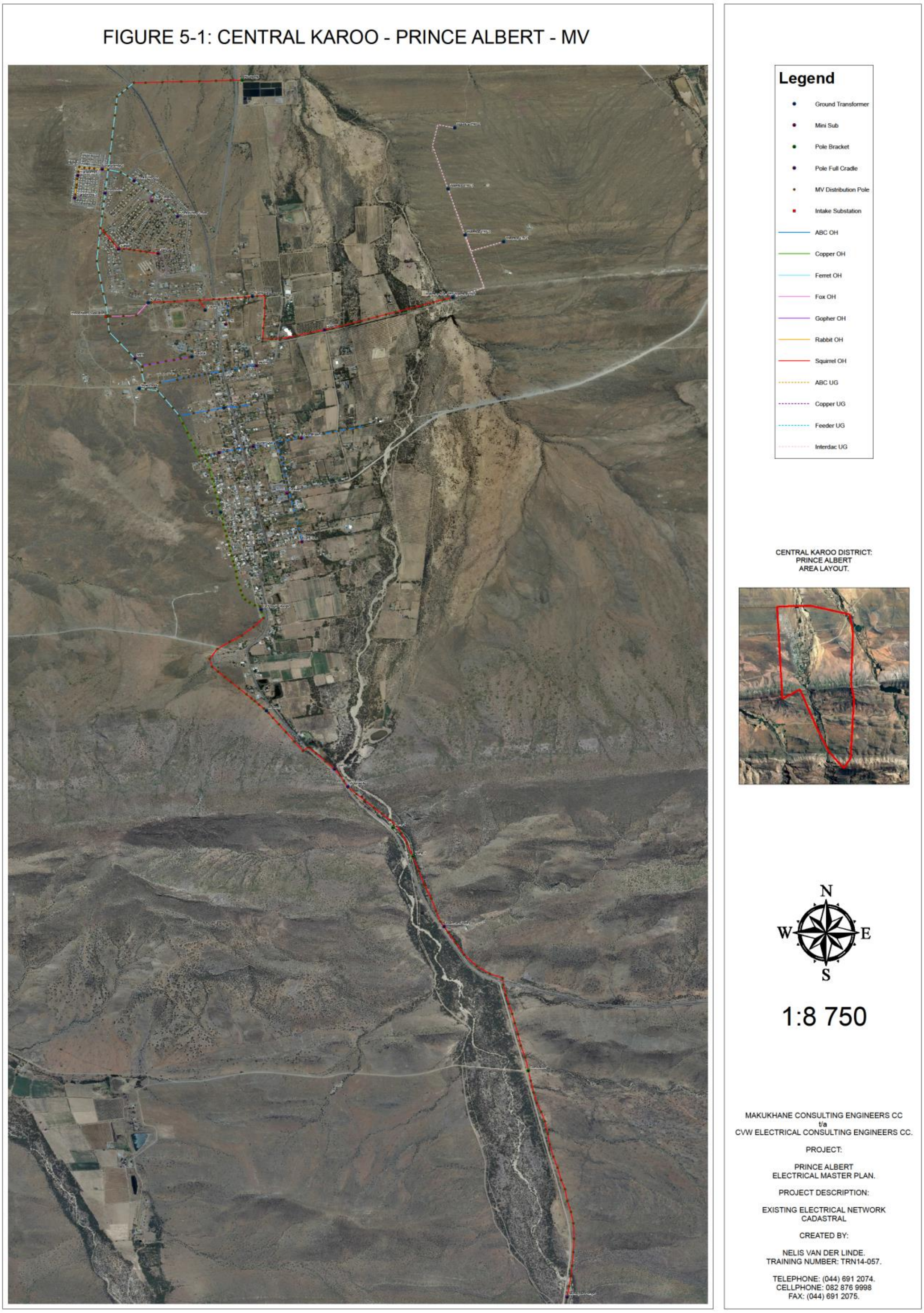
The village of Prince Albert sprang from the loan farm Queekvalleij, established by Zacharias and Dina de Beer in 1762. The fertile valley soon attracted other farmers, church services were held on the market square and by 1842 an NG church had been built and a thriving community established.

The town today is mainly the service centre for the surrounding wine and fruit growing areas in the Breede River Valley. Worcester lies at the N1 freeway connecting Cape Town and Gauteng and is surrounded by the Brandwacht, Overhex and Langeberg Mountains.

The majority of people in the Local Municipality have access to electricity (86.42%) for lighting, electricity (62.66%) for heating and electricity (76.10%) for cooking. Electricity provision is clearly linked to bulk services, which is provided by Eskom. This explains the high percentage of the population with adequate access to electricity services. In rural areas, the farms are also provided with Eskom electricity; however, there is still a backlog of 27.4%.

Figure 5-1 provides an aerial view, Distribution network.

Figure 5-1: ArcGIS aerial view, Distribution network.



5.1.1 Distribution Network

The main electricity supply to Prince Albert is through a 22kV, radial ACSR Over Head Line from Leeu-Gamka Eskom Substation. During 2016 a new Primary distribution substation was built. The Industrial 22kV substation is being supplied from Eskom at 22kV which in turn supplies the town of Prince Albert via three 22kV overhead lines. The majority of the distribution networks consist of 11kV underground and overhead cable networks with some network on the outskirts of the town being overhead lines. The green line from Leeu-Gamka to Prince Albert represent the 22 kV OH Line.

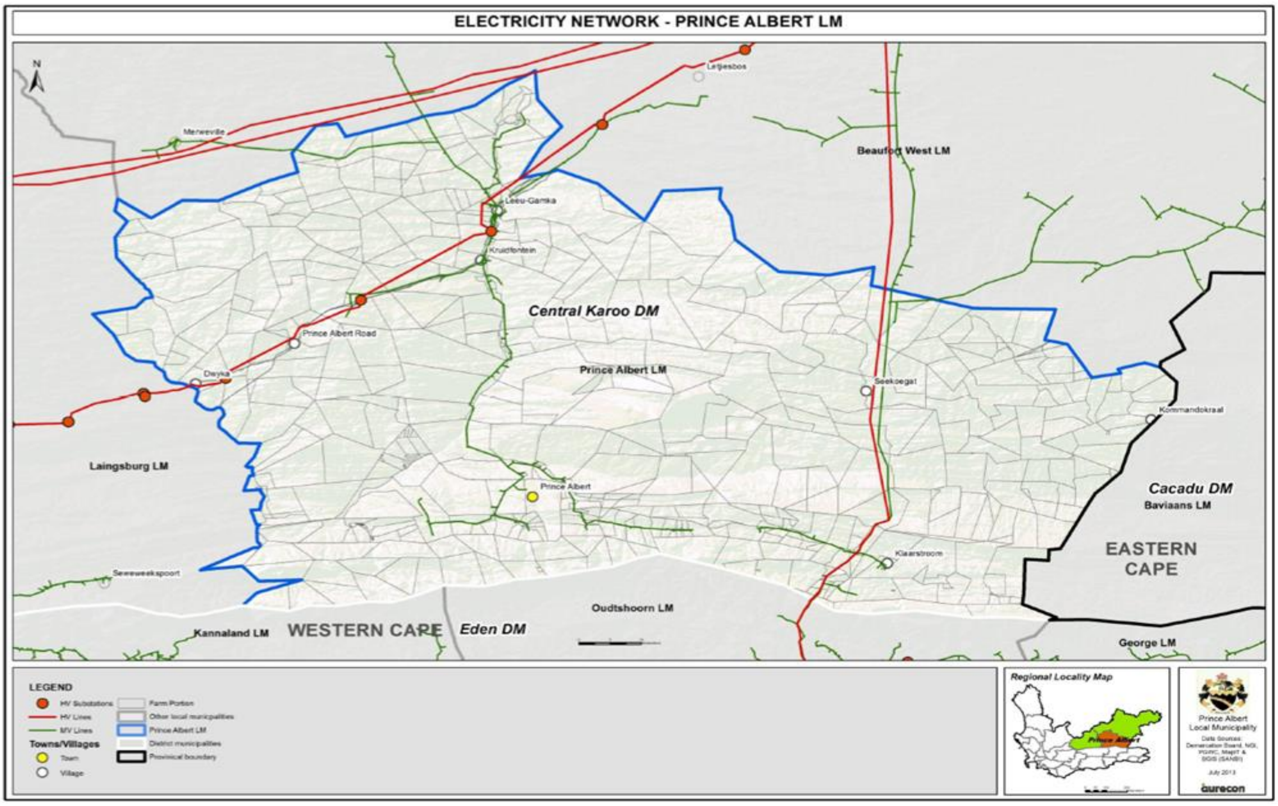


Figure 5-2: Eskom Distribution network – 22 kV OH Line

5.1.2 Load Growth

The existing load on the Prince Albert network is in the order of 2.5MW and is expected to grow to between 3.5 and 5.5 MW by 2030.

The most prominent development initiatives within Prince Albert are shown in Figure 5-1:

Table 38 | Housing Demand – Prince Albert Local Municipality (Source: IDP)

Prince Albert	Leeu Gamka	Klaarstroom	Total
842	502	144-60*	**1428**

Table 5-1: Housing Demand

5.1.3 Distribution Network Deficiencies

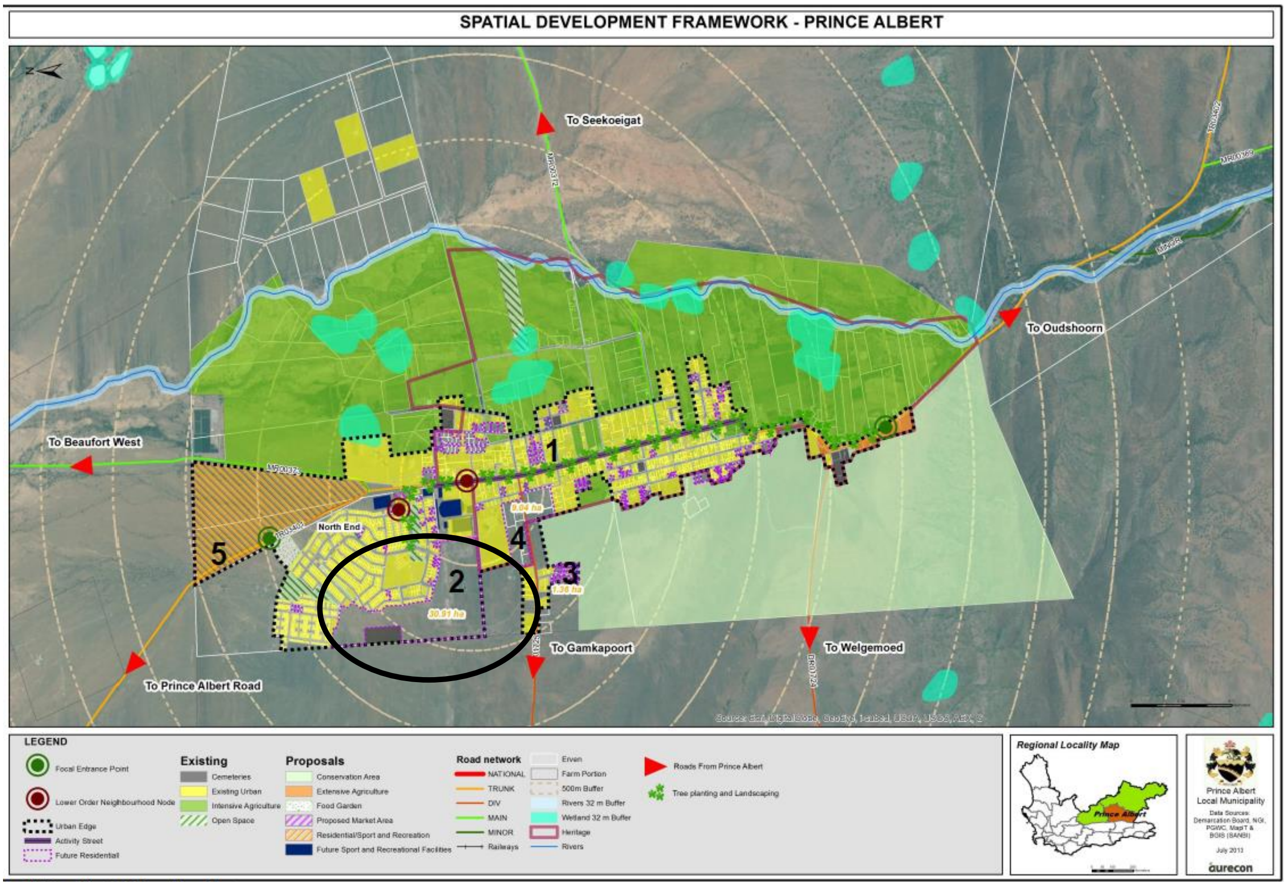
Analysis of the Prince Albert distribution network has shown the following:

5.1.3.1 Short-term Deficiencies

In the short-term, with the existing network configuration, the Prince Albert distribution network experiences thermal overload at the Waterkop pole mounted transformer. The network further requires refurbishment on numerous mini-subs and transformers. A large number of transformers are not protected with fuses.

5.1.3.2 Longer-term Deficiencies

With the expected load growth in the future, the above deficiencies will be more prominent. Voltages, just below steady-state criteria are also expected to continue. These are further worsened by the large development expected at the North End (Fig 5-4) area as well as the additional growth in the Prince Albert areas.



Map 51 | Prince Albert SDF Map – Prince Albert

Figure 5-4: North End Future Residential

5.2 NETWORK ANALYSIS

This report covers a Ten Year Master Plan for Prince Albert. Load flows modelled in

DIG-SILENT to determine the upgrading that would be required to normalise the electrical network and provide adequate capacity up to 10 years.

Network simulations were conducted on the existing and future Prince Albert network. Analysis was conducted on various network levels and configurations to effectively identify thermal and voltage violations arising due to existing and future load growth. A number of alternatives were tested to ensure technical viable solutions to these violations.

The following parameters were used in the preparation of this report:-

- As-built reticulation as at the time of collecting the information March 2016;
- Low cost housing residential areas: initial domestic After Diversity Maximum Demand (ADMD) of 1.8 kVA per domestic consumer as approved by Eskom;
- Formal, upmarket, residential housing areas: initial domestic After Diversity Maximum Demand (ADMD) of 2 kVA per domestic consumer (load growth was assumed at 0.5% per annum over 20 years), with the ultimate domestic ADMD of 3 kVA per consumer;
- Consumption pattern of commercial consumers remains constant with natural growth commensurate with similar environments;
- Proposed future developments; e.g. shopping complex, residential units, industrial developments are included herein;
- 100% nominal medium voltage at Eskom supply substation;
- 5 % voltage drop in the Medium Voltage network as per NRS Regulations;
- Safety Regulations of the OHS Act;

5.3 DIG-SILENT LOAD FLOW CALCULATIONS

The entire network of Prince Albert was modeled in DIgSILENT PowerFactory 14.1. The software is an overall functional integration and applicability to the modelling of generation-, transmission-, distribution- and industrial grids and the analysis of the interactions between these grids.

- Model No. 1 – All transformers and mini-subs were set to 50 % loading on the 22000/400 volt bus bar
- Model No. 2– All transformers and mini-subs were set to 80 % loading on the 22000/400 volt bus bar

(See Fig 4-4 and Fig 4-5 in Electrical Master plan 2016/17 File)

5.4 DIG-SILENT 3-PHASE SHORT CIRCUIT CALCULATIONS

The entire network of Prince Albert was modeled in DIgSILENT PowerFactory 14.1. The software is an overall functional integration and applicability to the modelling of generation-, transmission-, distribution- and industrial grids and the analysis of the interactions between these grids.

(See Fig 4-6 and Fig 4-7 in Electrical Master plan 2016/17 File)

5.5 SINGLE LINE LAYOUT PLAN – AS BUILT

(See Fig 4-1 in Electrical Master plan 2016/17 File)

5.6 PRINCE ALBERT MASTER LAYOUT PLAN

(See Fig 4-2 in Electrical Master plan 2016/17 File)

5.7 NETWORK RECOMMENDATIONS

With a long term vision, a definite plan needs to be established for network expansion and strengthening to ensure adequate performance. The plan should comply:

- Minimising system losses,
- Limiting environmental impact,
- Applying most economical technologies,
- Compliance to reliability and quality requirements of the customer, and
- Developing systems that can be maintained, improved and operated with the least possible amount of effort and cost.

Refurbishment forms a key part of this long term vision and must be carefully integrated with the strategic network expansion plan.

5.7.1 <u>MAJOR UPGRADES:</u>

5.7.1.1 Waterkop 100kVA 22/0.42kVA Pole Mounted Transformer (PMT)

The existing 100kVA 22/0.42kVA PMT has reached supply capacity. It is proposed that a 100kVA 22/0.42kVA PMT be replaced with a 315kVA 22/0.42kVA ground transformer, refer to DigSILENT Load Flow Calculations + Report

(See Fig 4-4 and Fig 4-5 in Electrical Master plan 2016/17 File)

5.7.1.2 Hospital 160KVA 22/0.42kV ground transformer has reached firm capacity and has oil leaks. It is proposed that a 160kVA 22/0.42kVA ground transformer be replaced with a 200kVA 22/0.42kVA ground transformer.

5.7.1.3 Meiring 160KVA 22/0.42kV Mini-sub has reached firm capacity. It is proposed that a 160kVA 22/0.42kVA Mini-sub be replaced with a 315kVA 22/0.42kVA Mini-sub.

5.7.1.4 Crosby 200KVA 22/0.42kV ground transformer has reached supply capacity and has oil leaks. It is proposed that a 200kVA 22/0.42kVA ground transformer be replaced with a 315kVA 22/0.42kVA ground transformer.

5.7.1.5 Both Bo Dorp and Nywerheids 100kVA 22/0.42kV ground transformers has reached their life span. It is proposed that both ground transformer be replaced with new but with the same kVA ground transformers.

(See Annexure A- Transformer Report in Electrical Master Plan 2016 File)

5.7.2 MAJOR REFURBISHMENTS:

5.7.2.1 Andries 200kVA 22/0.42kV ground transformer is experiencing thermal overload and has oil leaks. It is proposed that be refurbished.

5.7.2.2 Koelhoogte 400kVA 22/0.42kV ground transformers is experiencing thermal overload and has oil leaks. It is proposed that be refurbished.

5.7.3 REFURBISHMENT REQUIRED:

Numerous transformers need refurbishment in order to prolong their expected life span and continue providing adequate power to customers.

(See Annexure A- Transformer Report in Electrical Master Plan 2016 File)

6. CAPITAL AND FINANCIAL EVALUATION:

6.1 Background

One of the main criteria evaluating system alternatives is the extent of capital outlay. Not only must the solutions to the network problems be technically viable, but they must also be financially sound. The capital and financial analysis conducted on the Prince Albert network aims to set up a Short and Long term capital program which offers Prince Albert Municipality an acceptable return on investment. The following aspect apply:

- In order to perform a financial analysis, a basic capital program is compiled containing capital requirements for each proposed project,
- Financial analysis tests the viability of the capital expenditure in terms of:

  (a) The impact on future cash flows,

  (b) Net present worth of the investments, and

  (c) The Internal Rate of Return (IRR).

The financial analysis should ensure that the envisaged capital expenditure program is affordable to Prince Albert Municipality.

6.2 Costing of Capital Projects

Capital projects were identified through analysis and assessment of the following aspects:

- Expansion requirements, and
- Refurbishment requirements.

The capital program was developed by using standard equipment cost, contained in an equipment library. The output from the various evaluation systems was used to set up three capital program scenarios.

The capital program allow for:

- Distribution network Development and optimization
- Refurbishment requirements

The below values are VAT inclusive and should be regarded as 80 to 100 % correct.

Projects should be prioritized for each financial year.

In summary, the following needs to be implemented: -

- Replace/Installation of a new transformer;
- Refurbishment of Mini-sub's, pole mounted and ground transformers;

6.3.1 Major Upgrades required

No	Description	Cost	Year
6.3.1.1	Replacement of Waterkop 100kVA 22/0.42kV PMT with 315kVA 22/0.42kVA ground transformer.	R 257 802	2017/18
6.3.1.2	Hospital 160kVA 22/0.42kVA ground transformer be replaced with a 200kVA 22/0.42kVA ground transformer.	R 200 000	2017/18
6.3.1.3	Crosby 200kVA 22/0.42kVA ground transformer be replaced with a 315kVA 22/0.42kVA ground transformer.	R 257 802	2017/18
6.3.1.4	Nywerheids 100kVA 22/0.42kV ground transformer be replaced with a new 100kVA 22/0.42kV ground transformer.	R 108 058	2017/18
6.3.1.5	Bo Dorp 100kVA 22/0.42kV ground transformer be replaced with a new 100kVA 22/0.42kV ground transformer.	R 108 058	2017/18
6.3.1.6	Meiring 160kVA 22/0.42kVA Mini-sub be replaced with a 315kVA 22/0.42kVA Mini-sub.	R 357 802	2017/18
6.3.1.7	Andries ground transformer needs refurbishment.	R 80 000	2017/18
6.3.1.8	Koelhoogte ground transformer needs refurbishment.	R 80 000	2017/18

Table 6-1: Major Upgrades

6.3.2 Mini-Sub/ Transformer refurbishments required

No	Description	Cost	Year
6.3.2.1	200kVA 22/0.42kV Botterblom PMT	R 60 000	2018/19
6.3.2.2	100kVA 22/0.42kV Kronkel Weg Bo PMT	R 50 000	2018/19
6.3.2.3	200kVA 22/0.42kV 3de Laan PMT	R 60 000	2018/19
6.3.2.4	200kVA 22/0.42kV Karee PMT	R 60 000	2018/19
6.3.2.5	100kVA 22/0.42kV Hope PMT	R 50 000	2018/19
6.3.2.6	25kVA 22/0.42kV Scholtzkloof Ingang PMT	R 12 000	2018/19
6.3.2.7	200kVA 22/0.42kV Tusong Ground Transformer	R 60 000	2018/19
6.3.2.8	160kVA 22/0.42kV Hospital Ground Transformer	R 55 000	2019/20
6.3.2.9	100kVA 22/0.42kV Nywerheids Ground Transformer	R 50 000	2019/20
6.3.2.10	200kVA 22/0.42kV De Pressie Hoogte Ground Transformer	R 60 000	2019/20
6.3.2.11	400kVA 22/0.42kV Nieuwe Mini-sub	R 50 000	2019/20

Table 6-2: Mini-Sub/ Transformer refurbishments

6.3 Linking with Load Forecast Model

The load forecast model developed during this study provides vital input for the financial evaluation. Per unit purchase and selling rates are calculated and extrapolated according to the load growth of the study area. The load zones and their corresponding load parameters as defined in the Load Forecast model are used to calculate expected energy consumption and subsequent revenue.

7. Conclusions and Recommendations

All network projects were evaluated considering expansion due to anticipated load growth and network performance improvement. The evaluation of the existing and future networks assumed specific network improvements that were performed through standard engineering practice. Network studies were performed for distinct system loads, developed from the geographical load forecast.

The time frames and load representation were for:

- Base year (2016),
- Short-term (2017, 2018 and 2019), and
- Longer-term (2020, 2021, 2022, 2023, 2024 and 2025).

7.1 Network Expansion Recommendations

The study has identified and documented expansion and strengthening projects to ensure the adequate performance of the network within the Short- and Longer-term. These projects are shown in fig 7-1 and table 7-1 below.

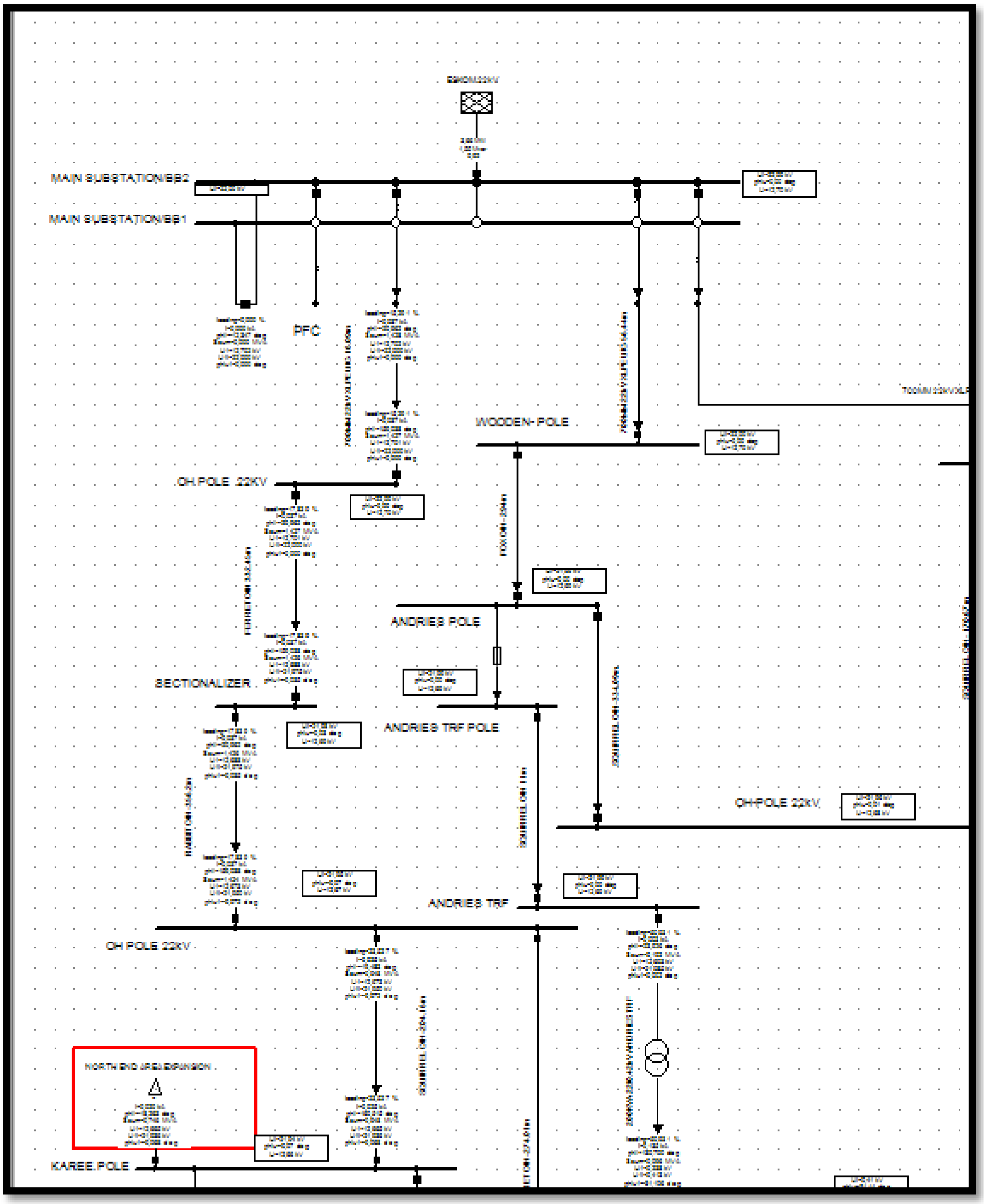


Fig 7-1: North End Expansion Recommendation

Project Name	Description	Budget Cost
22 kV Main Substation upgrade	2 000 kVAr Power Factor Correction Equipment	R 2 000 000.00
22 kV Main Substation upgrade – Eskom NMD Increase	Increase NMD from 2.5 to 3.5 MVA	R 2 500 000.00

Table 7-1: Network Expansion Recommendation